UNIVERSITATEA "BABEŞ-BOLYAI", CLUJ-NAPOCA
FACULTATEA DE PSIHOLOGIE ŞI ŞTIINŢE ALE EDUCAŢIEI

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TEZĂ DE DOCTORAT

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2010

UNIVERSITATEA "BABEŞ-BOLYAI", CLUJ-NAPOCA
FACULTATEA DE PSIHOLOGIE ŞI ŞTIINŢE ALE EDUCAŢIEI
CATEDRA DE PSIHOLOGIE

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ANXIETY ACROSS DEVELOPMENT: Temperamental predictors, emotion regulation strategies and attentional mechanisms

Conducător ştiinţific:
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CLUJ-NAPOCA
2010

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Acknowledgements

The present thesis and the research included in it would not have been possible without a few persons and institutions that have advised, supported, or helped me along the way.

I am grateful to my scientific supervisor, Prof. Mircea Miclea, for his support and insightful advice during the whole process of designing and bringing this thesis to completion. Throughout my years as a bachelor, master and PhD student, Dr. Oana Benga has been a constant advisor and supporter of my empirical endeavours. I owe her my involvement in developmental psychology, and I am grateful for the chance to work with her.

Many thanks go to my colleagues in the Developmental Psychlogy Lab of the Department of Psychology (Babeş-Bolyai University): Dr. Laura Visu-Petra, Dr. Thea Ionescu, Dr. Elena Geangu, Georgiana Susa, Irina Pitică and Lavinia Cheie. They have contributed with advice, feedback, practical help and many exciting scientific discussions during various phases of completing this thesis. From among this group, I am especially grateful to Dr. Laura Visu-Petra, who has been a valuable colleague, as well as a close friend and a source of wisdom during all these years.

No research would be possible without data. Therefore, this thesis would not have been possible without the children and parents who agreed to take part in our studies, as well as the undergraduate students who volunteered as participants. Invaluable support during the data gathering process has been provided by the principals and staff members of a few educational instituitions in Cluj-Napoca that were involved in the studies (in chronological order): principal Florica Rogoz, counselor Ana Maria Băiescu and the teachers of the „Academia Piticilor" Kindergarten; principal Angela Ştefan Bîrdea and the teachers of the „Babeş-Bolyai" University Kindergarten; principal Silvia Ţinică and teachers of of the „Horea" School; principal Mariana Dragomir, counselor Sarolta Mitea and teachers of the „Mihai Eminescu" Highschool. I am also grateful to the students who have provided practical help during the various research studies; thanks go to Irina Pitică and Georgiana Susa for help with data gathering for Study 2A (Chapter 5); to Alexandra Guşiţă, Lavinia Jişa and Dermina Vasc for Study 1B and 2B (Chapters 3 and 5, respectively); to Dermina Vasc, Daniela Bota and Mădălina Radu for their efficiency in scheduling adult participants and for their assistance during data collection in studies 1C, 2C and 3 (Chapters 3, 5 and 6).

The data in this thesis would not have been possible without the generosity of a few researchers who offered us access to questionnaires they had devised or adapted: Dr. Oana Benga (for the Romanian translations of the *Children's Behavior Questionnaire* and *Spence Preschool Anxiety Scale*), Dr. Samuel Putnam (for access to the *Temperament in Middle Childhood Questionnaire* and *Adult Temperament Questionnaire*), Dr. Nancy Eisenberg (for the *Children's Coping Styles Questionnaire*), Dr. Tim Ayers (for the manual of the *Children's Coping Strategies Checklist*), and Dr. Nadia Garnefski (for the *Cognitive Emotion Regulation Questionnaire*). My colleague Dr. Eva Kallay has contributed to the translation of the adult questionnaires. I am also grateful to D&D Consultants / Testcentral and Dr. Dragoş Iliescu for granting me permission to use the *State-Trait Anxiety Inventory*™, *form Y*. My thanks also go to Dr. Nilli Lavie and Dr. Laura Visu-Petra for advice in designing the perceptual load task used in study 3 (Chapter 6).

Financial support for the research included in this thesis came from various sources: a doctoral scholarship (2005-2008) from the Babeş-Bolyai University, and different grants: Grant CNCSIS-Bd no. 193/2005, Grant CEEX-ET no. 131/2006 (principal investigator Dr. Oana Benga); Grant CEEX-M1 no. 124/2006 (principal investigator: Dr. Mircea Miclea). I am grateful to the institutions and people involved. I am also grateful for financial support from Grant CNCSIS ID-48/2007 and to principal investigator Dr. Raul Mureşan.

A PhD student's journey would be much lonelier without support from friends. I was lucky enough to have such friends both in and outside of academia: Laura, Smaranda, Gabi, Anni, Nicoleta, Eva and Loredana. Last but not least, I owe a lot to the most important people in my life: to my mother, father and brother, for being a constant source of support and encouragement, despite not always understanding what I do.

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Abbreviations

ACC	Anterior cingulate cortex.
ACT	Attentional Control Theory
ANT	Attention Network Test
BI	Behavioral inhibition / Behaviorally inhibited
CS	Contention Scheduler
DLPFC	Dorsolateral prefrontal cortex
EC	Effortful Control
ER	Emotion regulation
NA	Negative Affect
PET	Processing Efficiency Theory
PFC	Prefrontal cortex
SAS	Supervisory Attentional System
SOA	Stimulus Onset Asynchrony
WM	Working memory

Introduction

Anxiety is probably the most common form of emotional problems that can occur during childhood, adolescence and adulthood. Its frequency, as well as its impact upon adaptive functioning, have determined researchers to attempt to find its potential causes, and to better understand its cognitive, behavioral and neurophysiological correlates. Within this context, developmental psychologists have a unique, privileged perspective, since they have the necessary intruments to look at *change*, or, more precisely, to investigate the manner in which factors associated with anxiety interact or modify their importance over the course of development.

The present thesis is an attempt to investigate anxiety from a developmental perspective, by looking – across different developmental samples – at individual differences (in temperament and emotion regulation) that might increase or decrease risk, and by investigating attentional functioning associated with anxiety. The thesis is divided in two parts, corresponding to the two topics investigated. Some of our studies were guided by relatively clear hypotheses, while others had a more exploratory nature. However, all of them have managed to provide some interesting answers to our questions, or at least to generate questions that remain to be tackled in future research.

Chapter 1.
Anxiety in children and adults

Anxiety disorders represent the most prevalent type of psychopathology in children, adolescents and adults. In adults, worldwide 12-month prevalence estimates range between 2.4% in Shanghai, China and 18.2% in the USA (Demyttenaere et al., 2004). In Europe, 12-month prevalence ranges between 5.8% and 12.0% (Alonso et al., 2004; Demyttenaere et al., 2004). Lifetime prevalence averages 28.8% in the USA (Kessler et al., 2005) and 13.6% in Europe (Alonso et al., 2004; see also Miu & Visu-Petra, 2010 for a recent review). In various studies, average prevalence estimates for children and adolescents range between approximately 5% for three-month estimates, 15% for 12-month estimates and 17.2% for lifetime estimates (typically, 12-month and lifetime estimates are generated based on adolescent samples; see Bernstein, Borchardt, & Perwien, 1996; Costello, Egger, & Angold, 2004; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Rapee, Schniering, & Hudson, 2009).

Anxiety refers to a set of behavioral, cognitive and physiological reactions, in response to perceived or expected threats. While fear responses in the face of potential danger represent an adaptive aspect of emotional functioning (e.g., Rothbart, 1988; Rothbart & Bates, 1998), anxiety reactions are generally excessive from the point of view of the feared stimulus, and they can be disabling to everyday functioning (Gordon & Hen, 2004; Gross & Hen, 2004). Whether focused on adults or children, the research literature has typically taken one of two possible approaches to the conceptualization of anxiety: the clinically-based (categorical) approach or the trait-based approach (see e.g., Miu & Visu-Petra, 2010 for a more extensive discussion of the two approaches). From a clinical point of view, individuals are categorized as having or not having an anxiety disorder if they show a certain number of characteristics of that disorder, manifest over a sufficient amount of time. This approach has generally used structured, standardized interviews (e.g., *Anxiety Disorders Interview Schedule*: Brown, Di Nardo, & Barlow, 1994; Silverman & Nelles, 1988; Silverman, Saavedra, & Pina, 2001; *Preschool Age Psychiatric Assessment*: Egger et al., 2006) that use clear cutoff points to distinguish between the presence or absence of an anxiety disorder in a person. The current version of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR) distinguishes among eight main types of anxiety disorders, relevant for adults as well as children and adolescents: separation anxiety disorder, generalized anxiety disorder, social phobia, specific phobia, obsessive-compulsive disorder, panic disorder, agoraphobia, and posttraumatic stress disorder (American Psychiatric Association, 2000; see also Dadds, James, Barrett, & Verhulst, 2004; Egger & Angold, 2006; Rapee et al., 2009); generalized anxiety disorder is the most common among children, while panic disorder and agoraphobia are the least common (Costello et al., 2004).

The second approach to anxiety emerged (in its current form) from personality research, and consequently it conceptualizes anxiety as a *trait* (i.e., a relatively constant predisposition to react or behave in a certain way; see Endler & Kocovski, 2001 for a review). Thus, *trait anxiety* refers to the generalized and enduring predisposition to react with a state of anxiety when encountering even mildly threatening or ambiguous stimuli (Spielberger, 1983). The concept of trait anxiety is partly based on the idea that, beyond the strict presence or absence of an anxiety *disorder*, in the general population anxiety symptoms vary continuously from very mild to very intense. This approach uses questionnaires to assess anxiety symptoms in adults (Endler, Parker, Bagby, & Cox, 1991; Ş. Miclea, Albu, & Ciuca, 2009; Spielberger, 1983) and children (e.g., Benga, Ţincaş, & Visu-Petra, 2010; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000; Edwards, Rapee, Kennedy, & Spence, 2010; Essau, Peter Muris, & Ederer, 2002; Muris, Merckelbach, Gadet, & Moulaert, 2000; Spence, 1998; Spence, Rapee, McDonald, & Ingram, 2001). The trait approach has been largely adopted by researchers investigating links between anxiety and cognitive processes in children (Dalgleish et al., 2003; Heim-Dreger, Kohlmann, Eschenbeck, & Burkhardt, 2006; Vasey, El-Hag, & Daleiden, 1996; Waters & Lipp, 2008; Waters & Valvoi, 2009) and adults (Bradley, Mogg, White, Groom, & De Bono, 1999; Eysenck, Derakshan, Santos, & Calvo, 2007; MacLeod, Mathews, & Tata, 1986; Mogg, Bradley, De Bono, & Painter, 1997; Williams, Mathews, & MacLeod, 1996).

1.1 Anxiety in children and adults: Development and outcomes

Most anxiety disorders are typically diagnosed starting in middle childhood (see Egger & Angold, 2006a, 2006b; Warren & Sroufe, 2004 for reviews). With respect to typical age of onset for different types of anxiety disorders, epidemiological studies indicate that specific phobias and separation anxiety tend to emerge in preschool or middle childhood, social phobia and obsessive-compulsive disorder have their onset in adolescence, while panic disorder emerges in late adolescence and adulthood. Data regarding generalized anxiety disorder is less clear: some studies place the onset in childhood, while others report adolescence or even adulthood as the starting age (Kessler et al., 2005; see also Chorpita, 2006; Rapee et al., 2009 for reviews).

Until the 1990s it was typical to consider anxiety as a problem that rarely affected young children (Rapee et al., 2009). One of the main causes for this reside in the fact that certain types of fears (e.g., of strangers, of animals, storms, imaginary creatures, etc.) constitute a normal part of development – especially during the toddler and preschool years. These fears generally subside in middle childhood, and are replaced by less intense and more realistic developmentally normative fears (e.g., regarding school grades, relationships with peers or teachers, etc.; see Muris, 2007; Warren & Sroufe, 2004 for details). Therefore, more serious and disruptive anxiety issues become more visible during this period of development. In addition, some symptoms typical for anxiety in older children and adults might take on a different form in preschoolers, or might not apply at all. For example, phobias (including social phobia) might manifest through crying, tantrums or clinging to the caregiver (Egger & Angold, 2006a), while older children, with better verbal abilities, are more capable of describing their symptoms. However, studies have shown that when DSM-based algorithms are used for diagnosis in preschoolers, prevalence and comorbidity of internalizing and externalizing disorders are within the range estimated for older children (Egger & Angold, 2006b; Sterba, Egger, & Angold, 2007). The overall prevalence of anxiety disorders tends to be relatively constant across development (Canino et al., 2004; Costello et al., 2003; Ford, Goodman, & Meltzer, 2003).

Whether or not clinically significant, there is evidence to suggest that continuous variation in anxiety symptoms can be reliably identified in the general child population. Recently, there have been notable efforts to create self- or parent-report questionnaires that allow the measurement of anxiety symptoms for the main anxiety disorders in preschoolers (Edwards et al., 2010; Spence et al., 2001), as well as schoolchildren and adolescents (Chorpita, Moffitt, &

Gray, 2005; Chorpita et al., 2000; Muris, Merckelbach, Ollendick, King, & Bogie, 2002; Spence, 1997, 1998). Research using such measures indicates slight (but mostly non-statistically significant) increases in anxiety symptoms across the preschool years (Benga et al., 2010; Edwards et al., 2010; Spence et al., 2001), and a reduction in symptom intensity across middle childhood and adolescence (Essau et al., 2002; Muris et al., 2000; Nauta et al., 2004; Spence, 1998).

Anxiety disorders are generally more prevalent in women (e.g., American Psychiatric Association, 2000; Hettema, Prescott, Myers, Neale, & Kendler, 2005; Kendler et al., 1995), but data is less clear when it comes to children. In preschoolers, most studies find small or non-significant differences in prevalence between boys and girls (Costello et al., 2004; Egger & Angold, 2006b; Lavigne et al., 1996), and this has been replicated with continuous measures of anxiety symptoms, which failed to find any differences in anxiety scores between girls and boys (Spence et al., 2001). In older children and adolescents, data is more mixed: some studies show higher prevalence for girls (Costello et al., 2004, 2003; Lewinsohn, Gotlib, Lewinsohn, Seeley, & Allen, 1998), while other studies have failed to find significant differences (Canino et al., 2004; Ford et al., 2003). However, even in studies where gender differences were identified, they were relatively small (see Rapee et al., 2009 for a review). However, questionnaire studies generally report higher anxiety scores for girls compared to boys (Chorpita et al., 2000; Essau et al., 2002; Muris, 2007; Muris, Meesters, & Knoops, 2005; Muris, Schmidt, & Merckelbach, 2000; Spence, 1998; but see Nauta et al., 2004 for an exception).

Typically, an early-onset untreated anxiety disorder tends to persist and continue into adolescence and adulthood (Bosquet & Byron Egeland, 2006; Spence, 1998), with negative outcomes for mental health, as well as academic or professional adjustment. Longitudinal studies often address questions of homotypic continuity (whether an anxiety disorder predicts having the same diagnosis in the future) and heterotypic continuity (whether an anxiety disorder significantly predicts different diagnoses in the future) associated with anxiety disorders (Costello et al., 2003). Such studies have found evidence for both homotypic and heterotypic continuity for anxiety, showing that having an anxiety disorder in childhood or adolescence increases the risk for a later anxiety disorder, major depression, and/or substance dependence (Costello et al., 2003; Ferdinand, Dieleman, Ormel, & Verhulst, 2007; Kessler et al., 2005; Rapee et al., 2009; Reef, Diamantopoulou, Van Meurs, Verhulst, & Van Der Ende, 2009; Rutter, Kim-Cohen, & Maughan, 2006; Wittchen, Beesdo, Bittner, & Goodwin, 2003; Woodward & Fergusson, 2001). Apart from predicting future psychopathology, some studies have found links between (clinical or trait) anxiety and low academic achievement (e.g., Davis, Ollendick, & Nebel-Schwalm, 2008; Ialongo, Edelsohn, Werthamer-Larsson, Crockett, & Kellam, 1995; Kusche, Cook, & Greenberg, 1993; Owens, Stevenson, Norgate, & Hadwin, 2008). For example, Ialongo et al. (1995) found that high scores on a self-report measure of anxious symptoms at age 5 predicted school performance four years later: children who had rated themselves as highly anxious were much more likely to be in the bottom third of their class in terms of academic achievement. Lastly, in adults anxiety is often accompanied by impairment in quality of life and subjective well-being (e.g., Henning, Turk, Mennin, Fresco, & Heimberg, 2007; Pollack et al., 2008; Rapaport, Fayyad, & Endicott, 2005), as well as cognitive failures and increased risk for accidents in the workplace (see Simpson, Wadsworth, Moss, & Smith, 2005 for a review).

1.2 Predictors / Risk factors

The high prevalence of anxiety and its deleterious impact on adjustment have motivated a high amount of research into its etiological factors. Moreover, while at this moment there is no clear cause – or combination of causes – that can predict with certainty whether someone will develop an anxiety disorder or not, there is clear evidence that anxiety disorders do have a genetic basis. First, children with an anxiety disorder are more likely to have first-degree relatives who also have an anxiety disorder, and this family loading tends to be specific (i.e., the same specific diagnosis – like for example social phobia – appears in both persons; see Hettema, Neale, & Kendler, 2001; Merikangas, Avenevoli, Dierker, & Grillon, 1999; Rapee et al., 2009 for reviews). Second, twin studies indicate a moderate (~ 30%) heritability of anxiety disorders (Hettema et al., 2001; Merikangas & Pine, 2002; Miu & Visu-Petra, 2010; Warren, Schmitz, & Emde, 1999), as well as trait anxiety (Lau, Eley, & Stevenson, 2006), and there are indications for a common genetic component across specific anxiety disorders (and perhaps also depression), since heritability is relatively constant across them (Gregory & Eley, 2007; Rapee et al., 2009). This latter observation supports the idea of a general, trait predisposition to anxiety. Lastly, genetic linkage and genetic association studies have identified several potential candidate gene polymorphisms that might be involved in anxiety disorders (see Gordon & Hen, 2004; Gross & Hen, 2004; Miu & Visu-Petra, 2010).

In line with this interest for finding the constitutional bases of anxiety, recent years have also witnessed an increasing interest in temperamental characteristics as potential predictors of anxiety (see e.g., Calkins & Fox, 2002; Lonigan & Phillips, 2001; Muris, Merckelbach, Wessel, & van de Ven, 1999; Rapee, 2002; Ţincaş, Benga, & Fox, 2006). Temperament is generally regarded as reflecting biologically-based individual differences in behavioral, cognitive, emotional and physiological aspects of reactivity/arousal and regulation (Goldsmith et al., 1987; Kagan, 1998; Rothbart, Ahadi, & D. E. Evans, 2000). It has been variously construed in terms of typologies (e.g., behaviorally inhibited; Kagan, Reznick, & Gibbons, 1989) or continuous factors (e.g., fearfulness, negative affect, inhibitory control; Rothbart, Ahadi, Hershey, & Fisher, 2001). Part of the literature investigating the link between temperament and anxiety has focused on *behavioral inhibition* (Kagan, 2003; Kagan et al., 1989; Kagan & Snidman, 1999), namely a temperamental style mainly characterized by a tendency to be shy and withdrawn in social settings. This research indicates that children categorized as behaviorally inhibited in infancy are more likely than non-inhibited children to develop an anxiety disorder later in life and are especially prone to social anxiety (e.g., Biederman et al., 1993; Biederman et al., 2001; Hirshfeld et al., 1992; Schwartz, Snidman, & Kagan, 1999), or have higher current or future levels of trait anxiety (Caspi, Henry, McGee, Moffitt, & Silva, 1995; Caspi, Moffitt, Newman, & Silva, 1996; Muris & Meesters, 2002; Shamir-Essakow, Ungerer, & Rapee, 2005). Other models (e.g., Rothbart & Bates, 1998, 2006) conceptualize temperament as a set of traits, in a manner similar to models of personality. Research using such models indicates that a generalized tendency to experience negative affectivity in everyday life, as well as poor general regulation of one's own behavior, cognition and emotion might predict anxiety in children (e.g., Calkins & Fox, 2002; Lemery, Essex, & Smider, 2002; Lonigan & Phillips, 2001; Meesters, Muris, & Rooijen, 2006; Muris, Mayer, Lint, & Hofman, 2008; Muris & Ollendick, 2005; Muris, Pennen, Sigmond, & Mayer, 2008; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007) as well as adults (Derryberry & Reed, 2002; Moriya & Tanno, 2008). The role of temperament in the development of anxiety will be discussed in more detail in the next chapter.

Despite the important contribution of intra-individual, constitutional mechanisms, studies indicate that environmental factors also play an important part in the development of anxiety (in fact, Lau et al., 2006 estimated that non-shared environmental factors explain approximately 54% of the variance in trait anxiety). Probably the most important environmental factors – especially in a child's early development – are her/his parents and the relationship established with them. Consequently, research has focused on parenting style and the attachment relationship as possible predictors of anxiety. Studies focusing on these two aspects have shown that parents who are overprotective or overcontrolling are more likely to have anxious children (Ballash, Leyfer, Buckley, & Woodruff-Borden, 2006; Bögels & Brechman-Toussaint, 2006; Bögels, van Oosten, Muris, & Smulders, 2001; van Brakel, Muris, Bögels, & Thomassen, 2006; McLeod, Wood, & Weisz, 2007; Rapee, 1997; Wood, McLeod, Sigman, Hwang, & Chu, 2003), and children who are insecurely attached to their parents are more likely to be anxious, especially if they are also behaviorally inhibited (Bar-Haim, Dan, Eshel, & Sagi-Schwartz, 2007; Bögels & Brechman-Toussaint, 2006; van Brakel et al., 2006; Warren, Huston, Egeland, & Sroufe, 1997). Other factors that have been shown to contribute to anxiety are represented by negative life events (e.g., Edwards, Holden, Felitti, & Anda, 2003; Heim & Nemeroff, 2001; Tweed, Schoenbach, George, & Blazer, 1989) and learning mechanisms such as classical conditioning, modeling or verbal learning (e.g., Field & Lawson, 2008; Field, Lawson, & Banerjee, 2008; Lissek et al., 2005).

However, it is clear that research investigating the development of anxiety must primarily take into account the manner in which individual factors relate and interact with each other.

1.3 Anxiety and cognition

With the rising of cognitive theory in the 1960s and 1970s, scientists and professionals focusing on psychopathology became increasingly aware of reciprocal relations between cognition and emotion. Cognitive theories of psychopathology (see Beck & Clark, 1997; Mathews & MacLeod, 1994; Mathews & Mackintosh, 1998) have successfully advanced the idea that one of its important manifestations consists of cognitive processing biases at the levels of attention, memory and interpretation. In anxiety, these cognitive correlates are relevant because they constitute potential mechanisms for maintaining it (Beck & Perkins, 2001; Dalgleish & Watts, 1990; Laurent & Stark, 1993; Legerstee et al., 2009).

Several studies have documented the fact that attentional resources of anxious individuals tend to be automatically captured by stimuli signaling threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Cisler & Koster, 2010; Mathews & MacLeod, 1994; Williams et al., 1996). Such *threat-related attentional biases* are a rather reliable characteristic of anxious cognition in general. In a recent meta-analysis on this issue (Bar-Haim et al., 2007), the authors concluded that the threat bias is a robust phenomenon, present in all types of anxiety disorders, in both clinically-anxious and high trait-anxious participants, and that the pattern of manifestation is similar in children and adults. However, research in children is less straightforward. While some studies have successfully replicated effects obtained in adults, (e.g., Heim-Dreger et al., 2006; Vasey et al., 1996; Vasey, Daleiden, Williams, & Brown, 1995), other research failed to find clear evidence for a threat-related bias in anxious children, and instead found a threat-related bias in both anxious children and controls (see e.g., Waters, Lipp, & Spence, 2004 for a review). It seems that the younger the children, the harder it is to find evidence for any anxiety-specific attentional bias (Hadwin, Garner, & Perez-Olivas, 2006) because the younger the children, the more likely it is that the attentional bias for threat will manifest in both anxious and non-anxious children.

Cognitive theory supports the view that anxious individuals tend to favor *threatening interpretations* of ambiguous situations. Most studies investigating this hypothesis have been conducted in adults, and they have used either homographs (words with identical spelling but different meanings depending on the context in which they appear – Amir, Beard, & Przeworski, 2005), or ambiguous stories (Constans, Penn, Ihen, & Hope, 1999; MacLeod & Cohen, 1993) as stimuli. Most results (see Mathews & MacLeod, 1994; Rusting, 1998 for reviews) tend to support the hypothesis of an interpretive threat bias in adults, and it seems to be present both in clinical groups and individuals with high trait anxiety (Constans et al., 1999; Eysenck, Mogg, May, Richards, & Mathews, 1991; Hirsch & Mathews, 1997, 2000; MacLeod & Cohen, 1993). In children, the methodology has included ambiguous words, vignettes, and pictures. For example, two independent studies in children aged 7-9 years (Hadwin, Frost, C C French, & A Richards, 1997) and 8 to 17 (Taghavi, Moradi, Neshat-Doost, Yule, & Dalgleish, 2000) respectively, used pictorially-presented stimuli and found that increased anxiety was associated with increased threat-related interpretations of the images. In a study using ambiguous social stories, Muris, Luermans, Merckelbach and Mayer (2000) were able to determine the point in the story when the child first generated negative judgments about the ending. They found that socially anxious children decided much earlier in the story about a negative ending, which was interpreted as indicator of a tendency to use less evidence in making predictions about potentially negative events.

Lastly, research has also investigated the potential links between anxiety and memory functioning. While data regarding long-term or autobiographical memory is scarce and somewhat mixed (see e.g., Burke & Mathews, 1992; Dalgleish & Watts, 1990; Miu, Heilman, Opre, & Miclea, 2005), there has been plenty of research relating anxiety to impairments in working memory, in children as well as adults, and using both emotional and non-emotional stimuli (Derakshan & Eysenck, 1998; Eysenck, Payne, & Derakshan, 2005; Hadwin, Brogan, & Stevenson, 2005; Visu-Petra, Miclea, Cheie, & Benga, 2009; Visu-Petra, Ţincaş, Cheie, & Benga, 2010; see Visu-Petra, Ciairano, & Miclea, 2006 for a review).

1.4 Anxiety and the brain

Anxiety has been linked with the functioning of the amygdala (see e.g., Bishop, 2007; Davis, 1992; LeDoux, 2000; Phelps, 2006; Phelps & LeDoux, 2005; Whalen et al., 2001), a structure located in the anterior medial temporal lobe. The amygdala has connections to the sensory and association neocortices, hypothalamus, brainstem nuclei, basal forebrain, ventral striatum, thalamus and hippocampus (Adolphs, 2003; Amaral, 2002; LeDoux, 2000a), all of which allow it to control behavior, physiological reactivity and memory processes. However, this structure also receives important connections from different areas in the prefrontal cortex, which is presumed to elicit a regulatory function over its activity (Sotres-Bayon, Bush, & LeDoux, 2004).

The amygdala has been related both to anxiety (LeDoux, 2000a) and temperamental behavioral inhibition (e.g., Kagan & Fox, 2006; Kagan, Snidman, Kahn, & Towsley, 2007). One of the ways in which the amygdala might be involved in fear and anxiety was proposed by LeDoux (1992, 2000a, 2000b), who suggested that sensory information from the environment reaches this structure via two different routes: the first, passing through the thalamus, provides coarse, schematic representations, but reaches the amygdala quickly. The second route brings information from the cortex, which reaches the amygdala more slowly, but provides more accurate information about environmental stimuli. The thalamic route might be useful in generating rapid responses based on limited information, while the cortical route allows for finer discriminations between stimuli, and, thus, for more accurate appraisals (LeDoux, 1992). One might speculate that over-activation of the quick route at the expense of the slower but more accurate one might be associated with dysfunctional levels of fear, and thus to anxiety.

The hypothesis of amygdala involvement in anxiety stemmed initially from animal studies, where an intact amygdala was shown to be necessary for fear conditioning (see LeDoux, 2000a; Phelps, 2006; Rosen & Donley, 2006 for reviews). In humans, amygdala activation has generally been associated with perception and recognition of threat-related stimuli – words, emotionally-charged images, or human faces expressing fear or anger (Phelps, 2006). However, this activation also seems to be related to personality and individual differences. For example, using fMRI associated with presentation of emotional pictures (positive vs. negative) or faces (happy vs. fearful) Canli and collaborators (Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002; Canli et al., 2001) found that amygdala activation was higher in the case of negative images (Canli et al., 2001) or images of fearful faces (Canli et al., 2002).

Another structure with potential involvement in anxiety is the prefrontal cortex (PFC). One generally accepted view is that the PFC is involved in the control of behavior, cognition and attention (Bush, Luu, & Posner, 2000; Carter et al., 2000; Miller & Cohen, 2001). Several authors have suggested that while the amygdala is involved in prioritizing the processing of threat, structures in the PFC are responsible for down-regulating amygdala activity (e.g., Bishop, 2007; Davidson, 2002; Quirk, Likhtik, Pelletier, & Pare, 2003). This proposal is based on evidence for the involvement of the PFC in fear extinction (e.g., Morgan, Romanski, & LeDoux, 1993) and fMRI studies showing that activity in the amygdala and the PFC tends to be negatively correlated in the presence of threatening stimuli (Bishop, 2007; Davidson, 2002; Hariri et al., 2002; Heinz et al., 2005). This latter correlation is generally weaker in participants with an anxiety disorder or high trait anxiety (Bishop, 2007), due to the fact that the PFC is less activated. It has been suggested that the impaired balance between the two neural structures might be responsible for the cognitive processing biases seen in anxious persons.

1.5 Conclusion and general characteristics of the thesis

In this chapter, we have introduced the problem of anxiety, by briefly reviewing aspects related to the epidemiology, development, predictors and correlates of anxiety. The rest of the thesis is organized in two parts, focusing on individual difference factors (temperament and emotion regulation strategies) as predictors of anxiety, and on the relationship of anxiety to attention, respectively. Despite its focus on different variables related to anxiety, a few conceptual and methodological aspects are common throughout the thesis, and should be emphasized here.

First, we conceptualize anxiety as *trait anxiety*, thus as a dimension that can vary continuously in the general population. However, in reviewing data from different research areas related to anxiety, we will continue to include studies with clinically assessed samples where relevant. For the purpose of conceptual clarity, throughout the thesis we will use the terms “anxiety” or “anxiety symptoms” respectively, when referring to anxiety conceptualized and measured as a trait, and symptoms assessed using a continuous scale. We will reserve terms such as "disorder" or "clinical" for anxiety conceptualized and measured from a clinical perspective. As a consequence of this conceptualization, the assessment of anxiety will be done on a questionnaire basis.

Second, we set out to approach anxiety and variables related to it from a *developmental* perspective. Often, this is understood as research involving children. However, for our approach to be truly developmental, it is not enough to focus on one instance, one "snapshot" from the course of development. Instead, from a methodological point of view, we need to approach the problem either longitudinally (following the same individuals over an extended period of time), or cross-sectionally (assessing, at the same time, different individuals found at different points in their development) (see Robinson, Schmidt, & Teti, 2005 for details on longitudinal and cross-sectional designs). We adopted the second, *cross-sectional approach* in the present thesis. More precisely, we chose to investigate each of our research objectives across three different developmental periods: preschool (4-6/7 years), middle childhood (6/7-10/11 years) and young adulthood (18-40 years)[1]. Our choice of childhood developmental periods was partly motivated by practical reasons (i.e., anxiety is difficult to asses in children younger than preschoolers, and they would not be able to perform tasks designed to assess some of the attentional mechanisms we were interested in). However, the main reasons for choosing to focus on preschoolers and schoolchildren resides in the fact that they represent stages when essential developments in self-regulatory mechanisms – such as attention, executive functions, control of everyday behavior, self-regulation of emotion – take place (Benga, 2004; Berger, Kofman, Livneh, & Henik, 2007; Crețu, 2006; Davidson, Amso, Anderson, & Diamond, 2006; Eisenberg & Morris, 2002; McCabe, Cunnington, & Brooks-Gunn, 2004; Ruff & Rothbart, 1996; Visu-Petra, 2008). Although our initial intention was to include adolescents as well, we finally decided against it; due to the many complex changes that take place during puberty and adolescence (at the level of brain, cognitive and emotional development; Arnsten & Shansky, 2004; Blakemore & Choudhury, 2006; Casey, Jones, & Hare, 2008), we considered that this age interval might best be tackled in a separate work, which could deal appropriately with all its complexities. As the reader will notice, the cross-sectional approach used here does not necessarily involve direct comparisons between the different developmental samples, but rather a focus on how relationships between the variables of interest change from one age period to the next.

Finally, at the level of *statistical methodology*, we attempted to avoid as much as possible the bivariate median-split approach that is frequent in anxiety research, especially when it comes to cognitive correlates of anxiety such as attention. Therefore, our statistical analyses are mostly based on correlation and regression procedures, which preserved the full variability of the data (we only used bivariate median splits in special circumstances – see Chapter 5 for examples). Our decision was based on several critiques of the bivariate-split approach in the literature, which pointed to the artificial reduction of statistical power, and the risk of generating misleading results when using the bivariate median split method (see e.g., Cohen, 1983; Irwin & McClelland, 2003; MacCallum, Zhang, Preacher, & Rucker, 2002).

To summarize, the present thesis investigates potential predictors of anxiety, as well as attentional functioning in anxiety, across three developmental samples: preschool, middle childhood and adulthood. We now turn to the first part of the thesis (Chapters 2 and 3), focusing on temperament and emotion regulation as predictors of anxiety symptoms.

[1] The only exception to this general design is the last study (Chapter 6), where – due to the difficulty of the task used – we were unable to include preschoolers.

Chapter 2.
Anxiety and individual differences in temperament and emotion regulation

As discussed in Chapter 1, research into the factors that predict anxiety disorders (or at least heightened levels of trait anxiety) has taken into account individual differences in temperament. On the other hand, recent research has started investigating the potential relationship between anxiety and a person's ability to regulate his/her emotions. In this chapter, we review both of these aspects and their potential links to anxiety, from a developmental perspective emphasizing the period spanning preschool to young adulthood. The purpose of this review is to identify patterns of findings across different developmental periods and to generate hypotheses for research.

2.1 Temperament[2]

Interest in individual differences has its roots in ancient Greece, with Galen's "humoral" theory as probably the first attempt to link relatively consistent patterns of human behavior and emotion to biology (see Kagan, 1998; Kagan & Fox, 2006 for historical reviews). In modern research, temperament is generally regarded as reflecting biologically based individual differences in behavioral, cognitive, emotional and physiological aspects of reactivity/arousal and self-regulation (Goldsmith et al., 1987; Kagan, 1998; Rothbart et al., 2000). Temperament belongs to the larger field of personality, along with other aspects such as the self-concept, personal values, beliefs, etc. (Caspi & Shiner, 2006; Rothbart, Ellis, & Michael I. Posner, 2004). However, temperamental characteristics have also been regarded as the developmental precursors of (adult) personality traits (Caspi & Shiner, 2006; Rothbart, 2007; Rothbart et al., 2000). The distinctions between the two constructs are rarely stated explicitly, and their sources very likely reside in the historically separate emergence of the two fields of study, one dealing mainly with developmental issues (temperament), while the other is traditionally more concerned with individual differences in adults (personality).

2.1.1 Definitions and models of temperament

Modern scientific temperament research emerged after the middle of the 20th century with the pioneering studies of Stella Chess and Alexander Thomas, who were the first to describe infants' temperamental traits based on systematic, observational research (Thomas & Chess, 1977; cited in Rothbart & Bates, 1998). Following their work, a variety of modern temperament models have emerged, integrating behavioral, cognitive and biological factors. Some of these

[2] Parts of the text included in this section are an adapted (and updated) version of a previously published journal article (Ţincaş, Benga, & Fox, 2006). Only the fragments written by the first author were included as such in the present thesis.

models investigate discrete temperament types (e.g., “behavioral inhibition”, Kagan, 1998), while others have adopted a multidimensional approach (Fox, Henderson, & Marshall, 2001; Goldsmith et al., 1987; Rothbart & Ahadi, 1994).

Despite their differences, most present-day models converge in their main assumptions about the characteristics of temperament (Frick, 2004): (1) temperament is inherited, or at least it has a constitutional (biological) basis; (2) its corresponding behavioral manifestations are observable early in life; and (3) it is relatively stable throughout development. The issue of stability and change in temperament is of particular relevance when considering potential precursors of emotional and behavioral problems. Most research indicates a moderate tendency toward stability in temperamental characteristics (e.g., Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Kagan, Snidman, Kahn, & Towsley, 2007; Pfeifer, Goldsmith, Davidson, & Rickman, 2002). An important observation to be made here regards the fact that trait stability does not necessarily imply stability in the phenotypic expression of behavior. As Pérez-Edgar and Fox (2005) note, over time both the triggers of certain behavioral characteristics and the individual’s abilities change, which may account for the external observable changes. It is also important to note that consistency in personality tends to increase as time passes, apparently stabilizing only in middle age (Roberts & DelVecchio, 2000), a fact that is congruent with the presence of changes in temperament throughout childhood.

In what follows, we briefly discuss the two approaches to temperament that dominate research at this point (see Benga, 2002; Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Pérez-Edgar & Fox, 2005; Rothbart & Bates, 1998 for more extensive reviews that include other models). The first approach was initiated by Jerome Kagan and his collaborators (for reviews see Kagan, 2003; Kagan & Snidman, 1991, 1999), and focuses on the concept of *behavioral inhibition to the unfamiliar*, assessed by observing the child’s initial behavioral reactions (e.g., failure to approach, reduction of smiling and verbalizations, etc.) to challenging situations, especially those involving unfamiliar adults or peers (Kagan, 1998; Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984; Kagan et al., 2007; Reznick et al., 1986). The second approach, initiated by Mary K. Rothbart (Rothbart et al., 2000; Rothbart & Bates, 1998; Rothbart & Derryberry, 1981), defines temperament in terms of biologically-based individual differences in *reactivity* and *self-regulation*. These differences are assumed to be influenced over time by genetic, maturational and environmental factors. Within this model, reactivity refers to “the excitability, responsivity, or arousability of the behavioral and physiological systems of the organism”, while self-regulation refers to “neural and behavioral processes functioning to modulate this underlying neural activity” (Rothbart & Derryberry, 1981, p. 40). Rather than being in conflict with each other, these two approaches to temperament merely reflect different views on human individual differences and their development: Kagan’s model focuses on behavioral typologies (viewing behaviorally inhibited and uninhibited children as belonging to different phenotypical categories), while Rothbart’s approach sees temperament as a cluster of continuous, rather than discrete traits.

2.1.1.1 Behavioral inhibition

The research program initiated by Kagan and his collaborators conceptualizes *behavioral inhibition* (BI) as a complex construct, with both behavioral and biological “markers” (Kagan, 1998; Kagan & Snidman, 1991, 1999; Schwartz, Snidman, & Kagan, 1999).

As already mentioned above, one essential characteristic of this model lies in the dichotomization of the construct (see Bar-Haim, Marshall, Fox, Schorr, & Gordon-Salant, 2003;

Biederman et al., 2001). That is, BI is regarded as a discrete constellation of traits, being argued that behaviorally inhibited (BI) and behaviorally uninhibited (BUI) children/adults represent distinct phenotypes, and, as such, they should be treated as separate groups in research studies. Relations with other variables (like anxiety for example) are apparently much easier to detect using this approach versus the continuous one (Kagan, 2003; Kagan & Snidman, 1999). This might be regarded as an advantage of this model, but it must also be observed that under certain circumstances this advantage might be a mere statistical artifact.

BI has been measured traditionally through laboratory procedures involving observation of the child in different novel contexts or in interactions with unfamiliar adults or peers. In these situations, BI children tend to display behaviors like reduced environmental exploration, long latencies to approach or interact with the new person (compared to other children), active avoidance, reduced verbalizations, and increased proximity to caregivers (see also Kagan et al., 1984; Reznick et al., 1986). While this is the typical pattern for an inhibited preschooler, overt manifestations of inhibited temperament, as well as the contexts in which they can be elicited vary developmentally. At four months, an inhibited infant encountering novel stimulation will most likely react with distress (mostly irritability) and motor activity; a four-year-old is much more likely to manifest the typical behavior described above in response to unfamiliar adults or peers (Kagan, 1998, 2003); in middle childhood or adolescence BI is most likely to be seen in verbal behavior (i.e., low number of independently initiated utterances, and short sentences in response to conversational bids from an unfamiliar person; Kagan et al., 2007). Longitudinal studies following children from 4 months through adolescence or adulthood (Calkins, Fox, & Marshall, 1996; Fox et al., 2001; Garcia Coll, Kagan, & Reznick, 1984; Kagan, 1998; Kagan et al., 2007) were able to establish the fact that approximately 20% of children are initially BI, and about 25-30% of them tend to remain inhibited throughout subsequent assessments.

However, despite changes in the surface features of inhibited behavior, its underlying biology is assumed to remain stable. As a neural substrate for BI, Kagan hypothesized individual differences in amygdala reactivity to novelty. This hypothesis is supported by the extensive connectivity of the amygdala with different response systems, which might account for its role in the modulation of physiological, motor and emotional reactivity (Kagan & Snidman, 1991, 1999; Kagan et al., 2007). Behaviorally inhibited children are characterized by heightened physiological reactivity (manifest in lower vagal tone and acceleration of heart rate in response to mild stress or unfamiliarity; Kagan, Reznick, & Gibbons, 1989), elevated salivary cortisol levels (measured at baseline – Kagan, Reznick, & Snidman, 1987; Schmidt et al., 1997, or in response to stressful events – Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996; Schmidt, Fox, Schulkin, & Gold, 1999). Another physiological parameter related to BI is the pattern of hemispheric activation in the prefrontal lobes, as measured by EEG: behaviorally inhibited children tend to show a pattern of stable right frontal EEG asymmetry, which, in adults, is indicative of a tendency to experience predominantly negative emotions (Davidson & Fox, 1989; Fox, Bell, & Jones, 1992; Fox, Calkins, & Bell, 1994; Fox et al., 2001; Henderson, Fox, & Rubin, 2001). The neuroimaging evidence on brain functioning in BI individuals seems to support the major assumption of Kagan's theory. For example, using fMRI, Schwartz and collaborators (Schwartz, Wright, Shin, Kagan, & Rauch, 2003) showed that amygdala reactivity when viewing familiar versus novel faces was higher in adults from Kagan's original sample who had been categorized as behaviorally inhibited in infancy. This study provides interesting evidence of continuity in the physiological reactivity systems that might underlie BI.

In summary, BI has been described as a distinctive temperamental type, characterized by withdrawn behavior in social situations, and reliable neuro-physiological reactivity. Thus far, results tend to support and validate the presence of chararacteristics that differentiate between BI and BUI individuals at both the behavioral and biological levels.

2.1.1.2 The multidimensional model of temperament

As previously stated, Rothbart's model construes temperament as a manifestation of the balance between emotional reactivity and self-regulation. These two facets of temperament are reflected in individual differences across several lower-order dimensions (or traits), further grouped into higher-order factors (see Table 2.1 for details). This structure of temperament emerged in several factor analysis studies, across different developmental samples, from infants to adults (see Derryberry & Rothbart, 1988; Gartstein & Rothbart, 2003; Putnam, Ellis, & Rothbart, 2001; Putnam, Gartstein, & Rothbart, 2006; Rothbart et al., 2000; Rothbart, Ahadi, Hershey, & Fisher, 2001; Rothbart, 1981). From a developmental perspective, this is probably the most remarkable and useful aspect of this model: that it allows assessment of temperament at different points in development, using the same, relatively consistent framework. Within this model, temperament has been assessed either through observation of the child's behavior during Lab-TAB (a standard laboratory battery for infants, toddlers and preschoolers; Bridges, Palmer, Morales, Hurtado, & Tsai, 1993; Buss & Goldsmith, 1998; Goldsmith & Rothbart, 1991), or through questionnaires, meant for self- or parent-report (Gartstein & Rothbart, 2003; Putnam et al., 2001; Putnam et al., 2006; Rothbart et al., 2001; Rothbart, 1981). Table 2.1 presents the structure of temperament as it emerged in questionnaire studies in the three developmental samples of interest for this thesis (i.e., preschool, middle childhood and adulthood), along with examples of items for each dimension.

Rothbart's temperament model is more similar to current trait theories of personality (such as the Five-Factor Model – see McCrae & Costa, 1999; McCrae & John, 1992 for details) than Kagan's model. At the highest hierarchical level are the dimensions (or factors) of *Surgency/Extraversion* (SE; similar to the Extraversion dimension from the Five-Factor Model), *Negative Affect* (NA; according to Rothbart & Bates, 2006 it is somewhat conceptually similar to Neuroticism, but it is arguable whether this is really true) and *Effortful Control* (EC; reminiscent of Conscientiousness). The first two dimensions reflect the reactivity aspect of temperament, namely level of activity, impulsivity, tendency to experience positive affect and to be sociable versus proneness to experience and express negative emotions, difficulty to recover from them or sensory discomfort. The third dimension – EC – refers to the ability to inhibit dominant, but inappropriate actions in order to generate a subdominant but more appropriate response, to detect errors and to correct them (Rothbart & Rueda, 2005; Rothbart & Bates, 1998). EC "allows us to resist the immediate influence of affect and either approach situations we fear or resist actions we desire in a flexible way" (Rothbart, Ellis, & Posner, 2004, p. 366). However, note that in itself the concept of EC reflects a person's general ability to implement self-control in everyday life, and is not directly involved in regulating emotion (for clarification, see the definitions and item examples included in Table 2.1).

Even though the main higher-order regulatory dimension of temperament is represented by EC, control of behavior is possible, in a more automatic fashion, before the emergence of this mechanism, through the development of a more "primitive" system which regulates behavior by inhibiting approach tendencies towards novel or high-intensity stimuli. This early system emerges between 6.5 and 13.5 months (Rothbart, 1988), and it is related to temperamental ratings of fearfulness (on the Infant Behavior Questionnaire – the instrument used to measure temperament in infants; Gartstein & Rothbart, 2003; Rothbart, 1981). This system is considered more reactive, passive and automatic (Michael I. Posner & Rothbart, 2000; Rothbart & Bates, 1998) but it has an important long-term function, since it is apparently involved in socialization and moral development, acting as a protective factor against the emergence of aggressive tendencies and behaviors (Kochanska, 1991). Thus, on a temperamental level, control of behavior and emotion is achieved through the intervention of two mechanisms: the more primitive, automatic, "fear" mechanism, and the more mature (and possibly evolutionarily more recent), strategic, EC mechanism.

EC is a component of self-regulation (Michael I. Posner & Rothbart, 2000; Rothbart et al., 2004), that is, the ability to modulate one's own physiological, emotional and behavioral reactions in ways that are appropriate for the context (Kopp, 1982; Vohs & Baumeister, 2004). Consequently, EC has been linked to the ability to delay gratification, to comply with parental requests, to moral development, and social and academic adjustment (see Eisenberg, Smith, Sadovsky, & Spinrad, 2004 for a review). Rothbart and collaborators (see e.g., Rothbart & Rueda, 2005 for a review) place the emergence of EC around the age of 2.5 years, when studies indicate that children first start to show consistent performance across laboratory tasks assessing inhibitory and attentional control (Kochanska & Knaack, 2003; Kochanska, Murray, & Coy, 1997; Kochanska, Murray, & Harlan, 2000 see also Gerardi-Caulton, 2000). Throughout the years, there have been studies indicating gender differences in self-regulatory abilities, which tend to favor girls (see e.g., McCabe, Cunnington, & Brooks-Gunn, 2004 for a review). For example, there is evidence that toddler and preschool girls are more compliant than boys with parental requests (R. Feldman & P. S. Klein, 2003), especially when these requests involve interdictions (Kochanska, Coy, & Murray, 2001; Kochanska et al., 1997; Kochanska, Tjebkes, & Forman, 1998). Additionally, some studies show that girls also have better EC skills, irrespective of whether these abilities are assessed through behavioral tasks in toddlers and preschoolers (Kochanska et al., 1997, 2000) or through questionnaires in preschoolers and school-age children (Eisenberg et al., 2001, 2005, 2003; Olson, Sameroff, Kerr, Lopez, & H. M. Wellman, 2005).

Thus, another way of conceptualizing temperament is through the balance between (positive or negative) emotional reactivity and behavioral self-regulation. The two temperament models discussed in this section should not be regarded as incompatible, but merely as different ways of looking at the same reality: one viewing temperament as a discrete phenotypical pattern, while the other depicts it as characteristics that go along a set of continuous and more or less separable dimensions. However, irrespective of the way one decides to view temperament, some of the characteristics it includes have been hypothesized to play an important role in the development of anxiety (in its clinical or trait form).

Table 2.1

Dimensions and sub-dimensions of the multidimensional model of temperament in preschool, middle childhood and adulthood.

Factor / Scale	Definition	Item examples		
		Preschool (CBQ[a])	**Middle childhood (TMCQ[b])**	**Adulthood (ATQ[c])**
Surgency / Extraversion				
Activity Level	Level of gross motor activity including rate and extent of locomotion.	*Seems always in a big hurry to get from one place to another.*	*Would rather play a sport than watch TV.*	-
Approach / Positive anticipation	Amount of excitement and positive anticipation for expected pleasurable activities.	*Gets so worked up before an exciting event that s(he) has trouble sitting still.*	-	-
High Intensity Pleasure	Amount of pleasure or enjoyment related to situations involving high stimulus intensity, rate, complexity, novelty, and incongruity.	*Likes going down high slides and other adventurous activities.*	*Likes going down high slides or other adventurous activities.*	*When listening to music, I usually like turn up the volume more than other people.*
Positive Affect	Latency, threshold, intensity, duration, and frequency of experiencing pleasure.			*Sometimes minor events cause me to feel intense happiness.*
Shyness*	Slow or inhibited approach in situations involving novelty or uncertainty.	*Often prefers to watch rather than join other children playing.*	*Becomes self conscious when around people.*	-
Sociability	Enjoyment derived from social interaction and being in the presence of others.	-	-	*I would enjoy a job that involves a lot of social interaction.*
Affiliation	The desire for warmth and closeness with others.	-	*Places great importance on friends.*	-
Impulsivity	Speed of response initiation.	*Usually rushes into an activity without thinking about it.*	*Tends to say the first thing that comes to mind, without stopping to think about it.*	

Negative affect				
Fear	Amount of negative affect, including unease, worry or nervousness related to anticipated pain or distress and/or potentially threatening situations.	*Is not afraid of large dogs and/or other animals.***	*Is scared of injections by the doctor.*	*Sometimes, I feel a sense of panic or terror for no apparent reason.*
Anger / Frustration	Amount of negative affect related to interruption of ongoing tasks or goal blocking.	*Has temper tantrums when s(he) doesn't get what s(he) wants.*	*Gets angry when called in from play before s/he is ready to quit.*	*I rarely become annoyed when I have to wait in a slow moving line.*
Sadness	Amount of negative affect and lowered mood and energy related to exposure to suffering, disappointment, and object loss.	*Cries sadly when a favorite toy gets lost or broken.*	*Her/his feelings are easily hurt.*	*Sometimes minor events cause me to feel intense sadness.*
Discomfort	Amount of negative affect related to sensory qualities of stimulation, including intensity, rate or complexity of light, movement, sound, and texture.	*Is not very bothered by pain.***	*Is bothered by light or color that is too bright.*	*Very bright colors sometimes bother me.*
Soothability / Falling Reactivity*	Rate of recovery from peak distress, excitement, or general arousal.	*Has a hard time settling down for a nap.*	*Has a hard time settling down after an exciting activity.*	-

Effortful Control				
Inhibitory Control	The capacity to suppress inappropriate approach behavior.	*Can lower his/her voice when asked to do so.*	*Has an easy time waiting to open a present.*	*It is easy for me to hold back my laughter in a situation when laughter wouldn't be appropriate.*
Attentional Focusing	Tendency to maintain attentional focus upon task-related channels; resistance to distraction.	*When picking up toys or other jobs, usually keeps at the task until it's done.*	*When working on an activity, has a hard time keeping her/his mind on it.***	*When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.*
Attentional Shifting	The ability to transfer attentional shifting from one activity to another.	*Can move easily from one activity to another.*	-	*When interrupted or distracted, I usually can easily shift my attention back to whatever I was doing before.*
Activation control	The ability to perform an action when there is a strong tendency to avoid it.	-	*Can make him/herself do homework, even when s/he wants to play.*	*I can make myself work on a difficult task even when I don't feel like trying.*
Low Intensity Pleasure	Amount of pleasure or enjoyment related to situations involving low stimulus intensity, rate, complexity, novelty, and incongruity.	*Rarely enjoys just being talked to.*	*Likes the crunching sound of leaves in the fall.*	-
Perceptual Sensitivity	Amount of detection of slight, low intensity stimuli from the external environment.	*Notices the smoothness or roughness of objects s(he) touches.*	*Notices small changes in the environment, like lights getting brighter in a room.*	-

* Sub-dimension with negative loading on its corresponding higher-order dimension.
** Reverse-coded item.
[a] *Children's Behavior Questionnaire* (Rothbart et al., 2001; see also Benga, 2004 for the Romanian version).
[b] *Temperament in Middle Childhood Questionnaire* (Simonds, 2006).
[c] *Adult Temperament Questionnaire* (Derryberry & Rothbart, 1988; D. E. Evans & Rothbart, 2007b; Rothbart et al., 2000).

2.1.2 Temperament and anxiety

Temperament traits are seen as possible precursors or predictors of psychopathology in children and adults (see reviews by Clark, 2005; Goldsmith & Lemery, 2000; Hirshfeld-Becker et al., 2003; Pérez-Edgar & Fox, 2005). However, establishing the exact nature of the relationship between these two constructs – as well as its plausible underlying mechanisms – is complicated for at least three reasons. First, there are multiple additional risk or protective factors (like, for example, parenting characteristics) coming into play on the pathway leading from a certain temperament profile to the presence or absence of psychopathological symptoms, so it is not very likely that the relation between temperament and psychopathology is a direct one. Second, as Frick (2004) and Lahey (2004) pointed out, some of the instruments used to measure temperament contain items that overlap with clinical criteria used to diagnose psychopathology. In this case, any relations between temperament and symptomatology obtained through such measures will be artificially inflated (however, some of these instruments do tend to retain their predictive value even after elimination of the overlapping items; see Lemery, Essex, & Smider, 2002; Lengua, West, & Sandler, 1998). Third, theoretical complications are added by the fact that different authors see the relation between temperament and anxiety in different ways: some conceptualize temperament as reflecting individual variability within the normal/typical range, with psychopathology being a distinctive entity that, under certain circumstances, can develop on the foundation of temperamental risk factors; other authors see psychopathology simply as an extreme manifestation of a certain temperamental pattern (Lahey, 2004).

In what follows, we attempt to draw a few tentative conclusions related to the temperament–anxiety link and its specificity. The studies reviewed for this purpose include at least one measure of temperament and one diagnostic measure for anxiety or internalizing symptoms (administered either concurrently, or at a later time point, with respect to the assessment of temperament). We included studies that assess internalizing problems as well as anxiety, because when it comes to children (especially preschoolers) these tend to dominate. The samples involve children, adolescents and young adults.

2.1.2.1 Behavioral inhibition and anxiety

Many studies of interest to the present topic have used BI as their means of conceptualizing temperament. The corresponding characteristics were assessed either through traditional laboratory observational procedures (e.g., Biederman et al., 2001, 1993) or through questionnaires administered to the parent and/or child (e.g., Muris, Merckelbach, Wessel, & van de Ven, 1999). The link between BI and anxiety is probably readily obvious due to the many characteristics that the two constructs seem to share (Pérez-Edgar & N. A. Fox, 2005).

A consistent proportion of this research has found a specific link between BI and social anxiety (see Ollendick & Hirshfeld-Becker, 2002 for a review on the topic). This link was most consistently found in participants from Kagan's early studies (see Kagan et al., 1984, 1987 for initial studies, and Kagan & Snidman, 1999; Kagan et al., 2007, for more recent results). The children in this sample were selected when they were 4 months old. They were subsequently assessed for BI at 14 and 21 months, and then re-evaluated when they were 4.5 and 7.5 years old. During this last assessment, parent and teacher ratings of child anxiety symptoms were obtained. Results indicated that although BI stability was modest, BI classification in infancy was significantly related to later development of anxious symptoms. In a further study, Schwartz et al. (1999) interviewed adolescents from this longitudinal sample. They found that a significant number of those who had been categorized as highly reactive in infancy were having symptoms of social anxiety, in the absence of significant manifestations of any other anxiety disorder. In another study, Biederman et al. (2001) included externalizing symptoms in their assessment of psychopathology to further test the predictive specificity of BI. Results replicated the BI–social anxiety link, and showed that it was a specific one (BI was not linked with externalizing problem). Most research that has found similar results has generally included participants from Kagan et al.'s (1984) original sample (Biederman et al., 2001, 1990; Hirshfeld et al., 1992; Schwartz et al., 1999). However, a few other studies – involving different samples and using questionnaires instead of the classical observational procedure – tend to support this specific link (C. Hayward, Killen, Kraemer, & C. B. Taylor, 1998; Muris & Meesters, 2002). Thus, there is some evidence indicating that behaviorally inhibited children have a higher probability of present or future social anxiety symptoms.

Apart from this specific relationship, other evidence points to a more general link. For example, Biederman and colleagues (Biederman et al., 1993) identified a higher risk for anxiety disorders *in general* in the case of stable BI children from a group of 4- to 11-year-olds rated three years before. Similar results were found by Shamir-Essakow, Ungerer and Rapee (2005) in 3- to 5-year-old children. A group of studies using the BI construct but relying exclusively on questionnaire measures indicate a similarly general role for BI in predicting concurrent anxiety symptoms. Muris et al. (1999) investigated the link between BI (child self-rated) and psychopathology (anxiety, worry, depression) in 12- to 14-year-old children. Their results showed generally higher levels of psychopathology symptoms in children (especially girls) who rated themselves as high in BI, but the strongest link was with anxiety symptoms. A subsequent study (Muris, Merckelbach, Schmidt, Gadet, & Bogie, 2001) identified relationships between BI and anxiety and BI and depression, respectively, in a large sample of adolescents (12-18 years). However, the link between BI and depression was mediated by anxiety. A similar relationship between BI and anxiety symptoms in general was found by van Brakel, Muris, Bögels and Thomassen (2006) in children aged 11-15 years. However, the BI measures used in these three studies might be criticized on the account that they were rather simple and general. Lastly, Caspi and colleagues (Caspi et al., 1996) found a relation between BI assessed at 3 years and symptoms of depression at 21 years, but no significant link to anxiety.

To summarize, despite the variability in assessment methods, and some contradictory findings, BI tends to be a relatively consistent predictor of anxiety, with some studies supporting a very specific link to social anxiety, while others indicating a more general relationship between BI and anxiety, or even BI and other internalizing disorders (e.g., depression). Although probably caution is necessary when interpreting the results of some studies (e.g., those assessing BI with short questionnaires), one is justified in concluding that the data does generally support the existence of a link between BI and anxiety.

2.1.2.2 NA and EC: The multidimensional model and anxiety

Research investigating temperament–anxiety links from the perspective of the multidimensional model has focused mainly on two of the three dimensions: NA and EC.

Negative Affect. In an attempt to link anxiety and depression to models of temperament/personality, Clark and Watson (see Clark & Watson, 1991, 2006; Clark, Watson, & Mineka, 1994) proposed the *tripartite model* for these two disorders. Research conducted from the perspective of this model has been clinically-focused for the most part, and has helped identify specific temperamental traits associated with anxiety and depression. Based on a review of the literature, Clark and Watson (1991) proposed that while NA is a common factor for both disorders (while depression is specifically associated with decreased positive affect). Later, they proposed that panic disorder is specifically associated with high autonomic arousal (Mineka, Watson, & Clark, 1998). It is less clear what specific factors are associated with other anxiety disorders or with trait anxiety in general (Clark & Watson, 2006). However, the NA–anxiety link has been consistently found in studies involving adults (e.g., Clements & Bailey, 2010; Moriya & Tanno, 2008), as well as children and adolescents from clinical and community samples, with ages ranging from 6 to 18, using both concurrent (Chorpita, 2006; Lonigan, Carey, & Finch, 1994; Lonigan, Hooe, David, & Kistner, 1999; Tully, Zajac, & Venning, 2009) as well as longitudinal measurements (Lonigan, B. M. Phillips, & Hooe, 2003). Moreover, improvement after treatment in clinically anxious patients is related to low baseline NA scores (L. A. Clark et al., 1994).

While global NA is clearly linked to anxiety, it does not necessarily constitute a specific predictor of clinical or trait anxiety, since NA is also linked to depression and even to externalizing problems (Lengua et al., 1998; Meesters et al., 2006; Rothbart & Bates, 1998). Some researchers using Rothbart's multidimensional model of temperament have argued that different types of negative emotionality are associated with different types of disorder symptoms. More precisely, temperamental fearfulness and sadness are more strongly related to anxiety and depression problems, while anger/frustration is more predictive of externalizing problems (e.g., Eisenberg et al., 2001; Eisenberg, Morris, & Spinrad, 2005; Eisenberg et al., 2004; Lemery et al., 2002; Rothbart & Bates, 1998; Rydell, Berlin, & Bohlin, 2003). However, the available data does not present a clear-cut picture. In the case of anger for example, while it is clear that anger/frustration levels are significantly lower in children prone to internalizing problems than in children prone to externalization (Eisenberg et al., 2001, 2005), some studies have found at least moderate correlations between anxiety and anger in children (e.g., Lemery et al., 2002) and adults (Clements & Bailey, 2010).

Effortful Control. Recent years have witnessed an increasing interest in the role of EC in the development of anxiety, based on some evidence that anxiety vulnerability is associated with low levels of EC (see Lonigan & Phillips, 2001; Muris & Ollendick, 2005; Nigg, 2006 for reviews). More precisely, several authors have suggested that – due to its self-regulatory aspects – EC might act as a protective factor, diminishing the risk for anxiety even in individuals with relatively high levels of NA. Most current research investigating this possibility tends to conceptualize EC as composed only of attentional control (focusing and shifting) and inhibitory control. Sub-dimensions like perceptual sensitivity or low intensity pleasure (Putnam & Rothbart, 2006; Rothbart et al., 2001) are typically excluded as they do not represent "pure" aspects of self-regulation.

It has been suggested that the contributions of NA and EC as predictors of anxiety might be either *additive* or *interactive*. More precisely, (1) high levels of NA and/or low levels of EC independently predict higher anxiety, and/or (2) EC moderates the link between NA and anxiety, so that even if someone has high levels of NA, a high EC protects them from vulnerability to anxiety (Lonigan & B. M. Phillips, 2001; Muris & Ollendick, 2005). Research involving adult participants has found support for the first hypothesis, showing a negative correlation between EC (or its sub-dimensions – especially attentional control) and trait anxiety (e.g., Clements & Bailey, 2010; Derryberry & Reed, 2002) or social anxiety (Moriya & Tanno, 2008). Derryberry and Reed (2002) found a moderate negative correlation (i.e., -.42) between attentional control and anxiety, while Moriya and Tanno (2008) found a similar correlation between attentional control and social anxiety (r = -.41), and a small correlation with state anxiety (r = -.25). Similar results have been obtained in children aged 7 years or older (Meesters et al., 2006; Muris et al., 2008; Muris et al., 2008; Oldehinkel et al., 2007). For example, in a non-clinical sample of children aged 8-13 years, Muris and collaborators (Muris et al., 2008a, 2008b) found correlations ranging between -.40 and -.62 between anxiety scores and self-report measures of attentional control and global EC, respectively.

While these studies have investigated the independent contributions of NA and EC to anxiety/internalizing problems, other research has found evidence for the second hypothesis, i.e., the potential interacting effects of these two dispositional characteristics (Meesters et al., 2006; Muris, 2006; Oldehinkel et al., 2007). For example, Oldehinkel et al. (2007) found evidence supporting both the independent and the moderating influence of EC in preadolescents and adolescents. More precisely, at higher levels of EC, the influence of fearfulness upon internalization was diminished. Similar results were found by Meesters et al. (2006) in a group of children aged 9 to 17 (here, the sub-dimension of attentional control was the moderator). Other studies, however, while finding evidence for independent effects, have failed to identify any interaction effects (e.g., Muris, de Jong, & Engelen, 2004). Thus, while it seems that NA and EC are reliable predictors of anxiety/internalizing problems in children and adults, results are at present mixed regarding whether the contributions of the two temperamental traits are additive or interactive.

The aforementioned studies have investigated relationships between anxiety/internalizing problems and NA and EC, in participants aged 7-8 years or older, but considerably fewer studies have taken into account preschool children, and their results appear to be more mixed than the ones presented so far. Data from one longitudinal study including preschoolers generally supports the results found in older samples (Eisenberg et al., 2001, 2005, 2004). More precisely, Eisenberg and collaborators found that children with internalizing problems were characterized by slightly lower levels of attentional control than were children in the control group, but were not different in terms of inhibitory control. However, another study (Blair, Denham, Kochanoff, & Whipple, 2004) failed to find a relationship between overall EC and internalizing problems in a sample of preschoolers. While these two studies took into account internalizing problems in general, with no distinction among them, one study involving children aged 3.5-4.5 years (Lemery et al., 2002) found a negative correlation between anxiety and inhibitory control (contrary to data from older children, which indicated attentional control as the most important factor), but not anxiety and attentional control. Lastly, a recent investigation (De Pauw, Mervielde, & Van Leeuwen, 2009) reported evidence for a link between low overall EC and internalizing problems in preschoolers. However, when taking into account separate disorders, EC was predictive of affective problems (dysthymia and major depressive disorder), but not anxiety.

To further complicate matters, some authors have suggested that EC levels that are *too high* (i.e., *over-regulation*) might also constitute a risk factor for anxiety (Derryberry & Rothbart, 1997). Support for this hypothesis comes from studies involving 3-4- (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Murray & Kochanska, 2002) and 5-year-old children (Thorell, Bohlin, & Rydell, 2004), which showed that in preschoolers high EC dimensions (assessed through behavioral batteries tapping executive inhibition and attention) predicted anxiety/internalizing behaviors in preschool children. For example, Thorell et al. (2004) found that executive inhibition was weakly linked to high BI, and it *potentiated* (instead of decreasing) the link between high BI and high social anxiety symptoms. We are not aware of any similar reports coming from studies involving older samples. However, it is possible that in preschoolers performance in EC tasks also benefits from high levels of *automatic* inhibitory tendencies, such as BI, or fearfulness (not only from *controlled* inhibition) (see Nigg, 2000 for a similar distinction between executive and motivational inhibition). In turn, this automatic inhibition is the factor that predicts high anxiety. Thus, while results regarding the contributions of EC to anxiety from middle childhood up are rather straightforward, it is significantly more difficult to draw a firm conclusion regarding the role of EC (or its sub-dimensions) in preschoolers. The main problem resides in the limited number of studies, most of which do not appear to have been specifically aimed at anxiety, but rather at the more broad category of internalizing problems.

In conclusion, the manner in which NA and EC combine in predicting anxiety raise a few interesting questions, worthy of further empirical exploration. While there are relatively clear links between NA and anxiety, the status of EC (and its sub-dimensions) is less clear, especially in preschool children. Within this age range, data is rather scarce and in most cases lacks a specific focus on anxiety. However, at any developmental level, the main question is still whether EC has an independent, additive role, or rather a moderating one in predicting anxiety.

2.1.3 Summary and conclusion

In this section, we have focused on the temperament–anxiety link, by taking into account two developmentally-relevant models of temperament, i.e., Kagan's BI and Rothbart's multidimensional model. We explored issues related to the specificity of this link (e.g., to what degree are BI or NA linked to other problems such as depression or externalizing symptoms), as well as the manner in which various aspects of temperament (e.g., NA and EC) combine to predict anxiety symptoms. We now turn to another aspect of emotional and self-regulatory development, one that has recently emerged as relevant for anxiety, namely emotion regulation.

2.2 Emotion regulation

The past decade has witnessed an impressive increase in interest for the topic of emotion regulation (ER), in the research focusing on adult functioning (see e.g., Gross, 1998, 2007). However, ER research has a longer history within developmental psychology, dating back at least to the pioneering work of Claire B. Kopp (1989; see also Campos, Campos, & Barrett, 1989). Kopp saw ER as referring to "the processes and the characteristics involved in coping with heightened levels of positive and negative emotions" (p. 343). Since Kopp's definition, there has been a lot of discussion in developmental research around the issue of how best to define ER (for examples of the variations and controversies surrounding ER in developmental research, see e.g., Cole, Martin, & Dennis, 2004; Eisenberg & Spinrad, 2004 or the other articles included in the the 2004 special issue of *Child Development* – volume 75, issue 2 – dedicated to ER). Most developmental researchers agree that ER is one of the fundamental skills involved in the development of emotional competence, along with abilities such as awareness of one's own emotions, understanding emotions in others, empathy, the ability to communicate emotions appropriately, etc. (see Halberstadt, Denham, & Dunsmore, 2001; Saarni, Campos, Camras, & Witherington, 2006 for details). ER is also a fundamental aspect of self-regulation, along with aspects like EC or executive functions (Bell & Wolfe, 2004; Calkins & Hill, 2007; Eisenberg, Hofer, & Vaughan, 2007; Kochanska et al., 2001, 1998; Kopp, 1982; Morris & Reilly, 1987; Rothbart et al., 2004).

While Kopp's (1989) definition emphasized the role of ER in coping with emotional reactions of "heightened" intensity, subsequent definitions do not include the requirement that an emotion be of heightened intensity to elicit regulatory attempts (see e.g., Bridges, Denham, & Ganiban, 2004; Campos, Frankel, & Camras, 2004; Eisenberg & Spinrad, 2004; Hoeksma, Oosterlaan, & Schipper, 2004; Thompson et al., 2008). According to one often cited current definition of ER, the construct incorporates a multitude of extrinsic and intrinsic processes, which help modulate the characteristics of emotional responses (in terms of their intensity and timing), with more or less adaptive ends (Thompson, 1994; Thompson et al., 2008). More precisely, through ER, emotional responses can be initiated, prevented or changed, by selecting or modifying the relevant situation, by attending selectively to different aspects of a situation, by changing the interpretation of the situation or by modulating one's behavioral responses to it (Eisenberg et al., 2007; Eisenberg & Morris, 2002; Gross, 1998).

Developmental research has devised numerous methods for measuring ER. For simplicity, we propose that they can be categorized taking into account two major criteria: (1) the way in which ER is construed: as a global characteristic of the individual versus as a set of distinct strategies (the "conceptual" criterion); and (2) the methodology used to assess ER (i.e, physiological measures, observation, or verbal report; see Eisenberg et al., 2005 for a review along this "methodological" criterion). First, from a conceptual point of view, some researchers tend to see ER as a global, undifferentiated aspect of emotional development and functioning. Such studies typically assess general regulation versus dysregulation of emotional expression and experience, and focus mostly on the intensity and context-appropriateness of emotional manifestations (e.g., Blandon, Calkins, Keane, & O'Brien, 2008; Bridges et al., 2004; Cole, Michel, & O'Donnell Teti, 1994; Hessler & Katz, 2007; Shields & Cicchetti, 1997; Thayer & Lane, 2000). Other researchers tend to see ER as a collection of distinct strategies that can be used to modulate the emotional experience and its overt expression (see e.g., Dennis & Kelemen, 2009; Eisenberg et al., 1993; Garnefski, Kraaij, & Spinhoven, 2001; Grolnick, Bridges, & Connell, 1996; Gross, 1998; Larsen & Prizmic, 2004; Stansbury & Sigman, 2000).

Second, as already mentioned, investigators have chosen to measure ER through different methodologies: by looking at physiological indices of arousal regulation, by observing overt behavior, or by taking the verbal report of participants (see Eisenberg & Morris, 2002; Eisenberg et al., 2005 for reviews of these three types of methodology). Physiological indices of ER have been used in children as well as adults, and they can include measures of heart rate variability such as the vagal tone (Porges, Doussard-Roosevelt, & Maiti, 1994; see also Blandon et al., 2008; Calkins, Smith, Gill, & Johnson, 1998; Calkins, Graziano, & Keane, 2007; Feldman, 2009), or of hormone levels such as cortisol (Gunnar, Brodersen, Krueger, & Rigatuso, 1996; Gunnar & Cheatham, 2003), which can be assessed in a resting state or after some manipulation meant to induce stress. These types of measures generally capture only global physiological correlates of ER. Observational procedures have been used mainly in children, from infancy to middle childhood (e.g., Calkins et al., 1998; Cole, Zahn-Waxler, Fox, Usher, & Welsh, 1996; Dennis, 2006; Grolnick et al., 1996; Reijntjes, Stegge, Terwogt, Kamphuis, & Telch, 2006b; Saarni, 1984; Stansbury & Sigman, 2000). These measures can focus either on global indices (e.g., the intensity, frequency and nature of facial/behavioral emotional expressivity; Cole et al., 1996; Dennis, 2006; Feldman, 2009; Rubin, Coplan, Fox, & Calkins, 1995), or on specific strategies (e.g., whether a child reacts to a laboratory frustrating situation by distracting him/herself with a toy, or by expressing anger; see Buss & Goldsmith, 1998; Calkins et al., 1998; Grolnick et al., 1996; Reijntjes et al., 2006; Stansbury & Sigman, 2000). Verbal report measures can include Q-sorts (Shields & Cicchetti, 1997), interviews (e.g., Blanchard-Fields & Coats, 2008) or diaries (e.g., Feldman Barrett, Gross, Christensen, & Benvenuto, 2001), but the most frequently used method is the questionnaire. In young children (from infants to young schoolchildren), questionnaires typically involve parent- or teacher-report (Eisenberg et al., 1993, 1995; Eisenberg, Shepard, Fabes, Murphy, & Guthrie, 1998), due to children's limited ability to report on their own cognitions and behavior. Self-report questionnaires are generally used in the case of adolescents and adults (e.g., Decker, Turk, Hess, & Murray, 2008; Garnefski et al., 2001; Gross & John, 2003). Most questionnaires conceptualize ER as distinct strategies (e.g., Eisenberg et al., 1993, 1995; Garnefski, Kraaij, & Spinhoven, 2001; Garnefski, Kraaij, & Spinrad, 2002), but there are also exceptions (for example, Shields & Cicchetti's, 1997 Emotion Regulation Checklist has items such as "Is a cheerful child" or "Exhibits wide mood swings", reflecting global ER tendencies; see Gratz & Roemer, 2004; Rydell et al., 2003 for other examples).

ER is very similar and strongly related to the concept of coping. In research focusing on adults, the most often cited definition of coping is the classic one put forward by Lazarus and Folkman (1984), who considered coping as consisting of "cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (p. 141). The developmental literature tends to emphasize regulatory processes when defining coping. For example, Compas, Connor-Smith, Saltzman, Thomsen and Wadsworth (2001) define coping as "efforts to regulate emotion, cognition, behavior, physiology, and the environment in response to stressful events or circumstances" (p. 89; see also Compas, 1987; Skinner, Edge, Altman, & Sherwood, 2003; Skinner & Zimmer-Gembeck, 2007).

It is clear that ER and coping overlap. What is less clear at this point, however, is how different these two constructs are, and if they really reflect distinct processes, or they refer, in fact, to the same set of processes, but with emphases placed on different aspects. Some authors argue for treating the two as different, and some of their arguments include (1) the fact that while coping deals mainly with negative emotions generated by stressful events, ER also takes into account regulation of *positive* emotions (e.g., Gross & Thompson, 2007; Gross, 1998); (2) coping tends to emphasize regulatory efforts focused on the external problem *as well as* the emotional reaction, while ER only refers to the latter (Folkman & Moskowitz, 2004; Skinner et al., 2003); (3) coping is limited to regulatory mechanisms activated in stressful circumstances, while ER applies to virtually any everyday context that would require emotional modulation (Compas et al., 2001; John & Gross, 2007; Skinner & Zimmer-Gembeck, 2007), etc. The first argument mentioned above holds some degree of truth, but this is probably due to the fact that historically, coping has emerged from research on stress. With respect to the second argument, if one looks at the various models and instruments for assessing ER or coping strategies in children and adults, it is not as easy to distinguish between the two, since many ER models include some type of strategies aimed at changing the unpleasant situation (see for example Garnefski et al., 2001). Additionally, the distinction between the two concepts is further complicated in young children who have limited control over their environments (Skinner & Zimmer-Gembeck, 2007). The third argument suggests that mild, everyday stressors elicit ER strategies while more intense negative events activate coping efforts. This implies that in order to distinguish between coping and ER we would need to establish a threshold between "stressful" events and non-stressful but unpleasant ones. Such a distinction would most likely be unproductive (if not entirely impossible to make). Observations such as these have prompted several authors to include ER and coping strategies in the same category (Bridges & Grolnick, 1995; Eisenberg et al., 1997; Garnefski et al., 2001), or to denounce the divide between the two fields of study as artificial and unhelpful for scientific progress (Compas, 2009).

In the present thesis, we conceptualize ER as a cluster of different *strategies* that can be used to modulate emotional experience and emotional responses. We prefer this approach (versus the global one) due to the fact that it allows for a more clear distinction between emotional reactivity (e.g., fear, sadness, joy) and its regulation (see e.g., Cole et al., 2004 versus Campos et al., 2004 for a discussion on this issue). Additionally, we adopt the stance that coping and ER are highly similar processes. Therefore, although we will continue to use the term "ER" in most contexts, in the following paragraphs we will also include evidence from coping research.

2.2.1 Emotion regulation / coping strategies

In the coping literature, Lazarus and Folkman (1984) proposed the now-classic distinction between "problem-focused coping" and "emotion-focused coping". The former refers to coping efforts aimed at managing the problem that has caused the distress, and can include – apart from concrete actions to solve the problem – cognitive elements such as planning or decision-making processes preceding these actions. The latter refers to coping directed at modulating the emotional response to the problem, and can include efforts to avoid, minimize, attend selectively to different aspects of the distress source, or reframe it in a positive way. Since the distinction proposed by Lazarus and Folkman (1984), there has been a consistent increase in taxonomies of coping and ER strategies (see Skinner et al., 2003 for a review). Additionally, current research and theorizing converges on the idea that it is more useful to conceptualize coping/ER in terms of distinct strategies, rather than simple dichotomies (e.g., Ayers, Sandler, West, & Roosa, 1996; Compas et al., 2001; Skinner et al., 2003).

It would be difficult at this point to review all possible ER/coping strategies, due to their sheer number. For example, in a recent systematic review of coping, Skinner et al. (2003) analyzed 100 frequently used coping instruments (designed for adults or children), and identified up to 400 different coping strategies included in these instruments. However, based on this analysis, Skinner and collaborators were able to extract certain commonalities. More precisely, they identified five core coping strategies (the ones with the highest number of occurrences in the analyzed instruments): (1) *problem-solving* (including concrete action to solve the problem, or "cognitive action": planning or thinking about possible solutions), (2) *support seeking* (asking for help in solving the problem, for advice, or for comfort/emotional support, etc.), (3) *escape/avoidance* (including efforts to disengage from the stressful situation, such as cognitive or behavioral avoidance, denial, or wishful thinking), (4) *distraction* (i.e., actively attempting to deal with the situation by engaging in other activities, such as hobbies, exercising, etc.), and (5) *positive cognitive restructuring* (active attempts to deal with the stressful situation by reframing it in a more positive light).

There are currently few taxonomies of ER strategies and consequently few instruments that explicitly claim to asses ER *per se* (even more so in the case of children). However, probably the most popular such taxonomy is the one proposed by James Gross (see e.g., Gross & Thompson, 2007; Gross, 1998; Ochsner & Gross, 2005). Gross (1998) distinguished between antecedent- and response-focused ER (i.e., strategies aimed at changing the situation before the emotion has been generated versus strategies aimed at modulating the responses to the situation). Gross (1998) proposed five broad families of ER strategies (see also Gross & Thompson, 2007 for a recent review): *situation selection* (approaching or avoiding certain situations, people or places, with the main purpose of preventing or generating an emotional response), *situation modification* (refers to active efforts to modify a situation, so as to alter its emotional impact), *attentional deployment* (strategies such as distraction, rumination, concentration, etc. that manipulate attentional focus so as to modulate one's emotional response), and *cognitive change* (changing the interpretation of the situation, in order to alter its emotional significance) and *response modulation* (directly influencing physiological, experiential, or behavioral responding; examples: using drugs or relaxation to diminish physiological arousal, or suppressing the emotional expressive behavior). As can be seen these strategies largely overlap with the five main coping strategies identified by Skinner et al. (2003). Research conducted by Gross and collaborators over the years indicates that, compared to attentional or cognitive reappraisal strategies, behavioral suppression strategies tend to have impairing effects on physiological parameters. For example, during exposure to a stressful film, reappraisal tended to decrease arousal (operationalized as blood pressure), while suppression tended to maintain it high (James J. Gross & Levenson, 1993, 1997). Similar effects were found in cognitive processes (suppression tends to impair memory performance; Richards & Gross, 2000), and at social interaction levels (suppression tends to decrease both negative and positive emotional behavior, while reappraisal only decreases negative emotional behavior, being associated with blood pressure increases in the interaction partner; Butler et al., 2003).

Another recent taxonomy is the list of cognitive ER strategies used by Garnefski and collaborators (Garnefski et al., 2001; Garnefski & Kraaij, 2007). The authors devised a questionnaire measuring nine cognitive ER strategies for dealing with negative emotions: *blaming oneself* for the unpleasant situation that has generated the negative emotions, *blaming others*, *acceptance* of the negative experience and resigning to what has happened, *refocus on planning* (involving planning actions/steps to take in order to solve the problem), *positive refocusing* (which involves thinking of other, pleasant matters instead of the actual event), *rumination* (thinking repeatedly about the feelings and thoughts associated with the unpleasant event), *positive reappraisal* (attributing a positive meaning to the event, reframing it in terms of personal growth), *putting into perspective* (playing down the unpleasantness or negativity of the event by comparison to other events), and *catastrophizing* (thoughts that emphasize the terror and gravity of the experience). Garnefski and collaborators have designed self-report questionnaires for assessing these strategies in adolescents and adults (Garnefski et al., 2001; Garnefski, Legerstee, Kraaij, van den Kommer, & Teerds, 2002), as well as children, starting with the age of 9 years (Garnefski, Rieffe, Jellesma, Terwogt, & Kraaij, 2007).

In preschoolers, most research to date has involved observation measures (see e.g., Cole, Dennis, Smith-Simon, & Cohen, 2009; Grolnick et al., 1996; Stansbury & Sigman, 2000). Most of these studies use laboratory procedures to induce frustration (e.g., blocking the child's access to an attractive figurine; having to wait to receive a reward) or general distress (e.g., separation from the caregiver), and then code behaviors indicative of ER. Within these types of tasks, investigators have coded behaviors indicative of *persistence* (sustained efforts to obtain a desired reward, despite the obstacles), *problem solving* (trying to find a solution), *support-seeking* (seeking emotional comfort or asking for help form an adult), *distraction* (shifting attention to a different activity), *cognitive attempts to understand or reappraise* the situation (by asking for more information, negotiating or giving a different interpretation to the situation), and *disruptive behavior* (violent or inappropriate behavior such as throwing toys on the floor). Most of these studies indicate that distracting oneself by focusing on a toy or an alternative activity tends to be the most effective strategy in reducing negative affect (see Reijntjes et al., 2006 for a similar result in older children). In the realm of questionnaire instruments, one of the few preschool-appropriate measures for ER strategies that we were able to identify is the Children's Coping Styles Questionnaire (CCSQ) designed by Eisenberg and collaborators (see Eisenberg et al., 1993, 1995, 1998; see Blair et al., 2004 for a recent use of this instrument) and destined for parent- or teacher-report. This instrument includes ten ER strategies: *cognitive restructuring* (thinking about the situation in a positive way); *distraction*; *emotional aggression* (using physical or verbal aggression to release negative feelings); *venting* (crying to release negative feelings); seeking the *emotional support* of an adult; behavioral *avoidance* of the distressing situation; *emotional intervention* (crying to elicit the intervention of an adult; *instrumental coping* (taking constructive action to change the situation); *instrumental aggression* (trying to solve the problem through physical or verbal aggression); and *doing nothing*.

In older children, most ER/coping questionnaires involve self-report and are either targeted at children aged 9/10 years or older, or focus on specific situations – such as conflict between parents – or medical problems (see e.g., Ayers et al., 1996; Compas et al., 2001; Donaldson, Prinstein, Danovsky, & Spirito, 2000; Spirito, Stark, & Williams, 1988). One often cited questionnaire is the Children's Coping Strategies Checklist (CCSC) designed by Ayers et al. (1996). This instrument has the advantage that it can be used as a general measure of ER/coping strategies (or if needed it can be adapted for a specific problem), and the strategies it assesses tend to overlap with the ones identified by Skinner et al. (2003) as being "core" strategies. Namely, CCSC assesses active coping (concrete or cognitive problem solving), avoidance, distraction, and support-seeking strategies.

As can be seen, the landscape of ER strategies is extremely heterogeneous from one developmental group to the next, and even within the same developmental group. However, despite this heterogeneity, there are a few developmental trends that are relatively general.

2.2.2 Development of emotion regulation

Eisenberg and Morris (2002; but see also Kopp & Neufeld, 2003; McCabe et al., 2004; Saarni et al., 2006; Walden & Smith, 1997) have described three major trends that characterize the development of ER in children. First, ER development follows a gradual transition from reliance on caregivers or other adults to provide regulatory intervention, to increasing use of *self*-regulation (Eisenberg & Morris, 2002; Walden & Smith, 1997). In infancy, adults are the main source of ER strategies: they control children's exposure to distressing events, they distract their attention (Harman, Rothbart, & Michael I. Posner, 1997), or provide support for soothing (by holding or rocking the infant). However, toward the end of the first year of life, infants become more and more effective at down-regulating negative affect by self-soothing strategies (such as thumb sucking, clasping of one's hair or clothes, rocking, etc; Eisenberg & Morris, 2002; Stifter & Braungart, 1995), gaze or motor avoidance (see Walden & Smith, 1997 for a review) or reorienting of one's attention (see Ruff & Rothbart, 1996). Toddlers and preschoolers are more and more effective at distracting themselves in frustrating or upsetting circumstances by actively playing with a toy or engaging with an adult present in the room (Cole et al., 2009; Grolnick et al., 1996; Stansbury & Sigman, 2000). The development of language further contributes to the increasing regulatory independence: children start to show evidence for active, cognitive ER strategies (such as negotiating or reframing the situation) at 3-4 years (Stansbury & Marian Sigman, 2000), and they gradually become more proficient at expressing their emotions verbally and asking for assistance in managing stressful situations and negative emotions (Kopp & Neufeld, 2003; Saarni et al., 2006; Stansbury & Marian Sigman, 2000), a trend that continues into the school years. While reliance on others (i.e., support seeking) remains an important strategy in adolescence and adulthood, the use of individual, self-reliant strategies increases significantly (e.g., Eschenbeck, Kohlmann, & Lohaus, 2007; Garnefski et al., 2002; Hampel & Petermann, 2005).

A second trend in ER development refers to an increase in the use of cognitive, internal ER strategies – as opposed to behavioral ones – (such as cognitive distraction, cognitive avoidance, reappraisal, rumination, catastrophizing, etc.) (Eisenberg & Morris, 2002). This developmental trend is influenced by children's increasing understanding of how emotions are generated and how they can be influenced by cognitive mechanisms (Lagattuta, Wellman, & Flavell, 1997; Saarni et al., 2006). More precisely, starting in preschool, when asked about the best strategy to reduce a negative emotion, children increasingly suggest cognitive distraction (i.e., thinking about something positive) as a strategy (Cole et al., 2009; Dearing et al., 2002; Dennis & Kelemen, 2009; Flavell, Flavell, & Green, 2001; Saarni et al., 2006).

The third ER developmental trend refers to an increasing proficiency in matching ER strategies with the nature of the emotion and of the situation that has caused it (see e.g., Compas et al., 2001; Eisenberg & Morris, 2002; Saarni et al., 2006; Skinner & Zimmer-Gembeck, 2007). This is related to the fact that children are increasingly capable of discerning between situations they can control (such as, for example, preparing for a test at school), where active, problem-focused strategies would be more appropriate, and situations they have no control over (such as a medical procedure), where strategies such as distraction or support-seeking are more effective (see e.g., Altshuler, Genevaro, Ruble, & Bonstein, 1995; Compas et al., 2001; Fields & Prinz, 1997; Rudolph, Dennig, & Weisz, 1995).

Apart from these three developmental trends, changes also occur in the relative use of different types of strategies across different developmental periods. Recently, Skinner and Zimmer-Gembeck (2007) identified and reviewed a number of 44 studies describing age-related changes in coping strategies. Based on this review, the authors showed that children's tendency to use strategies that involve *seeking support* from adults decrease over two periods of time: from 5 to 7 years, and from 9 to 12 tears, respectively. At the same time, the tendency to go to peers for support increases (especially during the 9-12 years interval). However, in line with their increasing ability to match ER strategies with the context, even older children would still ask adults for support in situations they perceived as uncontrollable. The use of *problem-solving* strategies – especially in their cognitive form (i.e., planning, mentally looking for solutions, etc.) – increases especially starting with middle childhood, and continues to increase into adulthood. The use of behavioral *distraction* strategies tends to increase until around age 12, while cognitive distraction continues to be increasingly used into adolescence. *Escape/avoidance* follows a similar trend, with increases until around age 12. The transition from childhood to adolescence is marked by an improvement in cognitive and reasoning abilities, which is associated with increased use of both adaptive strategies (e.g., cognitive restructuring) and maladaptive ones (such as rumination, self-blame, blaming others, catastrophizing), a trend that continues into the adult years (Garnefski et al., 2002).

One important influence in the development of ER is likely represented by EC. ER strategies vary in the degree to which they rely on automatic or controlled (voluntary) processes (Compas et al., 2001; Eisenberg & Spinrad, 2004; Skinner et al., 2003), but it is likely that good EC skills contribute to the development of adaptive ER strategies (Eisenberg et al., 1993; Eisenberg & Morris, 2002; Eisenberg et al., 2004). For example, Eisenberg et al. (1993) found that temperamental attentional control was positively related to constructive coping and negatively related to maladaptive ER strategies such as venting, aggressivity or avoidance. It is clear that a preschooler who, despite being angry at a peer who took his favorite toy, is able to negotiate, or to actively ask for help from an adult, is likely to also have better inhibitory and attentional control skills than a child who vents his/her frustration by crying or by being aggressive. On the other hand, there is plenty of research to suggest that attentional control mechanisms are an important part of ER throughout the life span. The most notable example would be that of *distraction* (i.e., shifting attentional focus away from a distressing situation, or distressing thoughts). Attentional distraction has been shown to have positive effects on mood in distressed infants (Dennis, 2006; Harman et al., 1997; Kopp, 1982, 1989), toddlers (Grolnick et al., 1996), preschoolers and schoolchildren (Eisenberg et al., 1993, 1995, 1998; Reijntjes, Stegge, Terwogt, Kamphuis, & Telch, 2006a), and adults (Nolen-Hoeksema, Morrow, & Fredrickson, 1993). Thus, EC and its sub-components likely constitute important skills in the development of ER. The relationship between the two aspects of self-regulation is probably an asymmetrical one (i.e., while good EC characteristics support the development of good ER strategies, the reverse is not necessarily true), but to our knowledge this is a possibility that has not been tested yet.

2.2.3 Gender differences in emotion regulation

As in the case of EC, some studies indicate the presence of gender differences in the use of ER strategies, in children as well as adults. Such studies have shown that in toddlers, girls are more likely to use emotional support-seeking strategies, while boys are more likely to use distraction during a delay task (Raver, 1996). In preschoolers and schoolchildren from a longitudinal sample assessed when they were 3-6, 5-8, and 7-10 years, respectively, Eisenberg et al. (1995, 1998) found that teachers rated girls as using more constructive coping strategies (such as instrumental coping or cognitive restructuring), more support seeking and more avoidance compared to boys (however, the latter two comparisons were only marginally significant). On the other hand, parents and teachers alike, perceived boys as more likely to use aggressive coping strategies compared to girls. Girls' tendency to use support-seeking and constructive (problem-solving) strategies to a higher degree than boys was recently replicated in a sample of children aged 7-16 years (Eschenbeck et al., 2007). However, within this sample, avoidance was higher in boys. Another study (Hampel & Petermann, 2005), while showing higher support-seeking in 6- to 14-year-old girls, found a decrease in adaptive coping strategies (distraction, positive self-talk) and an increase in maladaptive ones (such as rumination or aggression). In adults, Garnefski and collaborators (Garnefski, Teerds, Kraaij, Legerstee, & van den Kommer, 2004) found higher reports of positive refocusing, catastrophizing and rumination (see Nolen-Hoeksema et al., 1993 for a similar result on rumination). While we might link the higher positive refocusing scores to the findings of Eisenberg et al. (1995, 1998) and Eschenbeck et al. (2007) in children and adolescents (i.e, generally higher constructive coping in girls), the higher rumination and catastrophizing scores might be related to the higher incidence of depression and anxiety in women compared to men (Hettema, Prescott, Myers, Neale, & Kendler, 2005; Kendler et al., 1995; Nolen-Hoeksema, 2000).

2.2.4 Emotion regulation and anxiety

Despite some earlier studies showing links between certain coping strategies and symptoms of emotional psychopathology (e.g., Compas et al., 2001; Ebata & Moos, 1991; Herman-Stabl, Stemmler, & Petersen, 1995; Nolen-Hoeksema et al., 1993), interest in the possible links between anxiety and the ER skills of children and adults has emerged only recently. This interest was elicited by the potential of ER skills to contribute to the maintenance or extinction of anxiety (Cisler, Olatunji, Feldner, & Forsyth, 2010), as well as the possibility for creating interventions for clinical anxiety by targeting ER (Campbell-Sills & Barlow, 2007; Hannesdottir & Ollendick, 2007; Mennin, 2004; Mennin, Heimberg, Turk, & Fresco, 2002).

Part of the recent research involving adults has investigated the ER–anxiety link from the perspective of Gross' model (James J. Gross, 1998), focusing especially on the ER strategies of suppression and cognitive reappraisal (e.g., Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Decker et al., 2008; see Amstadter, 2008; Campbell-Sills & Barlow, 2007 for reviews). Generally, the few studies conducted thus far indicate that individuals with clinical anxiety and mood disorders find negative emotions less acceptable (Campbell-Sills et al., 2006), are more likely to use suppression to regulate negative affect (Amstadter, 2008; Campbell-Sills et al., 2006), and this is true especially in the case of women (Campbell-Sills et al., 2006). However, another recent study conducted from the same theoretical perspective but focusing on all types of ER strategies proposed by Gross found that compared to controls, participants with generalized anxiety disorder made more regulatory efforts *in general*, reporting increased use of rumination and suppression, but also situation selection or distraction, and no differences for other strategies (Decker et al., 2008a).

Working with a different taxonomy, Garnefski and collaborators (Garnefski et al., 2001; Garnefski & Kraaij, 2007; Garnefski, Kraaij, & van Etten, 2005; Garnefski et al., 2002) found small-to-moderate relationships between ER strategies such as self-blame, rumination and catastrophizing, and high (non-clinical) scores of anxiety and depression symptoms in adults and adolescents. On the other hand, positive reappraisal was significantly related to low anxiety and depression scores. The role of rumination (versus distraction) has been previously investigated in the coping literature, where evidence showed that depression is associated with increased use of rumination, and that this is true especially in the case of women (Nolen-Hoeksema et al., 1993; Nolen-Hoeksema, 2000). Similar results have recently emerged for anxiety: high (or clinical) anxiety is associated with higher ruminative tendencies and reduced use of distraction (e.g., Kocovski, Endler, Rector, & Flett, 2005; Wong & Moulds, 2009). Finally, a very recent study (Tortella-Feliu, Balle, & Sesé, 2010) conducted on a large (N >

1000) sample of adolescents and using Garnefski's taxonomy of ER strategies, moved beyond the simple ER–anxiety link, and found that negative ER mediated the link between NA and anxiety symptoms (here, negative ER was a composite measure including self-blame, rumination, catastrophizing, and blaming others).

In children and adolescents, most of the earlier coping literature shows that "engagement coping" (such as problem solving, cognitive reappraisal, support seeking, etc.) are related to lower levels of internalizing problems while "disengagement coping" strategies (such as denial or avoidance) are linked to higher internalization (Ebata & Moos, 1991; Herman-Stabl et al., 1995 see also Compas et al., 2001 for a review). Recent ER research tends to confirm these findings. As discussed previously, adolescents with high anxiety or depression tend to report using self-blame, rumination and catastrophizing to a high degree and positive reappraisal to a low degree (Garnefski et al., 2001, 2002, 2005). Additionally, these maladaptive ER strategies mediate the link between NA and anxiety (Tortella-Feliu et al., 2010), perhaps by amplifying and maintaining negative emotionality. Other recent research, conducted with children aged 10-17 and focusing on clinical anxiety, supports these general conclusions (Carthy, Horesh, Apter, Edge, & Gross, 2010; Carthy, Horesh, Apter, & Gross, 2010): anxious children use problem-solving and cognitive reappraisal strategies less frequently (in everyday life or in laboratory situations), they are less effective in using reappraisal to reduce negative affect, and are more likely to use avoidance and help-seeking in everyday life.

In the case of pre-adolescent children, there has been plenty of research linking ER to social competence and adjustment. As a consequence, there is now extensive evidence indicating the importance of constructive ER strategies (e.g., cognitive reappraisal / restructuring, distraction, support seeking) for the development of social competence and social success in children (e.g., Denham et al., 2003; Eisenberg et al., 1993, 1995, 1998; Fabes, Hanish, Martin, & Eisenberg, 2002). However, research linking ER to anxiety is relatively scarce. There is some evidence to indicate that global deficits in ER are linked to internalizing (or mixed) problems in preschool (Calkins, Graziano, & Keane, 2007; Cole et al., 1996; Rubin et al., 1995) and middle childhood (Rydell et al., 2003). Additionally, a relatively recent study involving 3-4 year-olds (Blair et al., 2004) found that constructive coping (e.g., instrumental coping, cognitive restructuring) significantly predicted reduced internalizing symptoms, while frequent use of emotional venting (crying to release frustration, crying to attract an adult's attention) and aggressive coping (verbal or instrumental aggression) significantly predicted externalizing problems. Blair et al. also found that the link between EC and internalizing behavior was moderated by passive coping (denial, distraction, avoidance) in boys and by constructive coping in girls. However, Blair and collaborators grouped together both avoidant and distraction strategies under the label "passive coping", despite suggestions in the literature that they belong to different dimensions of coping/ER (Ayers et al., 1996; Skinner et al., 2003). In addition, the authors chose to merge venting and aggressive strategies under the label "venting", despite previous differentiation between the two in Eisenberg's research (e.g., Eisenberg et al., 1993, 1995).

Thus, as our short review indicates, research focusing on adolescents and adults has found relatively specific ER strategies linked to anxiety (although in some cases they overlap with depression – see Garnefski's findings). However, in the case of children the data is more scarce and much less clear, especially since many studies have focused on outcomes such as social competence or internalizing problems in general, and have not investigated anxiety in particular.

2.2.5 Summary and conclusion

In this section, we have focused on ER. We discussed aspects related to its definition and measurement from the perspective of developmental research, as well as the adult-focused literature, and we adopted a conceptualization that sees ER as a set of relatively distinct strategies. We briefly presented some of the most important current taxonomies of ER/coping strategies, and discussed gender differences in ER with reference to these strategies. Finally, and most importantly, we discussed research linking ER to anxiety and showed that while this relatively new field has generated interesting and relatively clear results in adults and adolescents, there has been less research involving younger children.

2.3 Chapter summary and conclusion

In this chapter, we reviewed two possible intra-individual predictors of anxiety – temperament and ER strategies – and we discussed their relationship with anxiety symptoms in children and adults. In the case of temperament, our review indicates that while BI tends to be a reliable predictor of anxiety (both concurrently and longitudinally), research based of the multidimensional model of temperament shows a more complex picture. More precisely, while it is relatively clear that NA predicts anxiety (and depression) symptoms in children and adults, the contribution of EC (the self-regulatory dimension of temperament) is less clear. Thus far, two competing hypotheses have emerged: EC is seen either as an independent (negative) predictor of anxiety, or as a moderator of the link between NA and anxiety. However, based on the available evidence it is difficult to draw any developmentally relevant conclusions, because the two hypotheses have been systematically investigated only in middle childhood; studies focusing on adults have only looked at the first hypothesis, while most research involving preschoolers has looked at internalizing problems in general, with mixed results (some studies have even found evidence for a positive link between inhibitory control and anxiety in preschoolers).

The main conclusion of the second part of our review is that in general maladaptive ER strategies are linked to higher anxiety scores (there is less evidence for adaptive strategies) – at least in adults and adolescents. There has been very little research in preadolescent children to warrant any clear conclusions, which is unfortunate considering that the preschool and middle childhood years are important periods in the development of autonomy and *self*-regulation (Eisenberg & Morris, 2002; McCabe et al., 2004). Additionally, most of the research to date has investigated simple, correlation-based relationships. Therefore, apart from such an approach, it would also be interesting to see if ER strategies might mediate or moderate the relationship between NA and anxiety.

Lastly, some of the evidence we reviewed points to gender differences in the case of EC and ER. Additionally, there is some data suggesting gender-differentiated patterns of temperament–anxiety and ER–anxiety links. However, most of the literature does not address this phenomenon, despite its potential relevance in the light of adult gender differences in anxiety.

Thus, in the following chapter we aim to investigate the roles played by temperamental characteristics and ER strategies, across three developmental samples: preschoolers, schoolchildren and adults.

Chapter 3.
Anxiety and individual differences: Empirical studies

As discussed in the previous chapter, recent years have seen an increasing interest in investigating temperamental characteristics and ER strategies as potential predictors of anxiety, in children as well as adults. However, most research focuses on one interval of development, with different methodologies, which often generates contradictory findings. Additionally, research in children (especially in preschoolers) is still relatively scarce and tends to focus on global internalizing problems, with no specific differentiation between them. Thus, in the present chapter we focused on investigating the roles played by temperamental characteristics (more precisely NA and EC) and ER strategies in predicting the intensity of anxiety symptoms in children and adults. As stated in Chapter 1, we focused on three developmental samples: preschoolers, schoolchildren (middle childhood) and adults.

Our first objective was to investigate the role of temperament in the development of anxiety, from the perspective of the multidimensional model reviewed in Chapter 2. As already discussed, part of the literature focusing on the temperament–anxiety link has generated two different (but not necessarily incompatible) hypotheses regarding the roles of NA and EC in anxiety, namely the "additive" and the "interactive" hypothesis (e.g., Lonigan & Phillips, 2001; Muris & Ollendick, 2005). The first states that NA and EC make independent, unique contributions to anxiety. More precisely, high NA scores would increase the risk for high anxiety symptoms, while low EC scores would add to that risk, independently of the influence of NA. The second hypothesis states that EC moderates the relationship between NA and anxiety, so that when EC is sufficiently high, it acts as a protective factor, reducing the risk for high anxiety even in individuals with high NA. We were interested in investigating both of these hypotheses. If the additive hypothesis were correct, we would expect both NA and EC to be significant independent predictors of anxiety, and we would expect to find a positive relationship between NA and anxiety, and a negative one between EC and anxiety. If the interactive hypothesis were correct, we would expect the interaction between NA and EC to be a significant predictor of anxiety symptoms. Since previous studies have sometimes used sub-dimensions of EC (most notably attentional control) as predictors, we checked the involvement of these sub-dimensions as well. However, the primary focus was on EC as a global dimension.

Our second objective was to investigate the role of ER strategies in anxiety. Here, we were interested to determine which ER strategies were more likely to be linked to anxiety, but we also wanted to determine whether ER strategies played a more complex role in predicting anxiety symptoms. For this reason, we decided to test whether some ER strategies might act as mediators or moderators of the relationship between temperamental NA and anxiety. The first possibility is justified by the fact that higher levels of NA might elicit more intense regulatory efforts (see e.g., Decker, Turk, Hess, & Murray, 2008 for supporting evidence in adults). To the extent that such efforts are maladaptive they might result in an intensification of NA and thus plausibly an increase in anxiety symptoms. On the other hand, some ER strategies might also act as moderators of the NA–anxiety link, either by reducing, or enhancing the relationship between the two variables.

A third and somewhat secondary objective was to determine whether the patterns of predictors we found for anxiety were specific, or whether they would also apply to depression. This approach would allow us to determine whether it was justified to group the two types of emotional problems into one "internalizing" variable (especially in children) when investigating the role of NA and EC, or whether it was more productive to study them separately. Since a depression measure was not available for preschoolers, specificity was only investigated in schoolchildren and adults.

Finally, another secondary (and minor) objective was to determine whether EC and ER strategies were related. Since both are aspects of self-regulation, we expected to find at least some moderate positive correlations between EC and strategies reflecting active or adaptive ER, and negative correlations between EC and passive or generally maladaptive ER strategies.

Since some previous studies showed gender differences in EC and ER, we decided to conduct the analyses both at a whole-sample level, as well as separately for male and female groups.

3.1 Study 1A: Predictors of anxiety in preschoolers

3.1.1 Method

3.1.1.1 Participants and procedure

The children included in this study came from two kindergartens in Cluj-Napoca. A number of approximately 225 families were contacted initially with the aid of kindergarten staff (principal and teachers). Each family received a set of three questionnaires (described below) and an informed consent letter. Children whose parents agreed to participate (N = 119) and returned the questionnaires filled-in were included in the present study. Thus, the final sample consisted of 119 children (59 girls) aged 4-7 years (M = 66.50 months; SD = 10.82; range = 48-87 months).

3.1.1.2 Measures

Anxiety

The Romanian version of the *Spence Preschool Anxiety Scale* (SPAS; Spence, Rapee, McDonald, & Ingram, 2001; see Benga, Ţincaş, & Visu-Petra, 2010 for the Romanian version) was used as a measure of anxiety symptoms. The SPAS is a caregiver-report instrument composed of 28 items[3], with responses given on a 0-4 scale, where 0 = *not true at all* and 4 = *very often true*. The items assess problems related to five types of anxiety disorders: generalized anxiety (5 items; e.g., "Spends a large part of each day worrying about various things"), social anxiety (6 items; e.g., "Is afraid of talking in front of the class (preschool group)"), obsessive-compulsive disorder (5 items; e.g., "Washes his/her hands over and over many times each day"), physical injury fears (7 items; e.g., "Is afraid of insects and/or spiders"), and separation anxiety

[3] The SPAS contains six additional items referring to symptoms of PTSD, which were not included in the present analysis.

(5 items; e.g., "Is reluctant to go to sleep without you or to sleep away from home"). Scale and total scores are computed by summing responses to the relevant items. We only used the total score for the current analysis. The SPAS was shown to have an adequate structure and validity indices on the original sample (see Spence et al., 2001). The Romanian version of the SPAS has a good (or at least acceptable) internal consistency, as indicated by an analysis including 812 children, which found a Cronbach's α coefficient of .87 for the total scale, and α values ranging between .60 and .77 for the sub-scales (Benga et al., 2010). We only used the total score in the present analyses; in the current sample, the α coefficient for the total scale was .85.

Temperament

Parents were administered the Romanian version of the *Children's Behavior Questionnaire* (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001; see Benga, 2004 for the Romanian version), a 195-item caregiver-report instrument designed to measure 15 temperament dimensions reflecting aspects of behavioral/emotional reactivity and self-regulation (see Table 2.1 in Chapter 2 for details and item examples). The questionnaire asks parents to rate their child on a seven-point scale, ranging from 1 (*extremely untrue of your child*) to 7 (*extremely true of your child*). Scale and factor scores are obtained by computing the average score for items belonging to that scale or factor. Adequate internal consistency indices were reported for the original CBQ scales (Rothbart et al., 2001). For the purposes of the present study, we used the NA (Fear = 12 items, Sadness = 12 items, Anger/Frustration = 13 items), and the EC (Attentional control = 15 items, and Inhibitory control = 13 items) factors. As can be seen, we did not use all scales postulated by Rothbart et al. (2001) as belonging to that factor. This decision was made, on the one hand, because in most of the research linking temperament to emotional or behavioral problems these two factors are used in this manner (e.g., Eisenberg et al., 2001), and on the other hand, due to the fact that – computed in this manner – they represent purer measures of NA and EC (for example, the Soothability dimension included in NA represents a measure of self-regulation of negative affect rather than pure negative emotionality).

On an initial Romanian validation study involving 676 4-7-year-old children (Benga, 2004), the CBQ scales used here were reported to have Cronbach's α values ranging between .61 and .86 in 4- to 7-year-old children. In the current sample, internal consistency indices for the sub-scales were as follows: Fearfulness (α = .67); Sadness (α = .60); Anger/Frustration (α = .77), Attentional control (α = .62), and Inhibitory control (α = .80). The higher-order factors of NA and EC had α values of .80 and .82, respectively.

Emotion regulation

In order to assess children's ER strategies, we translated Eisenberg's *Children's Coping Styles Questionnaire* (CCSQ; Eisenberg et al., 1993, 1995). Parents were presented with three hypothetical interpersonal conflict situations, which usually elicit negative emotions in preschool children. For each of these hypothetical scenarios, they were asked to rate, on a seven-point scale, the likelihood that their child would engage in each of ten possible responses: (1) *Cognitive restructuring* (thinking about the situation in a positive way), (2) *Distraction* (doing something else to forget about the problem), (3) *Emotional aggression* (using physical or verbal aggression to release negative feelings), (4) *Venting* (crying to release negative feelings), (5) *Emotional support* (seeking the emotional support of an adult), (6) *Avoidance* (staying away from or leaving the situation), (7) *Emotional intervention* (crying to elicit the intervention of an adult), (8) *Instrumental coping* (taking constructive action to change the situation), (9) *Instrumental aggression* (trying to solve the problem through physical or verbal aggression) and (10) *Doing nothing*. Scores for each ER strategy were computed by averaging parents' responses to that strategy for each of the three situations.

Eisenberg et al. (1993) reported only internal consistency indices (which ranged from adequate to excellent) for the questionnaire. In terms of structure, they combined the items into three factors (constructive coping, emotional venting, and passive coping), based on theoretical considerations and item intercorrelations. Within this arrangement, they grouped distraction and avoidance strategies together under the label "passive coping". However, more recent research (e.g., Ayers, Sandler, West, & Roosa, 1996; Skinner, Edge, Altman, & Sherwood, 2003) suggests that the two strategies involve different degrees of self-control, and therefore should be considered separately. Therefore, for the present study, we decided to generate the different ER factors starting from an empirical basis. We conducted a principal components analysis using Varimax rotation over the ten ER strategies. A number of 114 participants were included in this analysis. The Keiser-Meyer-Olkin measure of sampling adequacy was .68, while Bartlett's test of sphericity resulted in a $\chi^2 = 249.43$, $p < .001$, indicating the adequacy of factor analysis for this data. We obtained four factors accounting for 67.44 % of the total variance. The first factor accounted for 28.34% of the total variance and included the strategies of Cognitive restructuring (loading = .82), Distraction (.76) and Instrumental coping (.71). We therefore named this factor *Active ER*. The second factor (accounted variance = 17.21%) loaded highly on Instrumental aggression (.85) and Emotional aggression (.84), and was therefore termed *Aggressive ER*. The third factor was composed of Emotional intervention (.75), Avoidance (.73) and Venting (.66). We therefore chose to name it *Passive ER*. The last factor (10.00 %) included only Emotional support (.95) and was therefore not involved in the current analysis. "Doing nothing" loaded weakly on both Aggressive regulation (-.34) and Active regulation (.32) and was therefore not used in the analyses included in this study. Thus, the final ER dimensions were as follows: (1) Active ER (Cognitive restructuring, Distraction, Instrumental coping; α = .79); (2) Passive ER (Emotional intervention, Avoidance, Venting; α = .82); (3) Aggressive ER (Emotional aggression, Instrumental aggression; α = .85); and (4) Emotional support (α = .79).

3.1.1.3 Missing data

In a few cases, parents did not fill in all three questionnaires, or the questionnaires had too many missing items, which made them unusable. Thus, one case was missing for Anxiety scores. Temperament data was missing for 3 children, while ER information was absent for 5 children.

3.1.2 Results

3.1.2.1 Preliminary analyses: gender and age

Before addressing the main research questions, we verified the presence of gender differences and correlations with age for all variables of interest. Descriptive statistics, for the entire sample and separated by gender, are presented in Table 3.1, which also includes the values of the independent samples t-test comparing scores for boys versus girls. As can be seen, we found no statistically significant differences between boys and girls for Anxiety. Similarly, there were no gender-related differences for NA or any of its sub-dimensions. However, girls had higher scores than boys for both EC and Attentional control. No gender differences were found for ER strategies.

None of the variables of interest varied as a function of age, except for Anxiety, which showed a moderate increase with age: $r = .34$, $p < .001$.

Table 3.1
Descriptive statistics for the entire preschool sample, and separated by gender.

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)	**df**	**t-test**
Anxiety (SPAS)	22.86 (13.08)	21.71 (11.52)	24.02 (14.48)	116	-0.96
Temperament (CBQ)					
Negative Affect (NA)	4.00 (0.55)	3.97 (0.50)	4.03 (0.59)	114	-0.55
Fear	3.86 (0.91)	3.78 (0.82)	3.95 (0.99)	114	-0.98
Sadness	3.93 (0.65)	3.88 (0.70)	3.99 (0.60)	114	-0.86
Anger/Frustration	4.21 (0.74)	4.26 (0.71)	4.16 (0.77)	114	0.73
Effortful Control (EC)	4.48 (0.49)	4.36 (0.44)	4.59 (0.52)	114	-2.69*
Attentional control	4.39 (0.50)	4.24 (0.44)	4.53 (0.52)	114	-3.13**
Inhibitory control	4.66 (0.69)	4.58 (0.65)	4.73 (0.73)	114	-1.19
Emotion regulation (CCSQ)					
Active ER	4.13 (1.06)	4.15 (1.17)	4.11 (0.97)	112	0.20
Passive ER	3.54 (1.22)	3.41 (1.27)	3.66 (1.16)	112	-1.09
Aggressive ER	2.42 (1.34)	2.66 (1.38)	2.20 (1.26)	112	1.87
Emotional support	4.20 (1.46)	4.11 (1.55)	4.30 (1.37)	112	-0.69

*$p < .05$; **$p < .01$

3.1.2.2 EC and ER

Correlations between all study variables are presented in Table 3.2 for the total sample, and in Table 3.3 separated by gender. As the data indicates, children with higher Aggressive ER also had lower EC ($r = -.39$, $p < .001$), Attentional control ($r = -.34$, $p < .001$) and Inhibitory control scores ($r = -.34$, $p < .001$). These relationships were present in girls (*r*s between -.28 and -.34, all *p*s < .05 – .01) as well as boys (*r*s between -.34 and -.39, all *p*s < .05 – .01). Active ER was correlated only with higher Inhibitory control scores ($r = .20$, $p < .05$). In the gender-separate analysis, this relationship was only found in boys, and here it dropped to marginally significant, due to the smaller sample size ($r = .25$, $p = .06$). Passive ER tendencies were unrelated with any of the temperamental self-regulation traits. Emotional support was marginally related to Inhibitory control in girls ($r = .24$, $p = .07$).

Table 3.2
Correlations between all study variables for the preschool sample.

	(1)	(2)	(2a)	(2b)	(2c)	(3)	(3a)	(3b)	(4)	(5)	(6)
(1) Anxiety	-										
Temperament											
(2) Negative Affect	.49***	-									
(2a) Fear	.62***	.72***	-								
(2b) Sadness	.26**	.74***	.30**	-							
(2c) Anger	.11	.67***	.10	.39***	-						
(3) Effortful Control	-.01	-.33***	-.10	-.11	-.50***	-					
(3a) Attentional control	-.08	-.36***	-.18	-.18	-.41***	.91***	-				
(3b) Inhibitory control	.09	-.18	.05	.02	-.47***	.80***	.49***	-			
Emotion regulation											
(4) Active ER	-.14	-.21*	-.20*	.00	-.22*	.14	.06	.20*	-		
(5) Passive ER	.26**	.41***	.20*	.39***	.31**	-.03	-.05	.01	-.08	-	
(6) Aggressive ER	.08	.32**	.00	.14	.58***	-.39***	-.34***	-.34***	-.22*	.34***	
(7) Emotional support	-.03	-.08	.02	-.11	-.11	.05	.05	.02	.14	.00	.00

$*p < .05$; $**p < .01$; $***p < .001$

Table 3.3
Correlations between study variables, for boys (below the diagonal) and girls (above the diagonal).

	(1)	(2)	(2a)	(2b)	(2c)	(3)	(3a)	(3b)	(4)	(5)	(6)	(7)
(1) Anxiety	-	.61***	.65***	.40**	.25^{+}	-.07	-.17	.10	-.22	.22	.03	-.07
Temperament												
(2) Negative Affect	.31*	-	.78***	.75***	.70***	-.31*	-.33*	-.19	-.39**	.43**	.41**	-.18
(2a) Fear	.56***	.64***	-	.39**	.19	-.10	-.20	.08	-.27*	.18	.04	-.02
(2b) Sadness	.10	.75***	.21	-	.45***	-.15	-.17	-.07	-.28*	.35**	.31*	-.10
(2c) Anger	-.08	.64***	.00	.37**	-	-.47***	-.35**	-.49***	-.31*	.47***	.62***	-.31*
(3) Effortful Control	.05	-.41**	-.17	-.13	-.55***	-	.92***	.82***	.09	.03	-.34**	.18
(3a) Attentional control	.02	-.48***	-.23^{+}	-.26^{+}	-.49***	.90***	-	.52***	.02	.00	-.28*	.10
(3b) Inhibitory control	.07	-.18	-.02	.09	-.45**	.79***	.44**	-	.16	.05	-.33*	.24^{+}
Emotion regulation												
(4) Active ER	-.06	-.04	-.13	.23	-.14	.20	.11	.25^{+}	-	-.19	-.10	.29*
(5) Passive ER	.32*	.38**	.21	.42**	.14	-.15	-.18	-.05	.01	-	.56***	-.13
(6) Aggressive ER	.16	.27*	-.01	.03	.54***	-.39**	-.34*	-.34*	-.33*	.20	-	-.18
(7) Emotional support	.01	.02	.06	-.14	.11	-.14	-.05	-.22	.02	.10	.18	-

$^{+}p < .10$; $*p < .05$; $**p < .01$; $***p < .001$

3.1.2.3 Temperamental predictors of anxiety

As Tables 3.2 and 3.3 indicate, high NA scores were related to high Anxiety scores (r = .49, $p < .001$ for the full sample; r = .61, $p < .001$ for girls; r = .31, $p < .05$ for boys). Among the NA sub-dimensions, Fear and Sadness showed the strongest links with NA. However, neither EC nor any of its sub-dimensions were related to Anxiety.

We investigated the additive and interactive hypotheses through hierarchical regression analyses. We used NA as a global variable, but tested EC as well as its sub-dimensions as independent predictors and moderators. However, for space-saving reasons, we focus mainly on analyses including EC as a predictor/moderator. Where we found statistically significant results that were different from the main analysis, we include them as well.

Due to evidence for some overlap between EC and NA (see the correlations in Tables 3.2 and 3.3), before proceeding to the analysis we determined the degree of multicollinearity between NA and EC (or its sub-dimensions) by checking the Tolerance and the Variance Inflation Factor (VIF). Both indices had values indicating no reason for concern regarding multicollinearity problems: in all analyses, Tolerance ≈ .90 and VIF < 2 (see e.g., Field, 2009; Sava, 2004 for details).

We carried out three separate hierarchical regression analyses according to the guidelines put forward by Aiken and West (1991; see also Cohen, Cohen, West, & Aiken, 2003; Sava, 2004). All predictor variables (NA, EC, Inhibitory control, Attentional control) were first centered, and two-way interaction terms were computed as the multiplicative products of these centered variables. Each analysis was conducted both at the level of the entire sample, as well as separately for boys and girls. Gender and age in months were first entered into each equation in order to partial out their effects (only age was entered in the first step for the gender-split analysis). NA was entered in the second step, followed (in the third step) by the potential moderator (EC, Inhibitory control, or Attentional control). The multiplicative term was entered in the fourth step. Effect sizes were computed according to Cohen's f^2 formulas for multiple regression and hierarchical multiple regression, respectively[4] (see Cohen, 1992).

As the data included in Table 3.4 indicates, the full model explained a large proportion of the variance in the total sample (R^2 = .39; f^2 = 0.64) and girls (R^2 = .52; f^2 = 1.08), while the effect was of a medium-large size in boys (R^2 = .21; f^2 = 0.27). The predictor that explained most of the variance was NA: after accounting for the effect of gender and age, it added 21% (f^2 = 0.32) in the total sample, 11% (f^2 = 0.13) in the case of boys, and 27% (f^2 = 0.53) in the case of girls, with relatively steep slopes in all cases (see the beta values for Step 2 in Table 3.4). EC was a direct predictor of Anxiety scores in the full sample (ΔR^2 = .03, f^2 = 0.05; β = .18, $p < .05$), indicating that children with better EC skills were more anxious. However, this effect was small, explaining only an additional 3% when added in the third step of the analysis. EC was not a significant moderator of the NA–Anxiety relationship. The interaction term added only 1% (f^2 = 0.02) or less to the amount of explained variance.

Attentional control was neither a significant independent predictor, nor a moderator of the relationship between NA and Anxiety. As an independent predictor, Inhibitory control contributed a small but significant amount of explanatory value to the model, and predicted higher anxiety scores in the case of the total sample (ΔR^2 = .03; f^2 = 0.05; β = .17, $p < .05$) and

[4] By convention, f^2 values of 0.02, 0.15, and 0.35 are considered small, medium, and large effects respectively (Cohen, 1992).

in the case of girls (ΔR^2 = .05; f^2 = 0.11; β = .23, p < .05), but not in the case of boys (ΔR^2 = .01; f^2 = 0.01; β = .06, *ns*). When adding the NA × Inhibitory control term we found a small moderating effect in the girls sub-sample (ΔR^2 = .03; f^2 = 0.07; β = .19, p < .05); this effect was smaller and non-significant in the full sample (ΔR^2 = .01; f^2 = 0.02; β = .10, *ns*) and in the case of boys (ΔR^2 = .00; f^2 = 0; β = .06, *ns*).

Table 3.4

Hierarchical multiple regression predicting Anxiety symptoms in preschoolers, with NA as a main predictor and EC as moderator.

	Total sample			Boys			Girls		
	B	SE B	β	B	SE B	β	B	SE B	β
Step 1	R^2 = .14***			R^2 = .06			R^2 = .22***		
Constant	-9.21	7.72		4.09	9.94		-17.34	10.57	
Gender	3.83	2.34	.15	-	-	-	-	-	-
Age	0.46	0.11	.38***	0.26	0.14	.25⁺	0.64	0.16	.46***
Step 2	ΔR^2 = .21***			ΔR^2 = .11*			ΔR^2 = .27***		
Constant	-5.24	6.77		2.31	9.48		-6.71	8.86	
Gender	2.83	2.05	.11	-	-	-	-	-	-
Age	0.40	0.10	.33***	0.29	0.14	.27*	0.48	0.14	.35**
NA	11.07	1.84	.46***	7.44	2.87	.33*	13.16	2.43	.53***
Step 3	ΔR^2 = .03*			ΔR^2 = .04			ΔR^2 = .02		
Constant	-5.21	6.65		2.19	9.36		-7.82	8.77	
Gender	1.64	2.08	.06	-	-	-	-	-	-
Age	0.41	0.09	.34***	0.29	0.13	.27*	0.49	0.13	.36**
NA	12.54	1.93	.52***	9.33	3.08	.41**	14.31	2.51	.58***
EC	4.90	2.19	.18*	5.43	3.53	.21	4.46	2.79	.16
Step 4	ΔR^2 = .01			ΔR^2 = .00			ΔR^2 = .01		
Constant	-4.58	6.67		2.92	9.55		-7.55	8.74	
Gender	1.62	2.08	.06	-	-	-	-	-	-
Age	0.41	0.09	.34***	0.28	0.14	.26*	0.50	0.13	.36***
NA	12.65	1.93	.53***	9.23	3.11	.40**	14.94	2.55	.60***
EC	4.99	2.19	.19*	5.62	3.58	.21	4.43	2.78	.16
NA × EC	3.76	3.34	.08	2.42	5.03	.06	5.44	4.55	.12

**p < .05; **p < .01; ***p < .001; ⁺p < .10*

We probed the NA × Inhibitory control interaction found in the girls' sub-sample by computing slopes for the mean level of Inhibitory control, as well as for values 1 SD above and 1 SD below the mean (see Aiken & West, 1991 or Cohen et al., 2003 for details). Slope statistical tests were carried out using ModGraph (Jose, 2008). The slope of the regression line was statistically significant at medium [t(55) = 2.93, p < .01] and high [t(55) = 5.56, p < .001] levels of Inhibitory control, but not at low values [t(55) = 0.44, *ns*]. As these results and Figure 3.1 indicate, NA significantly predicts anxiety only at medium and high levels of Inhibitory control.

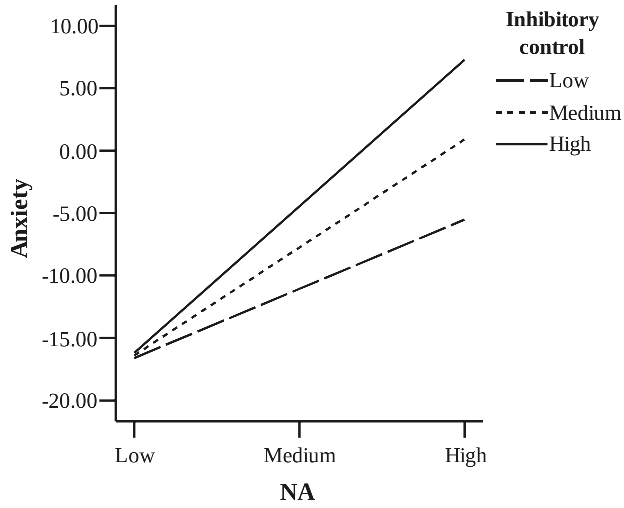

Figure 3.1. Interaction between NA and Inhibitory control in predicting Anxiety in the girls sub-sample.

3.1.2.4 ER and anxiety

As the correlations included in Tables 3.2 and 3.3 indicate, Anxiety was related to high Passive ER tendencies at the level of the total sample (r = .26, p < .05) and in the case of boys (r = .32, p < .05) but not girls (r = .22, *ns*). Out of the three Passive ER strategies, Venting was associated with anxiety in the total sample (r = .22, p < .05) and in girls (r = .29, p < .05), while Emotional intervention was linked to high anxiety in the full sample (r = .24, p < .05) and in boys (r = .30, p < .05). None of the other three types of ER strategies were significantly related to Anxiety.

Table 3.5
Results for the three steps testing the mediation of the relationship between NA and Anxiety by Passive ER in the preschool sample.

Step	Total sample			Boys			Girls		
	B	SE B	β	B	SE B	β	B	SE B	β
(1) NA → Anx	11.82	1.96	.49***	6.99	2.95	.31*	15.08	2.60	.61***
(2) NA → PER	0.90	0.19	.41***	0.95	0.32	.38**	0.86	0.24	.45**
(3) NA → (PER) → Anx	R^2 = .23; p < .001			R^2 = .11; p = .06			R^2 = .36; p < .001		
NA → Anx	10.69	2.22	.45***	4.59	3.50	.20	14.64	2.85	.62***
PER → Anx	0.53	1.01	.05	1.82	1.39	.19	-0.59	1.43	-.05
Sobel test	0.52; *SE* = 0.92; p = .60			1.20; *SE* = 1.44; p = .23			-0.65; *SE* = 1.25; p = .51		

Note: Anx = Anxiety; PER = Passive ER
**p < .05; **p < .01; ***p < .001*

Mediation analysis. We next tested whether Passive ER strategies mediated the link between NA and Anxiety. We only chose to test this type of ER strategies, because the correlation data indicated that this was the only potential mediator out of the three types of regulation strategies. We carried out the mediation analysis according to the classic steps put forward by Baron and Kenny (1986), which entail (1) showing that NA significantly predicts

Anxiety, (2) showing that NA predicts Passive ER and (3) showing that the relationship between NA and Anxiety becomes non-significant (or at least it is significantly reduced) when adding Passive ER to the equation (we controlled for age and gender in each analysis). We tested the statistical significance of the indirect effect using the Sobel test (see MacKinnon, 2008; Preacher & Hayes, 2004 for details, and for arguments for the use of significance tests in mediation analysis). Results of the three steps of the mediation analysis are presented in Table 3.5. As the table shows, adding Passive ER to the regression equation did not cancel the effect of NA (in any of the samples investigated), nor did it significantly reduce it. Additionally, the Sobel test was not statistically significant, indicating that there was no significant reduction of the effect of NA when Passive ER was added. Thus, Passive ER does not mediate the effect of NA upon Anxiety.

Moderation analysis. We verified whether Active or Passive ER moderated the relationship between NA and Anxiety, in a manner similar to the one presented above for the interaction between NA and EC. We failed to find any evidence that Active ER moderated the NA–Anxiety relationship (total sample: $\Delta R^2 = .00$, $f^2 = 0$; $\beta = -.06$, *ns*; boys: $\Delta R^2 = .00$, $f^2 = 0$; $\beta = -.06$, *ns*; girls: $\Delta R^2 = .00$, $f^2 = 0$; $\beta = -.07$, *ns*). The almost same pattern emerged for the NA × Passive ER interaction ($\Delta R^2 = .01$, $f^2 = 0.01$; $\beta = .11$, *ns* in the total sample; $\Delta R^2 = .00$, $f^2 = 0$; $\beta = .00$, *ns* in the case of boys), with the exception of the girls sample, where we found a small and marginally significant interaction effect: $\Delta R^2 = .04$, $f^2 = 0.08$; $\beta = .20$, $p = .05$. We probed this effect using ModGraph (Jose, 2008) and found that NA significantly predicted Anxiety at medium [$t(54) = 2.42$, $p < .05$] and high [$t(54) = 4.93$, $p < .001$] levels of Passive ER, but not at low values [$t(54) = 0.73$, *ns*]. (see Figure 3.2).

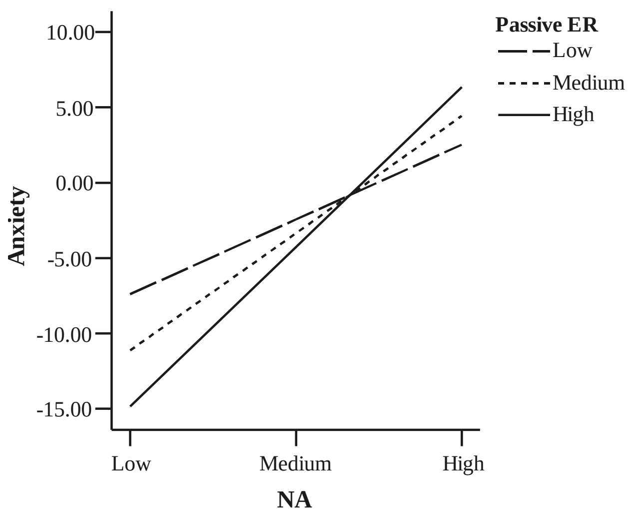

Figure 3.2. Interaction between NA and Passive ER in predicting Anxiety in the girls sub-sample.

3.1.3 Discussion

The present study focused on temperamental characteristics and ER strategies as potential predictors of anxiety symptoms in preschoolers. The results represent an important addition to the literature linking individual differences to anxiety symptoms, since within this literature a very small part of research has focused on preschool children, and most studies have used measures designed to capture internalizing problems in general rather than anxiety *per se*.

Before discussing the main results, we point out a few aspects revealed by our preliminary analyses. First, we did not find any gender-related differences in anxiety symptoms. However, as discussed in Chapter 1, while such differences tend to be relatively large in adults, studies show that they are small and inconsistent in children, especially this young (see Benga et al., 2010; Spence et al., 2001 for similar null differences using the same anxiety measure; see Costello, Egger, & Angold, 2004; Egger & Angold, 2006 for similar results using a clinical approach to anxiety). Second, in terms of age trends, we found a moderate increase in anxiety symptoms with increasing age. Again, this finding is in line with previous research showing increases in anxiety symptoms across the preschool years (Benga et al., 2010; S. L. Edwards et al., 2010; Spence et al., 2001), although the trend we found here might be slightly more pronounced than previous studies indicate. This trend is probably a partial reflection of the developmentally-normative increase in children's fears that occurs during the preschool years (see Muris, 2007; Warren & Sroufe, 2004 for details). Lastly, it is noteworthy that, in line with previous research showing better self-regulatory abilities in girls compared to boys (e.g., Eisenberg et al., 2001; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kochanska, Murray, & Harlan, 2000; McCabe, Cunnington, & Brooks-Gunn, 2004; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005), we also found higher EC and higher attentional control in the girls in our sample (however, boys and girls showed similar levels of inhibitory control).

A secondary objective of our study was to determine whether EC and its sub-dimensions were related to ER strategies. Our results generally support the fact that ER strategies are related to EC, but they indicate that poor EC skills are related to the development of aggressive ER strategies, to a larger extent than good EC skills are involved in adaptive ER (such as the use of active strategies or requests for emotional support).

With respect to our main analyses, unsurprisingly, NA was a clear moderate-to-strong predictor of anxiety (although its sub-dimensions related differently to anxiety), and this was true for the full sample, as well as the two gender-based sub-samples. However, more interesting was the involvement of EC and ER in predicting anxiety alongside NA. Regarding the role of EC, our data does not clearly support either the additive or the interactive hypothesis in this sample. More precisely, instead of decreasing anxiety vulnerability, our data indicates that EC (and especially inhibitory control) *increases* vulnerability (at least after accounting for the contribution of NA), as higher EC/inhibitory control scores predict higher anxiety symptoms (especially in girls). Additionally, we found evidence that inhibitory control moderates the relationship between NA and anxiety in girls. More precisely, NA was a significant predictor of anxiety symptoms in girls with high or medium inhibitory control, but not in those with low inhibitory control. (It should be noted, though, that the impact of inhibitory control upon anxiety was close to moderate at best, and the interaction effect was small). While these results are contrary to what we would expect, they are however in line with data obtained in a few previous studies (Kochanska et al., 1996; Murray & Kochanska, 2002; Thorell, Bohlin, & Rydell, 2004), which showed that higher EC or inhibitory control were related to higher internalizing/anxiety problems in preschoolers. In line with interpretations put forward in the studies cited above, we might distinguish between a controlled, voluntary form of inhibition, which the Inhibitory control scale attempts to capture (i.e., "The capacity to suppress inappropriate approach behavior"), and an automatic, involuntary form of inhibition.

This latter form might be captured by BI as described by Kagan (e.g., Kagan, 1998; Kagan, Reznick, & Snidman, 1987), or more generally, by what Nigg (2000) has termed *motivational* inhibition, or "bottom-up (limbic→cortical) interruption of ongoing behavior or suppression of behavioral response due to fear or anxiety in the presence of immediate novel social situation or cues for punishment" (p. 238)[5]. As one can see, the overt manifestation of these inhibitory mechanisms can be identical (i.e., stopping of an approach behavior), despite potentially different triggers (inhibitory control versus motivational inhibition). It is therefore possible that parents who answered our questionnaires have a hard time distinguishing between the two, and their responses reflect a mix (see also Eisenberg & Morris, 2002). For this reason, children who are motivationally inhibited and therefore more prone to anxiety would have inflated scores on the inhibitory control scale. However, as Kochanska's data shows (Kochanska et al., 1996; Murray & Kochanska, 2002), the same results are obtained when EC is measured via observational measures, thus in situations where parental reports play no role. It is therefore possible that the effects we see are not due solely to parental perceptions of their own children, but that they represent, in fact, a real lack of differentiation at the level of overt behavior.

As already mentioned, the effects of inhibitory control – as an independent predictor or as a moderator – were present mostly in girls. It is not entirely clear why this is the case, since previous studies did not report gender-differentiated patterns of results for this effect (see Kochanska et al., 1996; Murray & Kochanska, 2002; Thorell et al., 2004). Additionally, in our sample inhibitory control was the only EC dimension where girls and boys were relatively equal. One possible explanation for these results is that from the point of view of parents, the two types of inhibition we mentioned above are easier to confound in the case of girls than in boys. However, further studies are necessary to clarify whether this hypothesis is plausible or not.

In the case of ER, we were interested to determine whether certain strategies might mediate the NA–anxiety link, or whether having certain ER strategies might amplify or, on the contrary, diminish risk in children with high NA. While passive ER strategies (venting, avoidance and emotional intervention) were the strongest independent correlate of anxiety (especially in boys), we failed to find any evidence for their mediating role. However, we did find some indication that passive ER strategies acted as a moderator in girls. More precisely, while high NA did not predict high anxiety in girls who used passive ER strategies rarely, the impact of NA upon anxiety increased with increasing use of this type of strategies. It should be noted, though, that the interaction was marginally significant (it would probably become significant with a larger sample) and the effect was relatively small. Thus, our data indicates that passive ER strategies are linked to higher anxiety in boys as well as girls, but the patterning of this link differs in the two genders.

To summarize, this study has investigated the manner in which temperamental NA combines with self-regulatory influences coming from EC or ER strategies, to predict anxiety symptoms in preschool children. Our data shows that while NA is generally the most important predictor, self-regulatory characteristics have a higher impact in the case of girls, where higher inhibitory control and increased use of passive ER strategies amplify the effect of NA upon anxiety. In boys, apart from the impact of NA upon anxiety, we also found a moderately increased tendency to use passive ER strategies.

[5] It is not clear to what degree "motivational inhibition" and temperamental fear overlap. It is possible that they refer to the same construct. However, inhibitory control and fear were unrelated in the present study.

3.2 Study 1B: Predictors of anxiety in middle childhood

3.2.1 Method

3.2.1.1 Participants and procedure

Children who attended first to fourth grade from two schools in Cluj-Napoca were selected based on informed consents given by parents. Parents were contacted with the help of teachers and school principals. Each parent received an informed consent letter and three questionnaires assessing child characteristics (see descriptions below). A total number of approximately 390 parents were contacted in this manner, and 230 of them consented to take part in the study and returned filled-in questionnaires. Nine children were eliminated from the analyses due to having too many missing items in at least two of the measures. Thus, the final sample consisted of 221 children (116 girls) aged 6-11 years (M = 108.38 months; SD = 14.35; range = 80-134 months).

Additionally, children from third and fourth grade of one of the schools, whose parents had consented to involve them in the study, were also asked to complete the RCADS and CCSC-R1 questionnaires (described below). Each questionnaire was administered in a separate session to the whole class. The teacher was present throughout each assessment. Before handing out the questionnaires, children were informed that their participation was voluntary and that they did not have to participate if they did not want to. Children for whom there was no parental consent were allowed to participate if they insisted to do so, but their data was not used. The experimenter read the instructions and the items aloud to the children and explained them when necessary. Questionnaire presentation was counterbalanced between classes. This sample consisted of 66 children (32 girls) aged 8-11 years (M = 116.80 months; SD = 8.43; range = 97-134 months).

3.2.1.2 Measures

Anxiety and depression

The *Revised Child Anxiety and Depression Scales* (RCADS; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000) was used to assess anxiety and depression symptoms in the middle childhood sample. The RCADS is composed of 47 items referring to the frequency of occurrence of different anxiety and depression symptoms. The responses are given on a 0-4 scale, where 0 = *never* and 4 = *always*. The items assess problems related to depression (e.g., “Nothing is much fun anymore”), and five types of anxiety disorders: separation anxiety (7 items; e.g., “I feel scared if I have to sleep on my own.”), generalized anxiety (6 items; e.g., “I worry that something awful will happen to someone in my family”), panic (9 items; e.g., “I suddenly feel as if I can't breathe when there is no reason for this”), social anxiety (9 items; e.g., “I feel worried when I think someone is angry with me”), obsessive-compulsive disorder (6 items; e.g., “I have to keep checking that I have done things right (like the switch is off, or the door is locked)”). Scale and total scores are computed by summing responses to the relevant items. The RCADS was originally derived from the Spence Children's Anxiety Scale (SCAS; Spence, 1997, 1998) and designed as a self-report measure for children and adolescents. We translated the items of the original RCADS into Romanian. However, since our study required a parent-report measure especially in the younger children, we derived a parent-report version (RCADS-P), by rephrasing the items in the second person singular[6].

The RCADS was shown to have an adequate structure, and adequate validity and reliability indices on the original sample (see Chorpita, Moffitt, & Gray, 2005; Chorpita et al., 2000). Preliminary analyses on the Romanian parental version suggested a factorial structure similar to the original one. In the current sample, internal consistency indices for the anxiety sub-scales of the RCADS-P ranged between α = .63 and α = .80, while the full anxiety scale had a Crombach's α of .89. The internal consistency of the Depression scale was α = .71.

The child self-report version (RCADS) was administered to the older children in our sample (i.e., third and fourth graders). Internal consistency indices computed over the 66 children who were assessed with this version of the scale ranged between .63 and .83 for anxiety sub-scales. Crombach's α for the entire anxiety scale was .92, while the depression scale had an α = .71.

Temperament

Parents were administered the Romanian version of the *Temperament in Middle Childhood Questionnaire* (TMCQ; Simonds, 2006; Simonds & Rothbart, 2006), a 157-item caregiver-report instrument designed to measure 16 temperament dimensions reflecting aspects of behavioral/emotional reactivity and self-regulation. The questionnaire asks parents to rate their child on a five-point scale, ranging from 1 (*almost always untrue of your child*) to 5 (*almost always true of your child*), and offers them an additional response option – "does not apply" – for items which do not apply to that particular child. Scale and factor scores are obtained by computing the average score for items belonging to that scale or factor. We selected the NA sub-scales of Fear (9 items), Sadness (10 items), and Anger/Frustration (7 items) from the total questionnaire as measures of emotional reactivity, and the EC sub-scales of Attentional focusing (7 items; the TMCQ does not have a scale for Attentional shifting), Inhibitory control (8 items) and Activation control (15 items). In the current sample, internal consistency indices were as follows: Fearfulness (α = .77), Sadness (α = .77), Anger/Frustration (α = .79), Attentional focusing (α = .77), Inhibitory control (α = .64), Activation control (α = .61). Internal consistency indices for the higher-order factors of NA and EC were .87 and .83, respectively.

Emotion regulation

We translated the *Children's Coping Strategies Checklist, Revised version* (CCSC-R1; Ayers et al., 1996; Program for Prevention Research, Arizona State University, 1999), a self-report instrument assessing cognitive and behavioral coping strategies in children aged 9-13. The CCSC-R1 is composed of 54 items, with responses given on a 1 (*never*) to 5 (*most of the time*) scale. The items assess 13 coping strategies, grouped into four higher-order factors: Active coping strategies (including Problem-focused coping = 12 items, e.g., "You thought about which things are best to do to handle the problem", and Positive cognitive restructuring = 12 items, e.g., "You told yourself you have taken care of things like this before"), Distraction strategies (9 items; e.g., "You did something like video games or a hobby"), Avoidance strategies (8 items; e.g., "You avoided the people who made you feel bad") and Support

[6] Recently, Chorpita and collaborators have also developed a parent-report version of the RCADS (see Ebesutani, Bernstein, Nakamura, Chorpita, & Weisz, 2010), which is fundamentally identical (in item meaning) with the one we obtained.

seeking strategies (9 items; e.g., "You talked to someone who could help you figure out what to do"). The scores for the lower-order strategies and the higher-order factors are obtained by averaging across items belonging to that strategy/factor. As we were interested in coping strategies present in children since the age of 6 years, we developed a parent-report version (CCSC-R1-P) by rephrasing the translated items in the second person singular, and asking parents to report on their child's behavior. Preliminary data showed a factorial structure that was similar to the one of the original scale. Since it was possible that in some cases parents might not be aware whether their child was using that particular strategy (especially in the case of cognitive strategies), we added the response option "I don't know/Does not apply", which was not scored. For the CCSC-R1-P, internal consistency indices were as follows: $\alpha = .91$ for Active coping strategies, $\alpha = .76$ for Distraction, $\alpha = .75$ for Avoidance and $\alpha = .91$ for Support seeking.

The CCSC-R1 (self-report version) was administered to third- and fourth-graders. For this version, internal consistency indices were .92 for Active coping, .88 for Distraction, .79 for Avoidance, and .90 for Support seeking.

3.2.1.3 Missing data

Two children missed data for Anxiety and Depression. One child missed data on the TMCQ, while more data was missing for the following CCSC-R1-P ER strategies: Active coping ($N = 38$), Distraction ($N = 11$), Avoidance ($N = 26$), Support seeking ($N = 12$). In the child self-report sample, data was missing for Anxiety and Depression ($N = 5$) and for ER strategies ($N = 9$).

3.2.2 Results

3.2.2.1 Preliminary analyses: gender and age

As in the previous study, we first verified the presence of gender differences and correlations with age for anxiety, depression, temperament dimensions, and ER strategies. This was done both for the parent- and the child-report samples (in the latter case, analyses were carried out only for Anxiety, Depression and ER strategies). Descriptive statistics for all measures of interest are presented in Table 3.6 (parent-report data) and Table 3.7 (parent- versus child-report data, only for children aged 8-11 years).

In the parent-report sample, we found no significant difference between girls and boys for Anxiety or Depression. Girls had higher scores than boys for the temperament dimensions of Fear, EC, Attentional focusing and Inhibitory control (see Table 3.6 for details). Small correlations with age were found for Fear ($r = -.15$, $p < .05$), EC ($r = .16$, $p < .05$) and Inhibitory control ($r = .15$, $p < .01$).

In the child self-report group, girls had significantly higher Anxiety scores compared to boys [$t(59) = 2.08$, $p < .05$], but were similar for all other dimensions. No gender-related differences were found when we looked at parents' reports within this group (see Table 3.7 for details). When children reported on the variables of interest, Anxiety and Depression were not related to age ($r = .06$, *ns* and $r = .02$, *ns*, respectively). In the case of ER strategies we only found a marginally significant tendency to use Support-seeking strategies less as children grew older ($r = -.25$, $p = .06$); all other ER strategies were unrelated to age (all $|rs| < .17$, *ns*).

Table 3.6
Descriptive statistics for the entire middle childhood sample, and separated by gender

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)	**df**	**t-test**
Anxiety (RCADS-P)	19.78 (12.05)	19.22 (10.83)	20.27 (13.07)	216	-0.64
Depression (RCADS-P)	4.91 (3.13)	4.96 (3.00)	4.86 (3.25)	216	0.24
Temperament (TMCQ)					
Negative Affect (NA)	2.94 (0.57)	2.89 (0.56)	2.99 (0.57)	217	-1.36
Fear	2.84 (0.77)	2.66 (0.76)	2.99 (0.75)	217	-3.18**
Sadness	2.79 (0.57)	2.76 (0.56)	2.82 (0.59)	217	-0.78
Anger/Frustration	3.20 (0.72)	3.24 (0.73)	3.17 (0.70)	217	0.76
Effortful Control (EC)	3.24 (0.42)	3.17 (0.42)	3.31 (0.41)	217	-2.51*
Attention focusing	2.98 (0.65)	2.86 (0.67)	3.08 (0.61)	217	-2.58*
Inhibitory control	3.45 (0.54)	3.34 (0.58)	3.54 (0.49)	217	-2.79**
Activation control	3.31 (0.42)	3.31 (0.40)	3.30 (0.43)	217	0.06
Emotion regulation (CCSC-R1-P)					
Active coping	2.77 (0.53)	2.77 (0.47)	2.77 (0.58)	180	-0.01
Distraction	2.90 (0.56)	2.93 (0.57)	2.87 (0.55)	207	0.68
Avoidance	2.70 (0.47)	2.74 (0.44)	2.67 (0.50)	192	1.02
Support seeking	3.16 (0.69)	3.13 (0.69)	3.19 (0.70)	206	-0.62

$^*p < .05$; $^{**}p < .01$

3.2.2.2 Child- vs. parent-reported ER and anxiety

Ratings of Anxiety and Depression were moderately correlated in children and their parents: $r = .31$, $p < .05$ for Anxiety, $r = .32$, $p < .05$ for Depression.

A 2 (child gender) × 2 (respondent: parent vs. child) MANOVA with Anxiety and Depression scores as dependent variables indicated that children rated themselves as more anxious [$F(1, 123) = 9.26$, $p < .05$, $\eta_p^2 = .07$] and more depressed [$F(1, 123) = 5.28$, $p < .05$, $\eta_p^2 = .04$] than parents rated them (see Table 3.7 for descriptive statistics). Child gender had no impact on either anxiety [$F(1, 123) = 2.70$, $p = .10$, $\eta_p^2 = .02$] or depression [$F < 1$, *ns*] and it did not interact with respondent either in rating Anxiety [$F(1, 88) = 2.95$, $p = .09$, $\eta_p^2 = .02$] or Depression [$F < 1$, *ns*].

Ratings of ER strategies made by parents and children were related only in the case of Avoidant strategies ($r = .28$, $p < .05$) but not other strategies (*r*s between .05 and .23, all *ns*). Parents rated their children higher in all ER strategies than children did themselves: $F(1, 111) = 20.45$, $p < .001$, $\eta_p^2 = .16$ for Active strategies; $F(1, 111) = 13.93$, $p < .001$, $\eta_p^2 = .11$ for Distraction; $F(1, 111) = 19.43$, $p < .001$, $\eta_p^2 = .15$ for Avoidance; $F(1, 111) = 39.32$, $p < .001$, $\eta_p^2 = .26$ for Support seeking strategies. Child gender and its interaction with respondent had no effect on ratings of ER: all Fs ≤ 1, *ns*.

Table 3.7
Descriptive statistics for variables assessed through self-report, for the total middle childhood sample, and separated by gender

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)
Anxiety (RCADS-P)	16.83 (10.84)	16.91 (11.99)	16.75 (9.66)
Depression (RCADS-P)	4.98 (3.52)	5.24 (3.47)	4.72 (3.60)
Anxiety (RCADS)†	23.67 (14.47)	19.87 (11.13)	27.35 (16.44)
Depression (RCADS)†	6.49 (3.85)	6.43 (3.56)	6.55 (4.18)
Emotion regulation (CCSC-R1-P)			
Active coping	2.79 (0.53)	2.82 (0.50)	2.76 (0.56)
Distraction	2.92 (0.52)	3.02 (0.55)	2.81 (0.47)
Avoidance	2.70 (0.42)	2.77 (0.46)	2.63 (0.38)
Support seeking	3.15 (0.71)	3.01 (0.76)	3.29 (0.64)
Emotion regulation (CCSC-R1)†			
Active coping	2.32 (0.57)	2.36 (0.68)	2.28 (0.43)
Distraction	2.53 (0.81)	2.54 (0.83)	2.52 (0.81)
Avoidance	2.31 (0.52)	2.32 (0.59)	2.30 (0.43)
Support seeking	2.34 (0.74)	2.36 (0.85)	2.31 (0.63)

†Child self-report data.

3.2.2.3 Parent-report data: EC and ER

As Tables 3.8 and 3.9 indicate, EC and its sub-dimensions appear to be most strongly linked to Active coping strategies. With the exception of the Active coping–Attentional focusing relationship, which showed a small correlation (r = .19, p < .05), Active coping was moderately linked to high EC (r = .34, p < .001), Inhibitory control (r = .35, p < .001) and Activation control (r = .29, p < .001). Distraction was also weakly linked to Inhibitory (r = .18, p < .05) and Activation control (r = .17, p < .05), while Support seeking was weakly related to EC (r = .17, p < .05) and Activation control (r = .20, p < .05). In boys, both Active coping and Distraction showed small-to-moderate links with EC, Inhibitory control and Activation control (see Table 3.9, below the main diagonal). In girls, Active coping was moderately linked to EC, Inhibitory control and Activation control (Table 3.9, above the main diagonal). Support seeking was positively (but weakly) correlated with EC and its sub-dimensions in girls, but unrelated in boys.

Table 3.8
Correlations between all study variables for the middle childhood sample.

	(1)	(2)	(3)	(3a)	(3b)	(3c)	(4)	(4a)	(4b)	(4c)	(5)	(6)	(7)
(1) Anxiety	-												
(2) Depression	.59***	-											
Temperament													
(3) Negative Affect	.46***	.37***	-										
(3a) Fearfulness	.43***	.24***	.80***	-									
(3b) Sadness	.41***	.39***	.85***	.52***	-								
(3c) Anger	.31***	.32***	.83***	.41***	.65***	-							
(4) Effortful Control	-.14*	-.36***	-.37***	-.23**	-.31***	-.37***	-						
(4a) Attentional focusing	-.10	-.29***	-.36***	-.20**	-.32***	-.37***	.83***	-					
(4b) Inhibitory control	-.07	-.26***	-.20**	-.11	-.16*	-.23***	.81***	.48***	-				
(4c) Activation control	-.17*	-.30***	-.29***	-.23***	-.24***	-.24***	.67***	.32***	.41***	-			
Emotion regulation													
(5) Active coping	.06	-.10	-.08	-.14	-.02	-.01	.34***	.19*	.35***	.29***	-		
(6) Distraction	-.05	-.07	.07	.00	.10	.09	.09	-.08	.18**	.17*	.30***	-	
(7) Avoidance	.04	-.01	.12	.00	.15*	.18*	.05	-.07	.11	.13	.62***	.42***	-
(8) Support seeking	.12	-.08	.02	-.06	.09	.03	.17*	.12	.10	.20**	.57***	.07	.26***

**p < .05; **p < .01; ***p < .001*

Table 3.9
Correlations between study variables all study variables for the middle childhood sample, for boys (below the diagonal) and girls (above the diagonal).

	(1)	(2)	(3)	(3a)	(3b)	(3c)	(4)	(4a)	(4b)	(4c)	(5)	(6)	(7)	(8)
(1) Anxiety	-	.65***	.54***	.49***	.43***	.42***	-.20*	-.16	-.13	-.23*	.05	-.12	.02	.09
(2) Depression	.50***	-	.44***	.33***	.46***	.35***	-.45***	-.30**	-.39***	-.44***	-.19	-.16	-.03	-.10
Temperament														
(3) Negative Affect	.36***	.29**	-	.80***	.88***	.86***	-.49***	-.51***	-.30**	-.35***	-.13	.08	.15	-.06
(3a) Fearfulness	.35***	.16	.81***	-	.53***	.45***	-.39***	-.38***	-.22*	-.31**	-.24*	.06	-.02	-.14
(3b) Sadness	.39***	.30**	.82***	.52***	-	.75***	-.43***	-.43***	-.28**	-.30**	-.06	.06	.21*	-.02
(3c) Anger	.17	.27**	.81***	.41***	.55***	-	-.44***	-.48***	-.26**	-.28**	-.03	.09	.23*	.01
(4) Effortful Control	-.08	-.26**	-.27**	-.15	-.21*	-.29**	-	.82***	.81***	.78***	.33**	-.03	.01	.24*
(4a) Attentional focusing	-.06	-.29**	-.24*	-.11	-.24*	-.26**	.82***	-	.45***	.43***	.20	-.18	-.13	.19*
(4b) Inhibitory control	-.03	-.14	-.15	-.09	-.07	-.20*	.81***	.47***	-	.55***	.32**	.08	.07	.16
(4c) Activation control	-.09	-.14	-.21*	-.15	-.16	-.20*	.57***	.21*	.29**	-	.31**	.08	.13	.24*
Emotion regulation														
(5) Active coping	.09	.04	.01	-.02	.04	.02	.37***	.20	.40***	.25*	-	.29**	.57***	.65***
(6) Distraction	.05	.04	.07	-.03	.15	.08	.24*	.04	.28**	.27**	.31**	-	.53***	.06
(7) Avoidance	.08	.02	.10	.06	.07	.11	.12	.02	.18	.11	.70***	.29**	-	.29**
(8) Support seeking	.16	-.07	.10	.02	.21*	.05	.08	.03	.04	.15	.46***	.08	.24*	-

$*p < .05$; $**p < .01$; $***p < .001$

3.2.2.4 Parent-report data: Temperamental predictors of anxiety (and depression)

As Tables 3.8 and 3.9 indicate, high NA scores were related to both high Anxiety scores (r = .46, p < .001 for the full sample; r = .54, p < .001 for girls; r = .36, p < .001 for boys), as well as high Depression scores (r = .37, p < .001 for the full sample; r = .44, p < .001 for girls; r = .29, p < .01 for boys). This was true for all NA sub-dimensions, with the exception of Anger and Fear, which were unrelated to Anxiety and Depression, respectively, in the case of boys. EC was only weakly negatively related to Anxiety in the full sample (r = -.14, p < .05) and in girls (r = -.20, p < .05). However, it was more strongly related to Depression (r = -.36, p < .001 for the full sample; r = -.26, p < .01 for boys; r = -.45, p < .001 for girls).

We next tested the additive and interactive hypotheses using Anxiety as well as Depression as outcome variables. As in the previous study, Tolerance and VIF indices showed no reason for multicollinearity concerns: Tolerance ≈ .90 and VIF < 2. This indicated that NA and EC could be safely used as separate predictors in the same analysis.

Table 3.10

Hierarchical multiple regression predicting Anxiety in the middle childhood sample, with NA as a main predictor, and EC as moderator.

	Total sample			**Boys**			**Girls**		
	B	SE B	β	B	SE B	β	B	SE B	β
Step 1	R^2 = .01			R^2 = .02			R^2 = .00		
Constant	24.54	6.35		30.98	8.66		20.77	8.95	
Gender	0.97	1.65	.04	-	-	-	-	-	-
Age	-0.05	0.06	-.06	-0.11	0.08	-.14	0.00	0.08	-.01
Step 2	ΔR^2 = .21***			ΔR^2 = .13***			ΔR^2 = .29***		
Constant	21.05	5.66		28.17	8.15		15.72	7.62	
Gender	-0.05	1.48	.00	-	-	-	-	-	-
Age	-0.01	0.05	-.01	-0.08	0.07	-.10	0.04	0.07	.05
NA	9.89	1.30	.47***	7.03	1.83	.36***	12.24	1.81	.54***
Step 3	ΔR^2 = .00			ΔR^2 = .00			ΔR^2 = .00		
Constant	21.60	5.75		29.21	8.41		15.99	7.64	
Gender	-0.25	1.52	-.01	-	-	-	-	-	-
Age	-0.02	0.05	-.02	-0.09	0.08	-.11	0.04	0.07	.05
NA	10.21	1.41	.48***	7.29	1.90	.37***	13.08	2.08	.58***
EC	1.16	1.94	.04	1.38	2.61	.05	2.41	2.90	.08
Step 4	ΔR^2 = .03**			ΔR^2 = .00			ΔR^2 = .10***		
Constant	21.15	5.63		29.29	8.52		11.85	7.16	
Gender	-0.52	1.49	-.02	-	-	-	-	-	-
Age	-0.02	0.05	-.02	-0.09	0.08	-.12	0.06	0.07	.07
NA	10.24	1.38	.48***	7.30	1.92	.37***	12.87	1.93	.57***
EC	-0.52	1.98	-.02	1.33	2.68	.05	-0.94	2.81	-.03
NA × EC	-8.98	2.89	-.20**	-0.38	4.94	-.01	-15.14	3.50	-.34***

**p < .05; **p < .01; ***p < .001*

Hierarchical regression analyses were carried out exactly as described for the preschool study, and effect sizes were computed according to Cohen's f^2 formulas for multiple regression and hierarchical multiple regression, respectively. In this case, analyses for the three sub-dimensions of EC found results that were virtually identical to the ones found for EC. Therefore, we present only the analyses involving EC as a predictor/moderator.

Anxiety. Results of the hierarchical regression analysis with Anxiety as a criterion variable are presented in Table 3.10. As can be seen, the full model explains 25% of the variance in anxiety scores (R^2 = .25; f^2 = 0.33) when the entire sample is included in the analysis, 15% in boys (R^2 = .15; f^2 = 0.18), and 39% in girls (R^2 = .39; f^2 = 0.64). NA was a significant moderate-to-strong predictor of anxiety (f^2 = 0.27 in the total sample; f^2 = 0.15 in boys; f^2 = 0.41 in girls). In itself, EC was not a significant independent predictor of Anxiety scores, but in interaction with NA it appeared as a significant negative predictor of Anxiety scores in the full sample (β = -.20, p < .01) and in girls (β = -.34, p < .001). While the interaction term explained a relatively small amount of the variance in the total sample – i.e., (ΔR^2 = .03; f^2 = 0.04), it appeared to have a higher impact in the girls' sub-sample (ΔR^2 = .10; f^2 = 0.16). This effect was absent in boys, where adding the interaction term added nothing to the explained variance.

We probed the interaction for the full sample and for the girls' sub-sample by computing NA–Anxiety slopes for mean, high (+1 SD) and low (-1 SD) levels of EC. Slope statistical tests were carried out using ModGraph (Jose, 2008). The same pattern emerged in both samples: slopes were significant for both medium [t(213) = 3.54, p < .001 for the total sample; t(111) = 2.71, p < .01 for girls], and low values of EC [t(213) = 7.58, p < .001 for the total sample; t(111) = 8.02, p < .001 for girls], but not for high values [t(213) = 0.25, *ns* for the total sample; t(111) = 0.19, *ns* for girls]. As these results and Figures 3.3A and 3.3B indicate, high EC cancels the effect of NA upon Anxiety.

Depression. A hierarchical regression analysis to determine the potential moderating role of EC on the NA–Depression link was carried out in the manner described above for Anxiety. The results are presented in Table 3.11. NA was a significant predictor of Depression symptoms in all samples (f^2 = 0.17 in the total sample; f^2 = 0.10 in boys; f^2 = 0.27 in girls). After accounting for the effects of sex, age and NA, EC was also a significant predictor of lower Depression scores, and it explained a small-to-moderate amount of variance: 6% in the full sample (ΔR^2 = .06; f^2 = 0.08; β = -.28, p < .001), 4% in boys (ΔR^2 = .04; f^2 = 0.05; β = -.22, p < .05) and 7% in girls (ΔR^2 = .07; f^2 = 0.10; β = -.31, p < .01). EC was a significant moderator only in the full sample (β = -.16, p < .05) and in girls (β = -.30, p < .001), where the interactive term was a negative predictor of Depression scores. As can be seen, adding this interaction term added a relatively small percentage of explained variance in the total sample analysis (ΔR^2 = .02; f^2 = 0.03), and when only girls were included (ΔR^2 = .08; f^2 = 0.13).

We probed the interaction for the full sample and the girls sub-sample using the same methodology presented before. The same pattern emerged in both cases: the NA–Depression slope was statistically significant at low levels of EC [full sample t(213) = 4.94, p < .001; girls t(111) = 5.00, p < .001], but not at medium [t(213) = 1.55, *ns*; t(111) = 0.42, *ns*] and high ones [t(213) = 0.85, *ns*; t(111) = 0.60, *ns*]. As Figures 3.3C and 3.3D indicate, NA significantly predicts Depression scores only when EC is low.

Table 3.11
Hierarchical multiple regression predicting Depression in the middle childhood sample, with NA as a main predictor, and EC as moderator.

	Total sample			Boys			Girls		
	B	SE B	β	B	SE B	β	B	SE B	B
Step 1	R^2 = .00			R^2 = .00			R^2 = .01		
Constant	3.95	1.64		4.89	2.37		3.11	2.22	
Gender	-0.13	0.43	-.02	-	-	-	-	-	-
Age	0.01	0.01	.04	0.00	0.02	.00	0.02	0.02	.07
Step 2	ΔR^2 = .15***			ΔR^2 = .09**			ΔR^2 = .21***		
Constant	3.17	1.52		4.21	2.29		2.05	2.00	
Gender	-0.34	0.40	-.05	-	-	-	-	-	-
Age	0.02	0.01	.08	0.01	0.02	.03	0.03	0.02	.12
NA	2.13	0.35	.39***	1.60	0.52	.30**	2.57	0.48	.46***
Step 3	ΔR^2 = .06***			ΔR^2 = .04*			ΔR^2 = .07**		
Constant	2.20	1.48		3.07	2.31		1.77	1.91	
Gender	0.02	0.39	.00	-	-	-	-	-	-
Age	0.03	0.01	.12	0.02	0.02	.08	0.03	0.02	.13
NA	1.56	0.37	.28***	1.31	0.53	.24*	1.70	0.52	.30**
EC	-2.08	0.50	-.28***	-1.58	0.72	-.22*	-2.47	0.73	-.31**
Step 4	ΔR^2 = .02*			ΔR^2 = .00			ΔR^2 = .08***		
Constant	2.11	1.47		2.98	2.34		0.86	1.82	
Gender	-0.04	0.39	-.01	-	-	-	-	-	-
Age	0.02	0.01	.11	0.02	0.02	.09	0.03	0.02	.15*
NA	1.57	0.36	.28***	1.30	0.53	.24*	1.65	0.49	.29**
EC	-2.45	0.52	-.33***	-1.53	0.74	-.21*	-3.22	0.71	-.41***
NA × EC	-1.96	0.76	-.16*	0.43	1.37	.03	-3.36	0.89	-.30***

**p < .05; **p < .01; ***p < .001*

Depression. A hierarchical regression analysis to determine the potential moderating role of EC on the NA–Depression link was carried out in the manner described above for Anxiety. The results are presented in Table 3.11. NA was a significant predictor of Depression symptoms in all samples (f^2 = 0.17 in the total sample; f^2 = 0.10 in boys; f^2 = 0.27 in girls). After accounting for the effects of sex, age and NA, EC was also a significant predictor of lower Depression scores, and it explained a small-to-moderate amount of variance: 6% in the full sample (ΔR^2 = .06; f^2 = 0.08; β = -.28, p < .001), 4% in boys (ΔR^2 = .04; f^2 = 0.05; β = -.22, p < .05) and 7% in girls (ΔR^2 = .07; f^2 = 0.10; β = -.31, p < .01). EC was a significant moderator only in the full sample (β = -.16, p < .05) and in girls (β = -.30, p < .001), where the interactive term was a negative predictor of Depression scores. As can be seen, adding this interaction term added a relatively small percentage of explained variance in the total sample analysis (ΔR^2 = .02; f^2 = 0.03), and when only girls were included (ΔR^2 = .08; f^2 = 0.13).

We probed the interaction for the full sample and the girls sub-sample using the same methodology presented before. The same pattern emerged in both cases: the NA–Depression slope was statistically significant at low levels of EC [full sample t(213) = 4.94, p < .001; girls *t*(111) = 5.00, $p < .001$], but not at medium [*t*(213) = 1.55, *ns*; *t*(111) = 0.42, *ns*] and high ones [*t*(213) = 0.85, *ns*; *t*(111) = 0.60, *ns*]. As Figures 3.3C and 3.3D indicate, NA significantly predicts Depression scores only when EC is low.

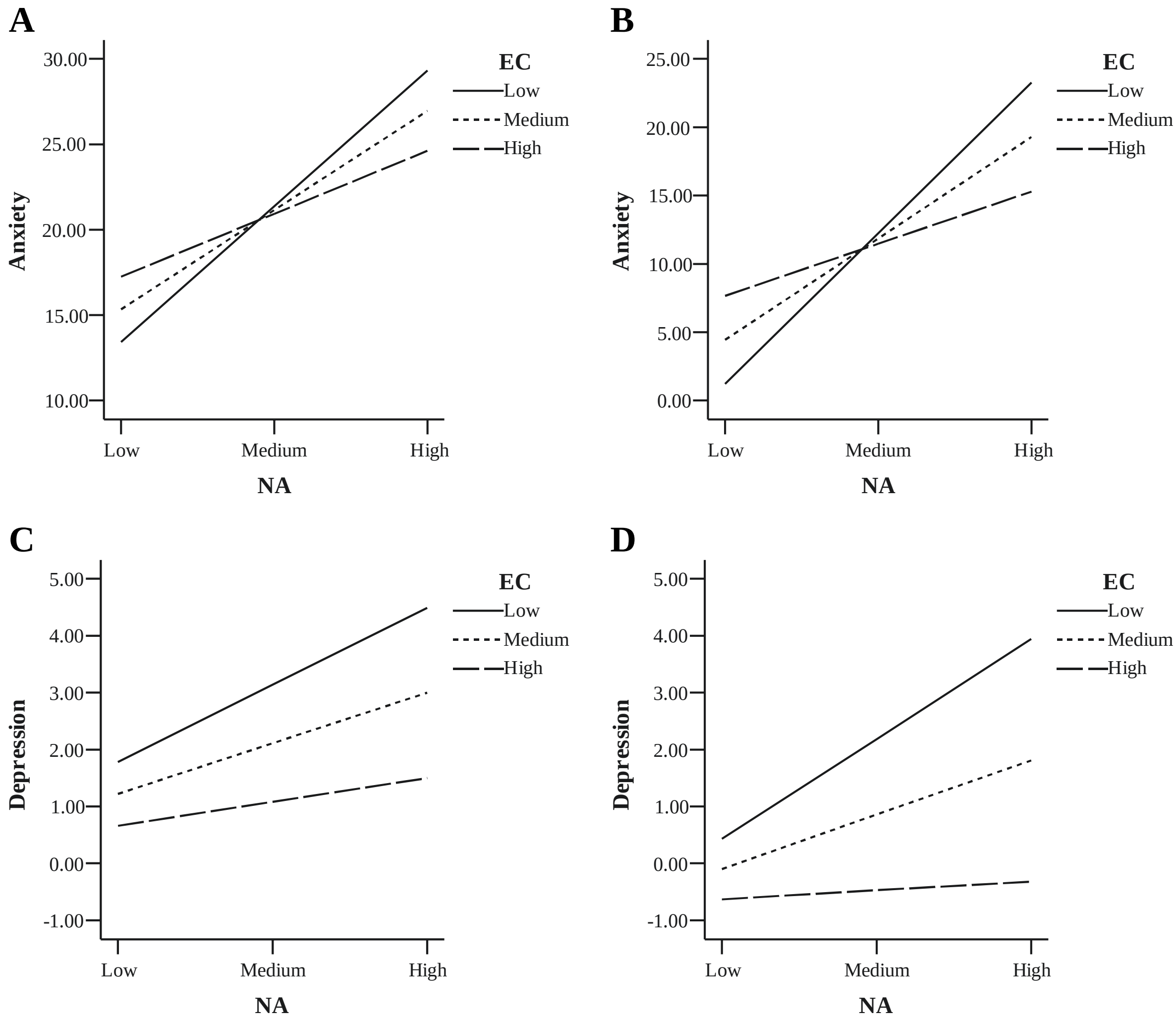

Figure 3.3. Interaction between NA and EC in middle childhood, with Anxiety (A, B) and Depression (C, D) as outcome variables. Anxiety in the total sample (A) and in girls (B); Depression in the total sample (C) and in girls (D).

3.2.2.5 Parent-report data: ER and anxiety/depression

In the parent-report data, there was no evidence for any link between ER strategies and Anxiety or Depression (see Tables 3.8 and 3.9). As a consequence, there was no evidence that ER strategies might mediate the relationship between NA and Anxiety or Depression.

We tested whether each ER strategy predicted or moderated the relationships between NA and Anxiety or Depression, respectively, through hierarchical regression analyses following the methodology described above. After accounting for the effect of NA, Distraction was a significant negative predictor of Depression in the case of girls: ($\Delta R^2 = .04$, $f^2 = 0.05$; $\beta = -.22$, $p < .05$). Support seeking was a significant independent predictor of Anxiety scores in the total sample ($\Delta R^2 = .02$, $f^2 = 0.03$; $\beta = .14$, $p < .05$) and in girls ($\Delta R^2 = .03$, $f^2 = 0.05$; $\beta = .18$, $p < .05$). All these effects were small. There was no evidence that any of the five ER strategies moderated the predictive effect of NA on Anxiety or Depression: for each analysis, adding the NA × ER interaction term contributed a small, non-significant amount to the explained variance: $\Delta R^2 = .00 – .02$, $f^2 < 0.03$; $|\beta| = .01 – .12$, *ns*.

3.2.2.6 Child-report data: ER and anxiety/depression

In the full sample, both Anxiety and Depression were associated with higher Avoidance: $r = .41$, $p < .01$ and $r = .42$, $p < .01$, respectively. This pattern was even stronger in the case of girls: $r = .68$, $p < .001$; $r = .62$, $p < .01$ for Anxiety and Depression, respectively (boys: $r = .22$, *ns* for Anxiety; $r = .28$, *ns* for Depression). No other statistically significant correlations were found in these two samples. In boys, there was a tendency for higher Anxiety scores to be associated with lower use of Distraction strategies ($r = -.35$, $p = .08$).

3.2.3 Discussion

The present study had essentially the same objectives and hypotheses as the previous study, with the exception that here – in addition to anxiety – we were also able to asses depression. This allowed us to determine whether the patterns of predictors we found for anxiety were specific, or whether they were also characteristic of depression. Additionally, due to the older age of children in this sample, we were able to collect self-report data from some of the 8- to 11-year-old children.

As in our previous study, preliminary analyses of the parent-report data found no gender differences in anxiety (or depression) symptoms. However, when we looked at the child self-report data, we did find higher anxiety and depression scores in girls. This discrepancy is in line with a report by Muris, Meesters, & Knoops (2005), who, in children aged 10-13 years, also found that gender differences were absent from parent-report data, but emerged when child self-reports were used. As pointed out by Muris (2007), such a discrepancy might be attributed to the fact that some anxiety symptoms that do not necessarily have overt behavioral manifestations (such as worry or somatic symptoms) are less accessible to parents. This interpretation is corroborated by the fact that – just like in Muris et al.'s (2005) study – we did find parent-reported gender differences in temperamental fear, a characteristic that has more overt, behavioral manifestations. Finally, as in the preschool study, girls were generally rated by parents as having better EC skills (compared to boys), thus replicating both our previous results, as well as findings from other studies (e.g., Eisenberg et al., 2005, 2003; McCabe et al., 2004; Olson et al., 2005). Age-related trends were relatively small and mostly unsurprising, showing reductions in temperamental fearfulness and the use of support-seeking strategies (the latter only in the child self-report data) on the one hand, as well as improvements in EC as children got older. We found no age-related changes in either parent- or child-reported anxiety, indicating that anxiety symptoms were relatively constant within this sample. This result is somewhat at odds with research reporting decreases in anxiety symptoms during middle childhood (e.g., Essau, Peter Muris, & Ederer, 2002; Muris, Merckelbach, Gadet, & Moulaert, 2000; Nauta et al., 2004; Spence, 1998). However, all these previous studies have used self-report measures, with much larger samples than the self-report sample in our study, and one study that included parent-assessed anxiety in middle childhood (Ebesutani et al., 2010) did not report whether they found any age-related changes in anxiety symptoms or not.

With respect to the relationship between EC and ER, results were generally similar to the ones found in preschoolers. Here the evidence supported the idea that good EC skills were linked to the development of adaptive ER strategies – especially active strategies (such as planning, practical problem-solving or cognitive restructuring). Distraction was related to EC especially in boys, while support seeking was linked to EC primarily in girls. While we are not aware of any previous research that might help us interpret this difference, it is possible that parents perceive distraction strategies as more socially acceptable in boys, and support-seeking strategies as more acceptable in girls, which might explain why they are differentially related to EC in the two genders.

Moving on to the main objectives of our study, we found – like in the case of preschoolers – that high NA predicted high anxiety scores (with moderate-to-strong effect sizes). The impact of NA was somewhat smaller in the case of depression. However, in this sample EC played a more important role than in the younger children, and its effect was largely in the expected direction, supporting the "interactive hypothesis" when anxiety was the outcome variable. More precisely, while EC was not a significant independent predictor of anxiety symptoms, it did moderate the impact of NA: children with medium or low levels of EC were prone to high anxiety symptoms if they had high NA scores, while children with high EC skills were "protected" from high anxiety even if they had high NA. This pattern was present in the full sample, but was most prominent in girls, and absent in boys. When we used depression as the outcome variable, the pattern of results was generally similar (including the gender-differentiated relationship pattern), with the exception that – along with the moderating effect of EC, there was also evidence to support the "additive hypothesis", as high EC predicted lower depression scores independent of the effect of NA. Thus, while only the interactive hypothesis was supported in the case of anxiety, the data supported both hypotheses when depression was used as an outcome variable. This indicates that there is a certain degree of specificity in the pattern of factors that predict anxiety, and that EC is potentially more important in reducing the risk for depression.

Previous similar studies have focused mostly on internalizing problems in general (e.g., Meesters, Muris, & Rooijen, 2006; Muris, 2006; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007), and have found evidence for both the additive and interactive hypotheses. Our results for anxiety are partially in line with these previous studies, in that we have found moderating effects of EC. However, we failed to identify evidence for an independent effect here. One of the reasons for this discrepancy might reside in the fact that while these previous studies have used child self-report measures to assess EC, we were constrained – primarily by the younger age of the children in our sample – to use parent-report measures. Another possible explanation for the discrepancy is related to potential cultural differences in EC between our sample and the ones (mostly Dutch) included in previous studies. However, the most likely explanation resides in the fact that while previous studies have combined anxiety and depression into an internalizing score, we chose to treat the two separately. An indication that this is probably the correct explanation comes from the fact that when we used depression as the outcome, we also found evidence for an independent, unique role of EC. Our results therefore emphasize the need to treat anxiety and depression as separate entities in future studies involving children.

Another point of departure between our results and those of previous research is the gender-differentiated pattern of relationships between NA, EC and anxiety/depression. None of the previous studies investigating these relationships reported gender-differentiated analyses, and thus we have no way of knowing whether similar patterns might have emerged in those samples. It is possible that the pattern we have found is largely due to the generally higher EC reported in girls, but more studies are needed to clarify this. However, these results indicate the potential value of gender-separate analyses, especially since anxiety and depression show different intensities/prevalence between men and women in adulthood (American Psychiatric Association, 2000; Hettema, Prescott, Myers, Neale, & Kendler, 2005; Kendler et al., 1995).

When investigating ER strategies related to anxiety and depression, we found no evidence for any links in the parent-report data, and the mediation and moderation analyses returned null results as well. However, when we looked at the child self-report sample, results were generally in line with previous research: children with higher anxiety and depression scores used avoidant ER strategies more frequently (and this was true especially in the case of girls), while boys with higher anxiety had a tendency to use distraction to a lesser degree. Overall, results from the self-report sample are congruent with previous data showing increased use of passive ER strategies such as avoidance in anxious children (Carthy et al., 2010; Bruce E. Compas et al., 2001).

To conclude, in the present study we investigated the roles of temperamental NA and EC, as well as ER strategies in predicting anxiety symptoms in middle childhood, and we were also interested to determine whether the pattern of predictors for anxiety would be different from the pattern of factors that would predict higher depression scores. We found evidence that high EC acted as a protective factor (especially in girls), limiting the role of NA as a risk factor for anxiety or depression. However, EC was also an independent negative predictor only in the case of depression. Links between ER and anxiety/depression were found only when child self-report data was used. Apart from these findings, our results also serve to highlight the importance of treating anxiety and depression as separate outcome entities, and the relevance of gender-differentiated analyses.

3.3 Study 1C: Predictors of anxiety in young adults

3.3.1 Method

3.3.1.1 Participants and procedure

Participants for this study were recruited from among the undergraduate students enrolled in the Psychology program at the Babeş-Bolyai University (BBU) in Cluj-Napoca. They were informed about the study through an announcement sent to their internet groups, and received course credit for participation. The study took place at the Developmental Psychology Lab in the Psychology Department of the BBU. Each participant was given a set of questionnaires to fill in individually (we only report on four of these questionnaires here – see description below). For each person, completion of the questionnaires lasted 1 hour at most.

The final sample was composed of 175 undergraduate students (152 females), aged 19-39 years (M = 21.77, SD = 4.17). It should be noted that due to the source of our participant pool and the nature of the selection process, the majority of our participants (i.e., N = 153) were below 25 years of age.

3.3.1.2 Measures

Anxiety and depression

Trait anxiety was assessed using the Romanian version of the *State Trait Anxiety Inventory* (STAI; Spielberger, 1983; see Pitariu & Peleasa, 2007 for the Romanian version; α = .81) and depression was assessed using the *Beck Depression Inventory* (BDI; Beck, Steer, & Carbin, 1988; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; α = .83). BDI was only applied to 90 participants.

Temperament

Participants completed Romanian version of the *Adult Temperament Questionnaire* (ATQ; Derryberry & Rothbart, 1988; Evans & Rothbart, 2007) a 177-item self-report instrument designed to measure 13 temperament dimensions, grouped into four higher-order dimensions reflecting aspects of behavioral/emotional reactivity and self-regulation (see Table 2.1, in Chapter 2, for item examples). The questionnaire asks participants to rate themselves on a seven-point scale where 1 = *extremely untrue of you* to 7 = *extremely true of you*, and offers them an additional response option – "not applicable" – for items which do not apply to them. Scale and factor scores are obtained by computing the average score for items belonging to that scale or factor. From the full questionnaire, we selected the NA (α = .90) sub-scales for Fearfulness (11 items; α = .83), Sadness (14 items; α = .85) and Anger/Frustration (13 items; α = .75), and the EC (α = .90) sub-scales of Attentional control (12 items; α = .86), Inhibitory control (11 items; α = .64) and Activation control (12 items; α = .86).

Emotion regulation

Participants completed the Romanian version of the *Cognitive Emotion Regulation Questionnaire* (CERQ; Garnefski, Legerstee, Kraaij, van den Kommer, & Teerds, 2002; Perţa et al., in preparation), a 36-item self-report questionnaire assessing nine cognitive ER strategies: Self-blame (α = .75[7]; e.g., "I feel that I am the one who is responsible for what has happened"), Acceptance (α = .66; e.g., "I think that I must learn to live with it"), Rumination (α = .79; e.g., "I want to understand why I feel the way I do about what I have experienced"), Positive Refocusing (α = .90; e.g., "I think of something nice instead of what has happened"), Refocus on Planning (α = .84; e.g., "I think about how to change the situation"), Positive Reappraisal (α = .85; e.g., "I think I can learn something from the situation"), Putting into Perspective (α = .84; e.g., "I think that it all could have been much worse"), Catastrophizing (α = .81; e.g., "I keep thinking about how terrible it is what I have experienced") and Other-blame (α = .80; e.g., "I feel that others are responsible for what has happened"). The CERQ contains 4 items for each ER strategy. Respondents are asked to rate the extent to which they use the different types of cognitive ER strategies on a five-point scale, where 1 means *(almost) never* and 5 means *(almost) always*. The score for each strategy is obtained by summing up the scores of the corresponding items. Garnefski and collaborators have reported good reliability and validity indices for the original (Dutch) version of the scale (see Garnefski & Kraaij, 2007; Garnefski et al., 2002). As can be seen, indices for the Romanian version used here were

[7] Indices for the current sample.

generally good or very goo, with the exception of the Acceptance scale, which showed only acceptable reliability.

In order to simplify some of the analyses, we were interested to reduce the number of ER strategies. An informal inspection of the strategies indicates that some of them tend to be adaptive / positive strategies, while others are rather maladaptive / negative strategies (see Tortella-Feliu, Balle, & Sesé, 2010 for a recent, similar approach). However, Acceptance is more difficult to place in one of these two categories, as it might be adaptive in some contexts and non-adaptive in others (see Garnefski, Kraaij, & Spinhoven, 2001). We therefore chose to take an empirical approach, similar to the one taken in the preschool study. We conducted a principal components analysis with Varimax rotation across the nine ER strategies (the Keiser-Meyer-Olkin measure of sampling adequacy was .67, while Bartlett's test of sphericity resulted in a $\chi^2 = 314.74$, $p < .001$, indicating the adequacy of factor analysis for this data). The analysis indicated a three-factor solution, accounting for 61.91% of the total variance. The first factor (27.58%) reunited the strategies of Positive Reappraisal (loading = .84), Putting into Perspective (.73), Refocus on Planning (.70) and Positive Refocusing (.59), indicating the plausibility of an adaptive / positive ER factor. The second (21.72%) and third (12.61%) factors loaded highly on the strategies Other-blame (.86), Catastrophizing (.75) on the one hand, and Self-blame (.84) and Rumination (.73) on the other hand. We decided to group these strategies onto one single factor, reflecting maladaptive / negative ER strategies. As expected, Acceptance included loadings of two factors: the first (positive regulation; .50) and second (the one comprising Other-blame and Catastrophizing; .42). Although the loadings were slightly different, we decided not to include Acceptance in any of the higher-order factors, because its loadings were lower than in the case of the other ER strategies. Thus, we ended up with two ER factors: *Adaptive ER* strategies ($\alpha = .89$; Positive Reappraisal, Putting into Perspective, Refocus on Planning and Positive Refocusing) and *Maladaptive ER* strategies ($\alpha = .82$; Other-blame, Catastrophizing, Self-blame and Rumination). The two factors were computed by summing the scores of their underlying dimensions. We used these higher-order factors in the more complex analyses, but we included the individual strategies in the simpler analyses.

3.3.1.3 Missing data

BDI was applied only in the case of 90 participants (therefore Depression scores were present only for these participants). ER data was missing for 7 participants.

3.3.2 Results

Due to the small number of males in our study, the more complex analyses (i.e., moderation and mediation) are presented only for the full and female sample.

3.3.2.1 Preliminary analyses: gender and age

Depression scores showed a significant departure from normality (Kolmogorov-Smirnov statistic = .14, $p < .001$), due to a positive skew in the data (i.e., very few participants had high scores on the BDI). We therefore used a square-root transformation on Depression scores. This approach was effective in normalizing the distribution (Kolmogorov-Smirnov statistic = .07, $p > .20$). However, there are some controversies regarding data transformations (for example, some authors have suggested that these normalizations can result in fundamentally different constructs; see Field, 2009 for details). We therefore decided to include both the original and the normalized data in some of the analyses.

Levene's test for equality of variances indicated that variance was equal between the male and female group for all variables of interest (all *F*s ≥ 3.00, $p > .05$), which meant that despite the extremely unequal samples, the two groups could be safely compared. Unlike in the children samples included in the previous two studies, the independent-samples *t*-test indicated several significant differences between males and females. These, as well as the corresponding descriptive statistics, can be found in Table 3.12. As this data indicates, women had higher scores for Anxiety, Depression, NA and all of its sub-dimensions. On the other hand, men had higher scores for EC, Attentional and Inhibitory control, but not Activation control, where the groups were relatively equal. Lastly, we found no statistically significant differences between males and females in any ER strategy.

Table 3.12
Descriptive statistics for study variables for the total adult sample, and separated by gender

	Total sample M (SD)	**Males** M (SD)	**Females** M (SD)	**df**	**t-test**
Anxiety (STAI-Trait)	43.61 (7.72)	39.39 (8.82)	44.25 (7.36)	173	-2.87**
Depression (BDI)	7.41 (6.25)	4.23 (4.71)	7.95 (6.34)	88	-2.02*
Depression normalized (BDI)	2.42 (1.26)	1.67 (1.26)	2.55 (1.22)	88	-2.39*
Temperament (ATQ)					
Negative Affect (NA)	4.02 (0.75)	3.30 (0.67)	4.13 (0.71)	173	-5.27***
Fear	4.16 (0.98)	3.21 (0.88)	4.30 (0.92)	173	-5.33***
Sadness	4.15 (0.98)	3.36 (0.83)	4.27 (0.94)	173	-4.39***
Anger/Frustration	3.75 (0.79)	3.34 (0.84)	3.82 (0.77)	173	-2.76**
Effortful Control (EC)	4.26 (0.72)	4.72 (0.64)	4.20 (0.70)	173	3.35**
Attentional control	4.01 (0.93)	4.71 (0.86)	3.90 (0.90)	173	4.03***
Inhibitory control	4.30 (0.70)	4.69 (0.70)	4.24 (0.68)	173	2.93**
Activation control	4.49 (0.99)	4.75 (0.95)	4.45 (1.00)	173	1.40
Emotion regulation (CERQ)					
Adaptive ER	52.64 (10.88)	52.32 (11.45)	52.69 (10.83)	166	-0.15
Positive Refocusing	9.77 (3.83)	9.82 (3.28)	9.76 (3.92)	166	0.07
Refocus on Planning	15.26 (3.30)	16.27 (3.45)	15.11 (3.26)	166	1.55
Positive Reappraisal	14.54 (3.77)	14.23 (3.77)	14.58 (3.78)	166	-0.41
Putting into Perspective	13.08 (3.89)	12.00 (4.16)	13.24 (3.83)	166	-1.40
Maladaptive ER	39.08 (7.85)	37.36 (8.31)	39.34 (7.77)	166	-1.10
Self-blame	10.71 (2.67)	10.50 (3.22)	10.75 (2.59)	166	-0.40
Rumination	13.06 (3.56)	12.14 (3.83)	13.20 (3.51)	166	-1.31
Catastrophizing	7.30 (3.12)	6.64 (2.30)	7.40 (3.22)	166	-1.07
Other-blame	8.01 (2.30)	8.09 (2.24)	7.99 (2.32)	166	0.19
Acceptance	12.40 (2.90)	12.05 (2.66)	12.46 (2.93)	166	-0.62

**p < .05; **p < .01; ***p < .001*

Due to the non-normal distribution of participants' age in our sample, we carried out nonparametric correlations (Spearman's ρ) between age and all variables of interest. Anxiety and Depression did not vary with age (ρ = .09, *ns* and ρ = -.15, *ns*). Age increase was associated with small decreases in NA and all its sub-dimensions (values between ρ = -.17, $p <$ .05 for Sadness and ρ = -.25, $p < .01$ for NA and Anger/Frustration), and small increases in EC, Attentional control and Inhibitory control (values between ρ = .17, $p < .05$ for Attentional control and ρ = .20, $p < .01$ for Inhibitory control). Adaptive ER did not vary as a function of age (ρ = -.08, *ns*), while Maladaptive ER showed a slight decrease as participants got older (ρ = -.18, $p < .05$); this latter pattern was replicated in the case of Rumination (ρ = -.28, $p < .001$). The rest of the ER strategies did not correlate with age.

3.3.2.2 EC and ER

As the data presented in Tables 3.13 and 3.14 indicates, with the exception of Inhibitory control (which was generally not related to ER), EC and its sub-dimensions were positively correlated with Adaptive ER and negatively related to Maladaptive ER. This pattern was present in the full sample (Table 3.13), as well as the female sub-sample (Table 3.14), across all ER strategies (with the exception of Putting into Perspective and Acceptance). Acceptance was generally unrelated to EC (with the exception of a small negative correlation with Activation control in the full sample: r = -.16, $p < .05$).

No statistically significant correlations were found between Adaptive ER and its underlying strategies and EC in men ($|r|$ = .03 – .35, *ns*), partially due to the small sample size (N = 22). Maladaptive ER was negatively related to Attentional control in this sub-sample (r = -.48, $p < .05$). Catastrophizing was linked to EC and its sub-dimensions (except Inhibitory control): r = -.48 – -.61, $p < .05$. The rest of the Maladaptive strategies were unrelated to EC and its sub-dimensions in men: $|r|$ = .02 – .30, *ns*.

3.3.2.3 Temperamental predictors of anxiety (and depression)

High NA scores were related to both high Anxiety scores (r = .42, $p < .001$ for the full sample; r = .37, $p < .001$ for women), as well as high Depression scores (r = .51, $p < .001$ for the full sample; r = .46, $p < .001$ for women). This was true especially for Fearfulness and Sadness, whereas Anger/Frustration was related only weakly to Anxiety or Depression in the full sample, or not an all in the case of women (see Tables 3.13 and 3.14 for details). In the male sample, correlations were in the expected direction: there was evidence that NA was related to Anxiety, although the correlation did not reach statistical significance (ρ = .37, p = .08); the NA–Depression correlation was not statistically significant (ρ = .41, p = .08), due to the small sample size (N = 13)[8]. Stronger, significant correlations were found between Fear and Anxiety (ρ = .51, $p < .05$), and Sadness and Depression, respectively (ρ = .64, $p < .05$).

Both Anxiety and Depression were moderately related to EC (r = -.34, $p < .001$ and r = -.33, $p < .01$, respectively). These correlations were somewhat weaker in the female sample, but still statistically significant (r = -.28, $p < .001$ and r = -.24, $p < .05$ for Anxiety and Depression, respectively). In general, EC sub-dimensions also followed this general pattern, with the exception of Inhibitory control, which was generally unrelated to either Anxiety, or Depression (see Tables 3.13 and 3.14). This general pattern was also present in the male sample (ρ = -.44, $p < .05$ for EC–Anxiety; ρ = -.48, p = .09 for EC–Depression), and it was stronger in relation to Attentional control (ρ = -.52, $p < .05$ for Anxiety; ρ = -.53; p = .06 for Depression).

[8] Due to the small number of cases who had Depression data, we chose to use non-parametric, Spearman's rho correlations here.

Table 3.13
Correlations between all study variables for the adult sample.

	(1)	(2)	(2')	(3)	(3a)	(3b)	(3c)	(4)	(4a)	(4b)	(4c)
(1) Anxiety	-										
(2) Depression	.67***	-									
(2') Depression normalized	.65***										
Temperament											
(3) Negative Affect	.42***	.48***	.51***	-							
(3a) Fearfulness	.44***	.38***	.41***	.90***	-						
(3b) Sadness	.38***	.48***	.51***	.87***	.74***	-					
(3c) Anger/Frustration	.17*	.26*	.28**	.67***	.40***	.33***	-				
(4) Effortful Control	-.34***	-.32**	-.33**	-.57***	-.50***	-.48***	-.42***	-			
(4a) Attentional control	-.34***	-.35**	-.38***	-.62***	-.59***	-.57***	-.35***	.85***	-		
(4b) Inhibitory control	-.17*	-.09	-.08	-.41***	-.29***	-.24**	-.52***	.70***	.41***	-	
(4c) Activation control	-.30***	-.31**	-.31**	-.36***	-.33***	-.33***	-.22**	.87***	.61***	.43***	-
Emotion regulation											
(5) Adaptive ER	-.18*	-.29**	-.19	-.21**	-.19*	-.26**	-.06	.27***	.24**	.09	.30***
(5a) Positive Refocusing	-.12	-.25*	-.15	-.23**	-.18*	-.23**	-.15*	.19*	.19*	.07	.18*
(5b) Refocus on Planning	-.16*	-.29**	-.20	-.20*	-.18*	-.18*	-.12	.26**	.17*	.18*	.28***
(5c) Positive Reappraisal	-.14	-.24*	-.17	-.18*	-.15*	-.24**	-.04	.32***	.26**	.13	.35***
(5d) Putting into Perspective	-.11	-.11	-.05	-.03	-.04	-.12	.12	.06	.08	-.09	.10
(6) Maladaptive ER	.25**	.43***	.46***	.53***	.47***	.49***	.34***	-.35***	-.41***	-.12	-.30***
(6a) Self-blame	.12	.24*	.26*	.29***	.29***	.30***	.12	-.16*	-.20*	-.01	-.16*
(6b) Rumination	.16*	.26*	.29**	.36***	.34***	.34***	.20*	-.18*	-.23**	-.02	-.17*
(6c) Catastrophizing	.30***	.40***	.40***	.50***	.45***	.43***	.35***	-.37***	-.45***	-.16*	-.28***
(6d) Other-blame	.06	.22*	.25*	.24**	.12	.23**	.25**	-.23**	-.21**	-.14	-.20*
(7) Acceptance	.05	.04	.04	.07	.09	.05	.03	-.10	-.06	-.02	-.16*

Note: Due to space limitations, correlations between ER strategies were omitted from this table.
**p < .05; **p < .01; ***p < .001*

Table 3.14
Correlations between study variables for females in the adult sample.

	(1)	(2)	(2')	(3)	(3a)	(3b)	(3c)	(4)	(4a)	(4b)	(4c)
(1) Anxiety	-										
(2) Depression	.67***	-									
(2') Depression normalized	.63***										
Temperament											
(3) Negative Affect	.37***	.46***	.46***	-							
(3a) Fearfulness	.39***	.33**	.34**	.89***	-						
(3b) Sadness	.36***	.45***	.46***	.86***	.74***	-					
(3c) Anger/Frustration	.12	.24*	.22	.64***	.36***	.27**	-				
(4) Effortful Control	-.28***	-.26*	-.24*	-.57***	-.46***	-.49***	-.41***	-			
(4a) Attentional control	-.27**	-.28*	-.29*	-.62***	-.54***	-.58***	-.33***	.84***	-		
(4b) Inhibitory control	-.11	-.05	.01	-.37***	-.25**	-.21*	-.47***	.70***	.40***	-	
(4c) Activation control	-.27**	-.27*	-.26*	-.39***	-.32***	-.38***	-.24**	.88***	.61***	.45***	-
Emotion regulation											
(5) Adaptive ER	-.23**	-.45***	-.37**	-.32***	-.24**	-.35***	-.16*	.33***	.31***	.14	.33***
(5a) Positive Refocusing	-.13	-.35**	-.29*	-.28**	-.18*	-.26**	-.22**	.21*	.21*	.11	.18*
(5b) Refocus on Planning	-.19*	-.37**	-.28*	-.24**	-.20*	-.22**	-.15	.28**	.21*	.17*	.29***
(5c) Positive Reappraisal	-.19*	-.36**	-.32**	-.28**	-.21*	-.32***	-.12	.38***	.34***	.18*	.37***
(5d) Putting into Perspective	-.16	-.23	-.20	-.15	-.13	-.22**	.02	.12	.15	-.02	.14
(6) Maladaptive ER	.23**	.37**	.38**	.54***	.47***	.48***	.34***	-.36***	-.40***	-.13	-.31***
(6a) Self-blame	.08	.19	.21	.25**	.27**	.25**	.08	-.19*	-.18*	-.02	-.21*
(6b) Rumination	.11	.15	.16	.34***	.32***	.31***	.17*	-.17*	-.19*	-.02	-.17*
(6c) Catastrophizing	.30***	.38**	.36**	.53***	.46***	.44***	.36***	-.35***	-.43***	-.15	-.25**
(6d) Other-blame	.10	.22	.26*	.27**	.15	.25**	.27**	-.24**	-.24**	-.16	-.19*
(7) Acceptance	-.01	-.03	-.06	.03	.03	.03	.01	-.08	-.01	-.03	-.14

Note: Due to space limitations, correlations between ER strategies were omitted from this table.
**p < .05; **p < .01; ***p < .001*

Like in the previous two studies, we were next interested to test the additive and interactive hypotheses. As before, there were no reasons for concern regarding multicollinearity between NA and EC: Tolerance ≈ .90 and VIF < 2.

Hierarchical regression analyses were carried out exactly as described in the previous two studies. Each analysis was conducted both at the level of the entire sample, as well as for the female sample.

Table 3.15

Hierarchical multiple regression predicting Anxiety symptoms in the adult sample, with NA as a main predictor and EC as a moderator.

	Total sample			**Females**		
	B	SE B	β	B	SE B	β
Step 1	R^2 = .08**			R^2 = .02		
Constant	47.05	3.62		50.56	3.28	
Gender	4.16	1.70	.18*	-	-	-
Age	-0.32	0.14	-.17*	-0.29	0.15	-.16
Step 2	ΔR^2 = .12***			ΔR^2 = .13***		
Constant	47.51	3.39		48.60	3.10	
Gender	1.20	1.70	.05	-	-	-
Age	-0.23	0.13	-.12	-0.20	0.14	-.11
NA	3.84	0.77	.37***	3.73	0.79	.36***
Step 3	ΔR^2 = .01			ΔR^2 = .01		
Constant	47.23	3.38		48.36	3.11	
Gender	1.09	1.69	.05	-	-	-
Age	-0.21	0.13	-.11	-0.19	0.14	-.10
NA	3.06	0.89	.30**	3.19	0.96	.31**
EC	-1.49	0.90	-.14	-0.97	0.96	-.09
Step 4	ΔR^2 = .01			ΔR^2 = .00		
Constant	47.95	3.40		48.73	3.17	
Gender	0.91	1.69	.04	-	-	-
Age	-0.22	0.13	-.12	-0.20	0.14	-.11
NA	3.02	0.89	.30**	3.19	0.96	.31**
EC	-1.52	0.90	-.14	-0.95	0.96	-.09
NA × EC	1.22	0.83	.10	0.62	1.00	.05

**p* < .05; ***p* < .01; ****p* < .001

Anxiety. Results of the hierarchical regression analysis with Anxiety as a criterion variable are presented in Table 3.15. As can be seen, the full model explains 22% of the variance in anxiety scores (R^2 = .22; f^2 = 0.28) when the entire sample is included in the analysis and 16% in the female sample (R^2 = .16; f^2 = 0.19). NA was a significant predictor of Anxiety, with a moderate effect (f^2 = 0.15 in both samples). EC was not a significant independent predictor of Anxiety scores in the full sample (ΔR^2 = .01; f^2 = 0.01; β = -.14, *ns*) or in females (ΔR^2 = .01; f^2 = 0.01; β = -.09, *ns*). There was also no evidence for a moderating role of EC: adding the interaction term to the model did not increase the amount of predicted variance almost at all (ΔR^2 = .01; f^2 = 0.01; β = .10, *ns* for the full sample; ΔR^2 = .01; f^2 = 0.01; β = .05, *ns* for the female sample).

Table 3.16
Hierarchical multiple regression predicting Depression symptoms in the adult sample, with NA as a main predictor and EC as a moderator.

	Total sample			Females		
	B	SE B	β	B	SE B	β
Step 1	R^2 = .07*			R^2 = .01		
Constant	2.15	0.73		2.99	0.64	
Gender	0.82	0.38	.23*	-	-	-
Age	-0.02	0.03	-.08	-0.02	0.03	-.08
Step 2	ΔR^2 = .20***			ΔR^2 = .20***		
Constant	2.72	0.66		2.76	0.57	
Gender	-0.07	0.38	-.02	-	-	-
Age	-0.01	0.02	-.04	-0.01	0.03	-.04
NA	0.94	0.20	.52***	0.90	0.21	.45***
Step 3	ΔR^2 = .00			ΔR^2 = .00		
Constant	2.71	0.67		2.78	0.59	
Gender	-0.07	0.39	-.02	-	-	-
Age	-0.01	0.02	-.04	-0.01	0.03	-.04
NA	0.93	0.24	.51***	0.93	0.25	.47***
EC	-0.02	0.20	-.01	0.05	0.22	.03
Step 4	ΔR^2 = .00			ΔR^2 = .01		
Constant	2.69	0.72		2.61	0.62	
Gender	-0.06	0.40	-.02	-	-	-
Age	-0.01	0.02	-.04	-0.01	0.03	-.02
NA	0.93	0.24	.51***	0.94	0.25	.47***
EC	-0.02	0.21	-.01	0.02	0.22	.01
NA × EC	-0.02	0.20	-.01	-0.23	0.25	-.10

**p < .05; **p < .01; ***p < .001*

Depression. A hierarchical regression analysis to determine the potential moderating role of EC on the NA–Depression[9] link was carried out in the manner described above for Anxiety. The results are presented in Table 3.16. The full model explains 27% of the variance in Depression scores (R^2 = .27; f^2 = 0.37) when the entire sample is included in the analysis, and 22% in the female sample (R^2 = .22; f^2 = 0.28). As can be seen, as usually, NA was a significant predictor of Depression symptoms in both samples (f^2 = 0.27 in the total sample, f^2 = 0.25 in the female sample). However, as in the case of Anxiety, in itself EC failed to significantly predict Depression (ΔR^2 = .00; f^2 = 0; β = -.01, *ns* for the total sample; ΔR^2 = .00; f^2 = 0; β = -.03, *ns* for females). Similarly, there was no evidence that EC moderated the link between NA and Depression (ΔR^2 = .00; f^2 = 0; β = -.01, *ns* for the total sample; ΔR^2 = .01; f^2 = 0.01; β = -.10, *ns* for females).

[9] Here we used the normalized Depression scores as the criterion variable.

The pattern of results found here, namely the presence of significant correlations between EC and Anxiety/Depression, and their disappearance in the presence of NA, indicates the possibility that, within this developmental sample, NA might *mediate* the link between EC and Anxiety or Depression. We therefore carried out a mediation analysis[10]. As in the preschool sample, we conducted the analysis according to the classic steps put forward by Baron and Kenny (1986) and then tested the statistical significance of the indirect effect using the Sobel test. Results of the three steps of the mediation analysis are presented in Table 3.17. In each case, we first controlled for the contribution of gender and age. As the table shows, the data indicates that NA mediates the relationship between EC and Anxiety, as well as Depression. Namely, the relationship between EC and Anxiety (or Depression) disappears when we add NA to the regression equation (third step), and the Sobel test confirms that the reduction in the effect is significant.

Table 3.17
Results for the three steps testing the mediation of the relationship between EC and Anxiety/Depression by NA in the adult sample.

Step	**Total sample**			**Females**		
	B	SE B	β	B	SE B	β
DV: Anxiety						
(1) EC → Anx.	-3.11	0.79	-.29***	-2.76	0.82	-.26**
(2) EC → NA	-0.53	0.07	-.50***	-0.56	0.07	-.56***
(3) EC → (NA) → Anx.	R^2 = .21; p < .001			R^2 = .16; p < .001		
EC → Anx.	-1.49	0.90	-.14	-0.97	0.96	-.09
NA → Anx.	3.06	0.89	.30**	3.19	0.96	.31**
Sobel test	-3.14; *SE* = 0.51; *p* < .01			-3.07; *SE* = 0.58; *p* < .01		
DV: Depression						
(1) EC → Depr.	-0.47	0.18	-.27*	-0.40	0.20	-.23*
(2) EC → NA	-0.48	0.08	-.51***	-0.48	0.08	-.56***
(3) EC → (NA) → Depr.	R^2 = .26; p < .001			R^2 = .21; p < .001		
EC → Depr.	-0.02	0.20	-.01	0.05	0.21	.03
NA → Depr.	0.93	0.24	.51***	0.94	0.25	.47***
Sobel test	-3.25; *SE* = 0.14; *p* < .01			-3.19; *SE* = 0.14; *p* < .01		

Note: Anx. = Anxiety; Depr. = Depression
**p < .05; **p < .01; ***p < .001*

3.3.2.4 ER and anxiety

Mediation. We only tested Maladaptive ER as a potential mediator of the NA–Anxiety or NA–Depression links. As the data included in Table 3.18 indicates, while Maladaptive ER did not mediate the relationship between NA and Anxiety, it was a partial mediator of the NA–Depression relationship in the full sample (however, since the slope of the NA–Depression

[10] Note that this was a *post-hoc* analysis, not one guided by our hypotheses.

relationship shows no indication of change, this partial mediation effect is probably very small[11]).

Table 3.18
Results for the three steps testing the mediation of the relationship between NA and Anxiety/Depression by Maladaptive ER in the adult sample.

Step	Total sample			Females		
	B	SE B	β	B	SE B	β
DV: Anxiety						
(1) NA → Anx.	4.02	0.79	.39***	3.94	0.82	.37***
(2) NA → MER	6.03	0.74	.58***	5.93	0.79	.54***
(3) NA → (MER) → Anx.	R^2 = .19; p < .001			R^2 = .15; p < .001		
NA → Anx.	3.81	0.94	.37***	3.74	0.97	.36***
MER → Anx.	0.04	0.08	.04	0.03	0.09	.03
Sobel test	0.50; *SE* = 0.48; *p* = .62			0.33; *SE* = 0.53; *p* = .54		
DV: Depression						
(1) NA → Depr.	0.92	0.20	.51***	0.88	0.22	.44***
(2) NA → MER	4.59	1.15	.46***	4.49	1.18	.41***
(3) NA → (MER) → Depr.	R^2 = .32; p < .001			R^2 = .24; p < .001		
NA → Depr.	0.67	0.21	.37**	0.69	0.23	.35**
MER → Depr.	0.05	0.02	.30**	0.04	0.02	.23
Sobel test	2.12; *SE* = 0.11; *p* < .05			1.77; *SE* = 0.10; *p* = .08		

Note: Anx. = Anxiety; Depr. = Depression; MER = Maladaptive ER
**p < .05; **p < .01; ***p < .001*

As in the case of EC, the pattern of correlations pointed to the possibility that NA mediates the relationship between Maladaptive ER and Anxiety or Depression. With Anxiety as an outcome variable, the mediation analysis showed that the effect of Maladaptive ER upon Anxiety dropped significantly (Sobel statistic = 3.40, *SE* = 0.06, $p < .001$) from $\beta = .25$, $p < .01$ to $\beta = .03$, *ns* when we controlled for the effect of NA (results were almost identical in the female sample). With Depression (normalized) scores as the dependent variable, we only found a partial mediation effect (Sobel statistic = 2.75, *SE* = 0.01, $p < .01$): when controlling for the effect of NA, the effect of Maladaptive ER upon Depression dropped from $\beta = .46$, $p < .001$ to $\beta = .30$, $p < .01$.

Moderation. We carried out hierarchical regression analyses to test both Adaptive ER and Maladaptive ER as potential moderators. Results are presented in Table 3.19 (note that the two potential moderators were tested in *separate* analyses). As the data indicates, the two types of ER strategies did not moderate the NA–Anxiety relationship. However, Adaptive ER was a significant moderator for the NA–Depression link ($f^2 = 0.09$). Probing this relationship indicated that NA predicted Depression at low [$t(80) = 6.27$, $p < .001$], medium [$t(80) = 4.08$, $p < .001$], but not high levels [$t(80) = 1.90$, $p = .06$] of Adaptive ER.

[11] We are not aware of any measures of effect size for Sobel tests.

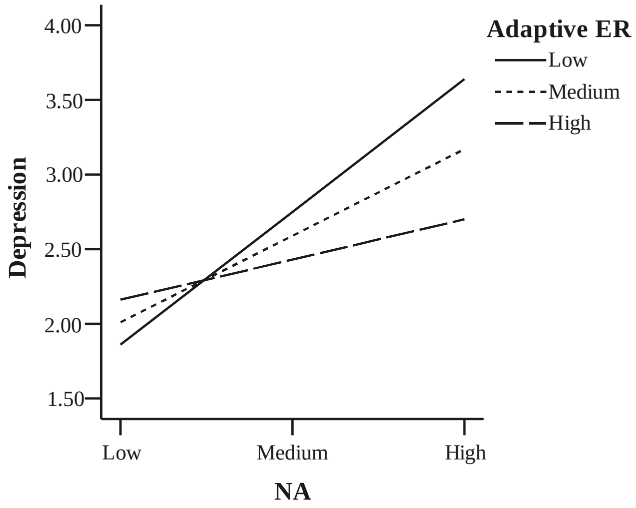

Figure 3.4. Interaction between NA and Adaptive ER in predicting Depression in the adult sample.

Table 3.19
Hierarchical multiple regression predicting Anxiety / Depression symptoms in the adult sample, with NA as a main predictor and Adaptive or Maladaptive ER as a moderator.

	Criterion: Anxiety						Criterion: Depression					
	Total			Females			Total			Females		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1	R^2 = .07*			R^2 = .02			R^2 = .06*			R^2 = .01		
Constant	47.07	4.09		50.18	3.84		2.25	0.85		3.09	0.76	
Gender	4.04	1.77	.18*	-	-	-	0.80	0.41	.22	-	-	-
Age	-0.32	0.16	-.15*	-0.27	0.18	-.13	-0.02	0.03	-.08	-0.02	0.03	-.08
Step 2	ΔR^2 = .13***			ΔR^2 = .14***			ΔR^2 = .19***			ΔR^2 = .19***		
NA	4.02	0.79	.39***	3.94	0.82	.37***	0.92	0.20	.51***	0.88	0.22	.44***
Step 3	ΔR^2 = .01			ΔR^2 = .01			ΔR^2 = .01			ΔR^2 = .06*		
	ΔR^2 = .00			ΔR^2 = .00			ΔR^2 = .07**			ΔR^2 = .04		
Adaptive ER	-0.08	0.05	-.11	-0.08	0.06	-.12	-0.01	0.01	-.10	-0.03	0.01	-.26*
Maladaptive ER	0.04	0.08	.04	0.03	0.09	.03	0.05	0.02	.30**	0.04	0.02	.23
Step 4	ΔR^2 = .01			ΔR^2 = .02			ΔR^2 = .07**			ΔR^2 = .02		
	ΔR^2 = .01			ΔR^2 = .01			ΔR^2 = .02			ΔR^2 = .00		
NA × Adaptive ER	0.07	0.06	.10	0.13	0.06	.16	-0.04	0.01	-.27**	-0.02	0.02	-.12
NA × Maladaptive ER	-0.09	0.07	-.09	-0.10	0.08	-.11	-0.03	0.02	-.13	-0.01	0.03	-.05

**p < .05; **p < .01; ***p < .001*

3.3.3 Discussion

The present study focused on the same general objectives as the previous two studies, but did so in a sample of adults.

Preliminary analyses indicated that compared to men, women had higher anxiety and depression scores, a finding that is in line with other data showing higher scores (or higher prevalence) of internalizing symptoms among women (American Psychiatric Association, 2000; Hettema et al., 2005; Kendler et al., 1995). In line with these results, we also found higher temperamental NA in women. On the other hand, in this sample EC was higher in men compared to women. This finding is at odds with the results of our previous two studies, as well as other research involving children and showing higher EC in girls (e.g., Feldman & Klein, 2003; Kochanska & Knaack, 2003; Kochanska et al., 1996, 2000). There are several possible explanations for these discrepancies. First, the reader should keep in mind that the male sample in this study was extremely small and therefore any results based on it have limited generalizability and should be regarded with caution (with a larger sample of men, we might see a disappearance of the EC difference, or even a reversal of the effect). Unfortunately, it is difficult to determine whether this difference might be a reliable one, since – to our knowledge – the few studies that have included measures of adult temperament did not explicitly report whether gender differences were present or not (see e.g., Clements & Bailey, 2010; Evans & Rothbart, 2007). Second, assuming the difference is a reliable one, it should be noted that most previous research (including the studies from the present chapter) has used parent-report or observational measures to assess EC (e.g., Gerardi-Caulton, 2000; Kochanska & Knaack, 2003; Kochanska, Murray, & Coy, 1997; Kochanska et al., 2000), while the present study involved a *self*-report measure of EC. Discrepancies might stem from these differences in assessment methods, but it is difficult to determine at this point which one reflects more accurately an individual's "true" EC abilities. Third, if our results reflect the true state of EC abilities in men versus women, they raise the intriguing possibility that at some point during development boys' EC skills "catch up" with those of girls and end up surpassing them. While this possibility is a speculation at this point, it is, nevertheless, a possibility worthy of further investigation.

The relationship between EC and ER followed our expectations and the general pattern found in the previous two studies, as adaptive ER strategies were generally related to good EC skills, while maladaptive ER strategies were related to low EC abilities.

With respect to the temperament–anxiety relationships, unsurprisingly, we again found that high NA predicted high anxiety and depression, but here NA was a stronger predictor for depression than anxiety. We found some limited correlational evidence that good EC skills were related to low anxiety and depression. This is in line with previous research in adults showing moderate-to-high negative correlations between anxiety and EC in adults and children (e.g., Clements & Bailey, 2010; Derryberry & Reed, 2002; Moriya & Tanno, 2008; Muris, Mayer, Lint, & Hofman, 2008; Muris, Pennen, Sigmond, & Mayer, 2008; Oldehinkel et al., 2007). However, when we accounted for the effect on NA in the hierarchical regression analysis, the impact of EC was cancelled, due to the overlap between the two. There was also no evidence that EC moderated the NA–anxiety / depression relationship. Despite these null results, the presence of a correlation between EC and anxiety / depression, and its disappearance in the presence of NA indicated a potential mediation relationship we had not foreseen in our initial hypotheses. Indeed, the mediation analysis found evidence that in this sample NA mediated both the EC–anxiety and the EC–depression relationship. In other words, it would seem that in adults EC influences anxiety/depression indirectly, by reducing NA. We are not aware of any study reporting similar results in adults. It is thus possible that the patterns of relationships between NA, EC and anxiety / depression change during development from childhood to adulthood. However, taking into account the fact that this mediation relationship was an incidental, post-hoc finding, and that there is no other similar data available in the literature, we are cautious in drawing any firm conclusions based at this point. Future research (perhaps with a longitudinal methodology) should establish whether this is a reliable pattern, or a simple statistical artifact.

Finally, as we would expect, high anxiety / depression scores were linked to frequent use of maladaptive ER strategies and less frequent use of adaptive ER strategies in a manner congruent with previous findings from adults (e.g., Garnefski et al., 2001; Garnefski & Kraaij, 2007; Garnefski, Kraaij, & van Etten, 2005; Garnefski et al., 2002). We failed to find any evidence supporting a mediating or moderating involvement of ER strategies in anxiety symptoms. However, adaptive ER moderated the NA–depression relationship: while NA predicted depression in participants with low or average use of adaptive ER strategies, frequent use of these ER strategies cancelled the risk for high depression even when NA was high. Apart from these results, in the case of anxiety we found a pattern similar to the one found in the case of EC. Namely, maladaptive ER influenced anxiety indirectly, by increasing NA (in other words NA mediated the relationship between maladaptive ER and anxiety). There was only partial evidence that this was also the case for depression (here the mediation model with maladaptive ER as a mediator was also partially supported). However, since this was also an incidental finding, the same precautions discussed for EC apply here, and further studies are necessary to determine whether this pattern of relationships between self-regulatory mechanisms (EC and ER), NA and anxiety are indeed characteristic for adults.

In summary, data in the adult sample failed to support either the additive or the interactive hypothesis concerning the role of NA and EC as predictors of anxiety (despite moderate negative correlations between EC and anxiety). Similarly, while the pattern of ER–anxiety correlations was as expected, ER strategies were neither significant mediators nor moderators of the relationship between NA and anxiety. Incidentally, we found some evidence to support the possibility that EC and maladaptive ER strategies predict anxiety indirectly, by modulating NA. Similar results were found for depression, with the exception that in this case we also found indication that adaptive ER strategies acted as moderators of the NA–depression relationship.

3.4 General discussion

As already discussed in Chapter 2, an important part of the developmental literature on anxiety (conceptualized as a disorder or as a trait) has focused on its potential temperamental predictors, most notably NA and EC, and has investigated the degree to which these two characteristics act as independent, additive predictors or/and whether they interact. More recently, interest has also started to emerge concerning the involvement of ER strategies in the development of anxiety, but here studies have been limited mostly to correlational data. However, in both of these areas of research, studies are either scarce, or data tends to be mixed, and – especially in children – they often lack a clear focus on anxiety, choosing instead to assess internalizing problems in general. Therefore, in the present chapter we investigated the role of temperamental NA and two potential self-regulatory influences – temperamental EC and ER strategies – as predictors of anxiety. In order to have a clearer developmental perspective on these relationships, we adopted a cross-sectional approach to the investigation, by focusing on three age samples: preschoolers, schoolchildren (middle childhood) and adults. Additionally, in order to determine whether the patterns of relationships between our chosen predictors and anxiety were specific for this type of emotional problem, we also assessed depression, where it was possible (namely in the middle childhood and adult sample). Finally, because the literature has shown gender differences on some of the measures we used, and because anxiety is overrepresented in adult women (compared to men), we were interested to determine whether the different variables we used as predictors would relate differently to anxiety depending on the gender of the person.

Results of the three studies included in this chapter have clarified some of our starting questions while at the same time raising others. However, the cross-sectional approach has proven valuable in showing that the patterns of relationships between individual characteristics and anxiety are not static throughout development. This was visible especially when investigating NA and EC as predictors of anxiety. NA was a relatively constant predictor of anxiety across all three age groups, with effect sizes ranging from moderate (in boys) to large (in girls). However, its impact was somewhat reduced in adults. These changes (across age samples as well as genders) are partly due to the different contributions of the three NA sub-dimensions (especially anger, which was not always clearly related to anxiety). More interesting developmental changes were found when we investigated the role of EC in predicting anxiety. More precisely, while in preschoolers the EC sub-dimension of inhibitory control was a risk factor for high anxiety (it predicted higher anxiety scores, and amplified the risk for anxiety in children with high NA – especially in girls), the relationship was completely changed in middle childhood, where high EC was a protective factor, limiting the risk for anxiety even in children with high NA (again, this was true especially in girls). This change is probably due to the fact that once children start school and are more and more engaged in tasks that require self-regulation, the difference between automatic and controlled inhibitory influences might become clearer for parents. In line with our discussion of the results in Study 1A, a complementary interpretation is that as EC abilities develop, there is also a genuine differentiation between automatic and controlled inhibition. In adults, incidental findings indicated the possibility that from childhood to adulthood EC gradually starts exerting a regulating influence on temperamental NA, thus modulating anxiety symptoms indirectly. While the incidental nature of these latter findings calls for caution in interpreting them, taken together, results from all three samples point to the possibility that the balance between (negative) emotional reactivity and EC shifts throughout development in its relationship with anxiety.

In the case of ER strategies, there was little change from one age sample to the next in the overall pattern of strategies most likely to be related to anxiety. In general, high anxiety was associated with frequent use of passive ER strategies like avoidance (in children) or maladaptive strategies such as catastrophizing (in adults). However, we did not find any evidence that ER mediated the link from NA to anxiety. On the contrary, in the case of adults it seemed rather that maladaptive ER might modulate NA and thus indirectly influence anxiety (but, as in the case of EC, this was an incidental finding to which the same cautionary note applies).

In the middle childhood and adult samples, we were able to assess depression symptoms (in addition to anxiety) and thus determine the degree of specificity of anxiety predictors. While we found many similarities between anxiety and depression predictors, there were enough differences to justify their separate investigation in future studies – especially those focusing on children, which often include the common category of "internalizing problems".

Our results also revealed interesting gender differences in the patterning of anxiety predictors. These differences can be attributed partly to differences in EC between the two genders, but this is likely not the whole story, since patterning differences were also found in the case of ER strategies (where there were no gender differences between the means). Additionally, patterning differences depend not so much on simple mean differences, as on different covariance patterns between variables. In the case of children, it is possible that some of these differences came from gender-based perceptions and expectations parents might have of their children's behavior. While the source of these gender differences is not entirely clear, our results emphasize the need to take participants' gender into account as a potential moderator when investigating internalizing problems.

All of our conclusions must be viewed taking into account certain limitations. First, our interpretations are limited by the cross-sectional (as opposed to longitudinal) nature of our data. It is not clear if similar results (for examples, the change in the role played by EC) would be found if our methodology was applied to the same individuals at different points in time. Additionally, while we used temperament and ER as *predictors* of anxiety symptoms, we measured all characteristics simultaneously. Supplementary measurements of anxiety, at future points in time, would add validity to our data. Second, while we did not focus on NA sub-dimensions in the present study, they do tend to contribute differently to anxiety (and depression) symptoms (as indicated by correlational data). The most notable sub-dimension was anger, which, while being related to anxiety in some cases (especially in girls), was unrelated in others. Future studies should determine the combination of NA sub-dimensions that best predict anxiety, and whether this combination is different in males and females. Third, as some of our data in study 1B showed, the use of parent- as opposed to *self*-report can lead to different results. However, self-report is difficult (if not even impossible) to use reliably in young children, and an alternative measure such as observation would be difficult to use in a large sample of children. Third, despite our efforts, our adult sample was extremely unequal in terms of gender representation, which limits the generalizability of our conclusions to women only.

These limits notwithstanding, the present results make an important contribution to the understanding of individual differences in temperament and ER strategies as factors involved in the development of anxiety in children and adults.

Chapter 4.
Anxiety and attention: From threat processing to general attentional functioning

The present chapter (as well as the rest of the thesis) focuses on the relationship between anxiety and attention. As shown in the first chapter of this thesis, anxiety is associated with alterations in cognitive functioning. One of the most well-known phenomena is the so-called threat-related attentional bias, namely anxious individuals' tendency to detect and process threat-signaling stimuli faster. This phenomenon is relatively robust in adults, but less straightforward in the case of children. However, little is known about attentional functioning in anxiety apart from this relatively narrow aspect. For this reason, in the present chapter we attempt to go beyond the threat-related bias by turning to fundamental attention research, and trying to determine how much of it has infused anxiety research in children and adults.

4.1 Attention in anxiety

As mentioned in the first chapter of the present thesis, anxiety is often associated with changes in the functioning of attention. The most prominent of these changes is represented by the so-called threat-related attentional biases. This phenomenon has generated much research and theorizing, but while it has been a very reliable effect in adults (in both trait and clinical anxiety), in children findings have been mixed. Apart from this, there is also some evidence that higher anxiety is associated with increased distractibility (especially in emotional contexts involving threat), but here the data is much more scarce, and almost non-existent in the case of children. Theorizing has followed the trend of empirical findings by focusing mostly on threat processing, with one recent exception that approaches the anxiety-attention relationship from a more general perspective.

4.1.1 A summary of mainstream empirical facts

The relationship between anxiety and attention has been investigated mostly in relation to threat perception. The largest part of the literature – in adults and children – focuses on this aspect, while research investigating general attentional mechanisms outside the realm of emotional processing is relatively scarce (see Table 4.1, at the end of this chapter). In what follows, we briefly review some of this mainstream literature (for more comprehensive reviews, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Cisler & Koster, 2010; Hadwin, Garner, & Perez-Olivas, 2006; Miu & Visu-Petra, 2010; Vasey & MacLeod, 2001).

One of the most robust cognitive phenomena in anxiety is represented by threat-related attentional biases, more precisely the tendency of anxious individuals to selectively allocate processing resources to threatening material (MacLeod, Andrew Mathews, & Tata, 1986;

Mathews & MacLeod, 1994; Williams, Mathews, & MacLeod, 1996). The most frequently used tasks in this research area have been the emotional Stroop, the dot-probe, and the visual search task.

The emotional Stroop task (Mathews & MacLeod, 1985) is a variation of the traditional Stroop task (Stroop, 1935; for a description of the classic version of the Stroop task, see paragraph 4.2.2 and Table 4.1), but instead of color names, it uses emotionally-valenced words or pictures, relevant for the problem under investigation (and the age of the participants). However, the procedure is similar to the traditional one: participants are required to name the color of the ink used for printing the words or pictures. Anxious adult participants tend to be slower in naming the color of threatening words, compared to neutral words, and the magnitude of this discrepancy has been larger in their case than in the case of non-anxious participants (e.g., Avram, Balteş, Miclea, & Miu, 2010; Becker, Rinck, Margraf, & Roth, 2001; MacLeod, 1991; Mathews & MacLeod, 1985; Reinholdt-Dunne, Mogg, & Bradley, 2009; de Ruiter & Brosschot, 1994; Williams et al., 1996). In the *dot-probe paradigm* (MacLeod et al., 1986) participants are briefly presented with two stimuli (words or images), appearing symmetrically on the left-right or upper-lower parts of the display. One of these stimuli is threat-related, while the other one is either neutral or has a positive emotional valence. After these stimuli disappear, one of them is replaced by a dot, which the participant is required to detect. Anxious participants are typically faster to respond to probes that replace threat-related stimuli than to those replacing neutral ones (e.g., Bradley, Mogg, White, Groom, & De Bono, 1999; MacLeod et al., 1986; Mogg, Bradley, De Bono, & Painter, 1997; but see also Koster, Crombez, Verschuere, & De Houwer, 2004). The *visual search task* typically requires participants to detect a specific stimulus within a multitude of other stimuli (which can be placed at random positions on the display, or they can be arranged in a matrix; see Wolfe, 1998, 2010 for details and Table 4.1 for a description of the general structure of the task). In its emotional version, the stimuli can be words or images (faces, snakes, spiders, etc.), and usually participants are asked to find a target stimulus (e.g., an angry face among neutral or happy faces) among the "crowd" of other stimuli (e.g., Hadwin et al., 2003; Öhman, Flykt, & Esteves, 2001; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005). Typically, anxious adult participants are faster to detect threatening targets in displays of neutral or pleasant stimuli, but are impaired when neutral or pleasant targets are surrounded by threatening stimuli (see Cisler & Koster, 2010 for review).

The tendency of anxious persons to favor threat-related stimuli has been reliably found in adults, both in clinically diagnosed and nonclinical participants, using all three experimental paradigms mentioned above (see Bar-Haim et al., 2007; Cisler & Koster, 2010 for recent reviews).

In the case of children, almost all research to date has used the Stroop or the dot-probe task, and thus far, the data presents a more mixed picture than in the case of adults. While some studies have found supporting evidence for the presence of selective attention to threat in children and adolescents (e.g., Dalgleish et al., 2003; Heim-Dreger, Kohlmann, Eschenbeck, & Burkhardt, 2006; Vasey, El-Hag, & Daleiden, 1996; Waters & Lipp, 2008; Waters & Valvoi, 2009), others have failed to do so, indicating the presence of a generalized threat-related attentional bias, unrelated to the child's level of anxiety (e.g., Ehrenreich & Gross, 2002; Kindt, Bierman, & Brosschot, 1997; Susa, Pitica, & Benga, 2008; Waters, Lipp, & Spence, 2004). This pattern of results was found especially in children younger than 10-11 years (see Kindt & Van Den Hout, 2001 for a review). Causes for these discrepancies might reside in the type of task used, the general methodology, the inclusion of clinical or non-clinical samples, or the children's age (Ehrenreich & Gross, 2002; Hadwin et al., 2006; Kindt & Van Den Hout, 2001; Puliafico & Kendall, 2006).

Apart from research regarding threat-related biases, there is some evidence (although more limited) that anxiety is also associated with higher distractibility in situations involving non-emotional distractors (Alting & Markham, 1993; Eysenck & Byrne, 1992; Eysenck & Graydon, 1989; Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998; Mathews, May, Mogg, & Eysenck, 1990 but see Keogh & French, 1997 for an exception) as well as situations where distractors are threat-related (Byrne & Eysenck, 1995; Calvo, Avero, & Lundqvist, 2006; Gerdes, Alpers, & Pauli, 2008; Keogh & French, 2001; Keogh, Bond, French, Richards, & Davis, 2004; Rinck, Becker, Kellermann, & Roth, 2003; Rinck et al., 2005).

Earlier research generated some data indicating that high trait anxiety was associated with higher distractibility even in the absence of emotional stimuli. For example, Eysenck and Graydon (1989) used a task that involved transforming letter strings, accompanied by distracting white noise. They found that neurotic introverts were significantly more distracted by the noise compared to stable extraverts. In another study, Mathews et al. (1990) asked participants to identify a word that was displayed alone or accompanied by other (distracting) words. The performance of participants with high anxiety was more affected by the presence of distractors. However, even in these early studies there was evidence that distractibility was higher when distractors were threat-related (Eysenck & Byrne, 1992; Mathews et al., 1990). More recent research, using the visual search paradigm, tends to confirm these previous findings. For example, it was shown that trait anxiety is associated with slower detection of happy faces among angry distractors (Byrne & Eysenck, 1995), that persons with generalized anxiety disorder (GAD) are slower to detect neutral words among GAD-related words (Rinck et al., 2003), or that the visual search performance of spider-phobic individuals is impaired by spider distractors (Gerdes et al., 2008; Rinck et al., 2005).

There is, to date, little published research relevant for the issue of distractibility in anxious children, and most of it fails to support this hypothesis. Some evidence indicates that 7- to 11-year-old anxious children are faster to detect the presence (Waters & Lipp, 2008) or absence (Hadwin et al., 2003) of angry faces among neutral distractors, but they are not necessarily more distracted by them.

Thus, as can be seen, there is robust evidence documenting the preferential processing of threat-related stimuli in adults with high anxiety and some limited research supporting the idea of higher distractibility. Evidence is more limited and more contradictory in the case of children.

4.1.2 Theoretical perspectives

Within this field, a large part of current theorizing has followed the trend of empirical data, and thus has attempted to formulate models that would describe and explain the specific mechanisms behind threat-related attentional biases. We first briefly discuss the most prominent models explaining threat-related attentional biases (again, the reader is invited to consult Bar-Haim et al., 2007 and Cisler & Koster, 2010 for more extensive reviews), and then focus on a more general theory proposed by Eysenck and collaborators (Michael W Eysenck et al., 2007).

4.1.2.1 Models of threat-related attentional biases

Most traditional explanations of attentional biases suggest that high anxiety is associated with a tendency to detect threat during an early, “preattentive” (involuntary, automatic) stage of visual processing, and – in some cases – a tendency to avoid the threatening stimulus during later, "attentional" (controlled, voluntary) phases of attentional processing (Mathews & MacLeod, 1994; Mogg & Bradley, 1998; Öhman, 2005; Öhman & Mineka, 2001; Williams et al., 1996). These ideas have their roots in dual-stage processing models of attention (e.g., Treisman & Gormican, 1988; Treisman & Gelade, 1980; Wolfe, 1994), which propose that there are two phases in visual processing. During the early (preattentive) phase, the visual field is processed in parallel and stimulus features are detected before the stimuli are recognized and selected for attentive processing per se (Treisman, 2006; Treisman & Gormican, 1988 see also Theeuwes, 2010; Treisman, 2006 for reviews). During preattentive processing, salient features (such as a distinct color or orientation of a stimulus among stimuli of a different color/orientation, the movement of a stimulus in a stationary background, sudden appearance, etc.) can make a stimulus "pop-out" from the background and thus be detected in an automatic, effortless manner (Theeuwes, 1994; Treisman & Gelade, 1980). Most models of threat-related attentional biases hypothesize that this is what happens in the case of anxious participants: for them, features signaling threat tend to "pop out" from the background.

The different models of threat-related attentional biases assign the tasks of preattentive and attentive processing to various processing entities. For example, Williams et al. (1988; cited in (Williams, Watts, MacLeod, & Mathews, 1997) postulate the existence of an *affective decision mechanism* (ADM) that determines the level of threat in the incoming information. A high level of threat activates a *resource allocation mechanism*, which – if trait anxiety is high in that person – assigns a higher priority to the threatening information and distributes attentional resources accordingly. At the same time, someone with low anxiety will ignore the threat and continue focusing on their current task.

Another model – suggested by Mathews and Mackintosh (1998) – postulates the existence of a *threat evaluation system* (TES) similar to Williams et al.'s ADM. Stimuli from the environment feed into representations of both target stimuli and distractors. The former can be enhanced by voluntary effort based on task demands, while the latter can be enhanced by the TES. The TES assesses the level of threat represented by incoming stimuli and feeds into the distractor system. In persons with higher anxiety, the output of the TES is enhanced by anxiety level, so that threatening distractors have a higher chance of "winning" the competition with task stimuli.

Mogg and Bradley (1998) proposed the so-called *cognitive-motivational model*, which postulates two main processing systems. First, a *Valence Evaluation System*, which accomplishes the initial, preattentive assessment of environment stimuli. It is influenced by these stimuli, but also by the context in which they appear, by the person's current arousal level and by prior learning experiences. This system tends to be more reactive in individuals with high trait anxiety. This system then feeds into the *Goal Engagement System*, which is responsible for allocating resources depending on the current goals of the person. If a stimulus is assessed as being highly threatening, current behavior is interrupted, and processing resources are automatically allocated to the threatening stimulus. They suggest that avoidance may occur in the case of stimuli with a low threat value.

Another frequently cited model (Öhman, 2005; Öhman & Mineka, 2001; see also Lundqvist, Esteves, & Ohman, 1999) approached the issue of threat-related attentional biases from an evolutionary perspective. The model proposes that the stimulus input is analyzed in a first stage by a *feature detection system* which allows the identification of potentially threatening stimuli based on their simple features (e.g., a sudden movement, the shape of frowned eyebrows, etc.). Information from the feature detection system can then directly – without the need for conscious mediation – influence and activate the so-called *fear module* (Öhman & Mineka, 2001), most likely located in the amygdala (Öhman, 2005). The fear module is responsible for activating the fear (fight/flight) response with all its physiological, cognitive and behavioral correlates.

While all these models assume that the central phenomenon is the tendency of anxious individuals to detect threat *faster*, some empirical findings – generated most prominently by Elaine Fox and collaborators (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Georgiou et al., 2005; see also Yiend & Mathews, 2001), suggests otherwise. More precisely, this data indicates that threat-signaling stimuli are not necessarily detected faster, but rather they tend to *hold* attention, making disengagement more difficult for people with high anxiety. However, Fox and collaborators (see especially Georgiou et al., 2005) suggested that this deficient disengagement mechanism might be complementary to the fast detection one suggested by previous research.

4.1.2.2 Development of threat-related biases and the role of self-regulation

The precise role played by attentional biases in the development of anxiety is not yet clear, and there has not been much theorizing on this topic. It is possible that these biases act as a mediator between negative affect and anxiety (Lonigan, Vasey, Phillips, & Hazen, 2004), or they might contribute to the persistence of anxiety symptoms. For example, Legerstee and collaborators (Legerstee et al., 2009), found significantly better treatment outcomes for children and adolescents with an anxiety disorder who had a lower pre-treatment attentional bias for threatening images. However, one observation resulted from research on threat-related attentional biases in children was the fact that, as children age, the attentional bias tends to decrease in non-anxious children, but it increases (or at least remains constant) in anxious children (Kindt & Van Den Hout, 2001). This observation prompted Kindt and Van Den Hout to suggest that failure to learn to inhibit selective attention for threat might distinguish between these two types of developmental trajectories. More precisely, the authors suggested that probably all children start off with an initial attentional bias for threat, which subsequently disappears in those with low anxiety, and what makes the difference between the two groups is the ability to disengage attention from threat. In other words, children might actually learn to disengage their attention from stimuli signaling threat, and failing to do so would put one at risk for anxiety. This theoretical account also suggests that temperamental EC might be involved in the development of the ability to disengage attention from threat.

There have been at least two studies that tend to support Kindt & Van Den Hout's latter hypothesis, in children and adolescents (Lonigan & Vasey, 2008) as well as adults (Derryberry & Reed, 2002). Lonigan and Vasey used a dot probe task in a sample of children and adolescents aged 9 to 18 years, and found that EC moderated the relationship between NA and a threat-related bias, since only children with high NA and low EC showed the classical bias for threat. In adults, Derryberry and Reed tested the moderating role of attentional control, using an emotional version of the spatial cueing task (see Table 4.1 and paragraph 4.2.2 for details). At long delays between the cue and target, participants with high anxiety who also had high attentional control scores displayed no evidence for a threat-related attentional bias.

Thus, while the precise role and developmental course of threat-related biases in anxiety is not clearly understood, it appears that EC might act as a protective factor here too.

4.1.2.3 Attentional Control Theory

Attentional Control Theory (ACT; Eysenck et al., 2007) is a recent attempt to look at the relationship between anxiety and cognitive performance from a more general – and at the same time more parsimonious – perspective. It originated from the earlier *Processing Efficiency Theory* (PET) of Eysenck and Calvo (1992). PET focused on anxiety-related impairments during various cognitive tasks and took WM as the main underlying mechanism. Eysenck and Calvo proposed that the main performance-disruptive factor in anxiety was represented by worrisome thoughts that intruded during cognitive tasks. Worry was assumed to adversely affect working memory, and more precisely its central executive component (a control system which manages the distribution of processing resources and connects WM with long-term memory; see Baddeley, 1996, 2003, 2007 for details) because it depleted processing resources that should have been allocated to the target task. While the models we discussed previously were only concerned with situations involving emotional stimuli, PET was only concerned with non-emotional tasks. This was one important limitation in its explanatory scope, along with – as indicated by Eysenck et al., 2007 – its failure to specify the components of the central executive most likely to be affected by anxiety, and its lack of any clear specifications regarding distractibility and the effect of distracting stimuli in anxiety.

Thus, ACT emerged from an effort to solve some of the limitations of PET and to extend its explanatory scope to both emotional and non-emotional contexts. The main assumption of ACT is that anxiety affects performance through its negative effects on attentional control. Although attentional control is not clearly defined in Eysenck et al.'s (2007) presentation of ACT, based on the different contexts where the term is used in the original article and in other sources (Derakshan & Eysenck, 2009), attentional control can be seen as the implementation of the functions of the central executive during cognitive tasks (mostly those involving WM and attention).

One of the main hypotheses of ACT states that the disruptive effects of anxiety upon attentional control are the result of an impairment in the balance between bottom-up (or stimulus-driven) and top-down (or goal-driven) attentional mechanisms. Eysenck et al. have based their conceptualization of the two systems on models from fundamental research on attention, such as the model of Corbetta and Shulman (2002) or Posner and Petersen (1990) (to be detailed below). Such models posit that the top-down system modulates attention by implementing current task goals and expectations, while the bottom-up attentional system is recruited by behaviorally relevant sensory events "particularly when they are salient and unattended" (Corbetta & Shulman, 2002, pp. 201-202). Eysenck et al. (2007) postulate that the stimulus-driven attentional system *dominates* in anxious individuals, at the expense of the goal-driven attentional system. This implies that individuals with higher anxiety levels are more vulnerable to having their attentional resources captured by salient stimuli, whether these are task-relevant or not. Stimuli can be salient either due to their sensory properties or due to their motivational/emotional content. Since emotionally threatening stimuli are more salient for anxious individuals, it is likely that their effects will be more pronounced than those of stimuli that are salient based on purely sensory grounds.

Another important set of hypotheses of ACT relates to the functions of the central executive, as identified by Miyake et al. (2000; see also Friedman & Miyake, 2004). While initial accounts of working memory had depicted the central executive as a monolithic structure, in 1996 Baddeley suggested the possibility that this entity might accomplish several distinct functions. There have been different suggestions as to what these functions might be (e.g., Baddeley, 1996; Shallice & Burgess, 1991; Smith & Jonides, 1999; see also Visu-Petra, 2008 for an extensive review), but the most recent and most successful has been the one put forward by Miyake et al. (2000). These authors took an empirical approach to the issue, by carrying out latent-variable analysis over data resulted from tasks considered to tap executive functions. They were able to reliably distinguish among three functions that shared a common factor: inhibition of automatic or prepotent responses, shifting between different tasks or mental sets, and updating and monitoring of working memory contents. Later, Friedman and Miyake (2004) expanded on the sub-components of the inhibition function. They initially distinguished between three types of inhibition: (1) prepotent response inhibition (the ability to deliberately suppress automatic, dominant, prepotent responses), (2) resistance to distractor interference (the ability to filter out distracting stimuli which are irrelevant to the task at hand, or resolving this interference), and (3) resistance to proactive interference (the ability to resist memory intrusions from information that is no longer relevant). Confirmatory factor analyses indicated that the first two functions were highly related, which prompted the authors to combine them into the "response-distractor inhibition" function.

Returning to ACT, out of the three main central executive functions, Eysenck and collaborators predicted that anxiety would mostly impair the inhibition and shifting functions, with effects on updating seen most often under stressful circumstances (Eysenck et al., 2007; see also Derakshan & Eysenck, 2009). Evidence up to this point tends to support these predictions, at least in the case of adults (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Derakshan & . Eysenck, 2009; Derakshan, Smyth, & Eysenck, 2009; Hopko et al., 1998).

Taking into account the main concepts of ACT and those involved in the first part of this thesis, some terminological clarifications are in order. First, it is not clear from Eysenck et al.'s (2007) description of the concept of "attentional control" how much it overlaps with *temperamental* attentional control. The authors cite research indicating that temperamental attentional control is lower in individuals (adults) with high trait anxiety as support for ACT, which indicates that the two concepts overlap. However, Eysenck et al. include the executive functions of inhibition, shifting and updating as playing a part in achieving attentional control, which indicates that they see this concept as being broader than temperamental attentional control. We can therefore conclude that the concept of attentional control, as included in ACT, is different in its scope from temperamental attentional control, and, as already stated, it refers to the effectiveness of executive function implementation. To avoid confusion, throughout the rest of this thesis, we will only use the term "attentional control" in reference to the temperament dimension. When it comes to ACT, we will mainly focus on the issue of bottom-up versus top-down mechanisms; this will allow us to avoid using the term "attentional control" altogether in this context (since top-down mechanisms can be seen, in fact, as the implementation of executive functions in attentional performance).

A second terminological observation refers to executive inhibition versus temperamental inhibitory control. Based on the fact that behavioral (non-questionnaire) measures of EC sometimes use traditional executive inhibition tasks as measures of inhibitory control (see e.g., Kochanska & Knaack, 2003; Kochanska, Murray, & Harlan, 2000; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996), we can conclude that temperamental inhibitory control represents the reflection of executive inhibition on a behavioral level.

4.1.3 Summary and conclusion

As discussed above, most research that deals with the relationship between attention and anxiety has focused on the problem of threat-related attentional biases. Likewise, most theorizing has followed the same trend, focusing on this narrow aspect of attentional functioning in anxiety. Thus, little is known about how attentional mechanisms of anxious individuals function in general – in neutral, as well as emotional contexts. We feel that anxiety research might benefit greatly from paying more attention (pun intended) to data and theories coming from fundamental attention research (see Weierich, Treat, & Hollingworth, 2008 for a similar critique). Therefore, in the next section of this chapter, we will attempt to present a brief review of attention, with a focus both on its definition in early research, as well as the main functions investigated in current research.

ACT (Eysenck et al., 2007) is one exception to the general trend of research presented above, as it attempts to look at the relationship between anxiety and attention from the more general perspective of bottom-up and top-down attentional mechanisms. The hypothesis of an imbalance between these two types of processes has the advantage of offering a wider explanatory scope, and being, at the same time, more parsimonious than previous theories. Additionally, there are already several models and a large amount of basic research to inform any attempt at investigating attentional mechanisms in anxiety from the perspective of this hypothesis. However, there is little clear specification of the characteristics of top-down and bottom-up attentional mechanisms within ACT, as the authors have merely cited two of the approaches to these mechanisms, without going into detail about them. Therefore, in the next section of this chapter we will also briefly review some of the most important current models referring to this distinction.

Last but not least, research into the anxiety-attention relationship has had little developmental focus. As discussed above, there is a relatively large amount of (mixed) data when it comes to the tendency for faster detection of threatening stimuli. However, there is almost no research that can tell us whether the attentional mechanisms of children with higher anxious tendencies develop differently from those of other children, or whether anxious children are more distractible than their peers (as adults seem to be). In the next section, we will therefore also discuss the development of attentional functioning in children.

4.2 What is attention?

Despite its importance in cognitive and emotional functioning, attention is probably one of the most elusive and difficult to define processes. While William James is often quoted as saying that "everyone knows what attention is" (James, 1890, p. 261), most researchers nowadays would be reluctant to give such a confident answer. In fact, a survey of current research would probably generate an answer closer to Harold E. Pashler's statement that "No one knows what attention is, and there may even not be an 'it' there to be known about (although of course there might be)" (Pashler, 1998a, p. 1). However, early modern attention research has been marked by attempts to generate a unitary definition and a unitary theory of attention.

4.2.1 Attentional metaphors: Classic models of attention

Although scholarly interest in attention dates back to at least Descartes (see Tsotsos, Itti, & Rees, 2005 for a short historical review), modern attention research is considered to have emerged soon after World War II. The revival of research in attention was largely due to a shift away from behaviorism in the 1950s (see Neumann, 1996; Sanders, 1997) and the emergence of cognitive psychology. The initial stages were marked by a tendency to describe and explain attention as a unitary phenomenon. These early models are frequently referred to as "conceptual metaphors", because they often construed attention by taking systems described in other fields (e.g., information technology, economy, etc.), and assigning the properties of those systems as properties of attention (see Fernandez-Duque & Johnson, 1999, 2002; Miclea, 1999; Neumann, 1996; Sanders, 1997; Styles, 2006 for reviews).

In what follows, we will briefly describe each attentional metaphor that dominated the field at one time or another. In discussing these models, we mainly take a historical approach, describing the models roughly in the order in which they emerged (for other, more extensive reviews, see Pashler, 1998a; Styles, 2006).

4.2.1.1 Attention as a filter

In the early days of modern attention research, interest in the phenomenon stemmed from situations encountered in natural settings, where attention could significantly influence performance (for example, the situation of flight controllers who had to communicate with several pilots at the same time; see Neumann, 1996; Styles, 2006; Tsotsos et al., 2005 for reviews). Contexts such as this, as well as more mundane observations – like, for example – the now famous "cocktail-party phenomenon" (Cherry, 1953; see Bronkhorst, 2000 for a recent review) sparked interest in people's ability to attend selectively to different sources of information while ignoring others (see Driver, 2001 for a review of selective attention).

The experimental paradigm of choice during this stage of attention research was the classic dichotic listening task (Cherry, 1953; Poulton, 1953). Generally, it consisted of presenting two (or sometimes more) verbal streams through headphones and then asking participants to report on one or more aspects of the messages. The two messages were either transmitted to both ears at the same time, or were physically separated (one message to each ear). The amount of attention to the two messages was manipulated through experimental instructions. Most often, participants were asked to selectively attend to one of the messages, and a very efficient way of doing that was by using the "shadowing" technique (i.e., repeating aloud the message to be attended). The most important findings of research using dichotic listening were (1) that physical acoustic differences between the messages, as well as physical separation or shadowing significantly improved participants' ability to attend to only one message; and (2) while these manipulations resulted in virtually flawless reporting of the attended message, participants were able to report extremely little about the unattended message. For example, they were not able to report the content of the unattended message or even to notice that the message had switched from English to German. However, they could report physical aspects of the unattended message, such as the fact that the voice had changed from male to female, or that a bleep sound was present at some point during the message (see Neumann, 1996; Pashler, 1998b; Styles, 2006 for reviews).

Broadbent (1958) summarized this type of research in his book *Perception and communication*, and proposed what is now considered the first articulated model of attention to account for the data. He took telecommunications engineering as the source for his model, and derived many of its characteristics from Shannon and Weaver's (1949) mathematical theory of communication, also known as "information theory" (this theory attempted to formalize communication as information transmission from a sender to a receiver through a channel with limited capacity). Therefore, Broadbent proposed that it would be theoretically useful to regard the cognitive/nervous system as a channel with a limited rate of information transmission.

According to the model, sensory information was transmitted in parallel to a short-term store which encoded the physical characteristics of the message (such as pitch, location of the source, etc.) and acted as a parallel buffer (similar to Atkinson & Shiffrin's 1968 "sensory memory"), where information was processed and remained active for a limited amount of time. The short-term store was followed by a limited capacity channel (a serial processor) and the output system (e.g., motor or verbal responses). Due to the limited processing capacity of the transmission channel, the space between the short-term store and the channel was occupied by a selective *filter* which blocked irrelevant messages from being processed further, so as to avoid overloading the channel. Thus, attention was viewed here as a physical device – the filter – in the cognitive system (Fernandez-Duque & Johnson, 1999; Styles, 2006).

Due to empirical evidence indicating that sensory cues aided in message selection and that only sensory information appeared to be retained from the ignored messages, Broadbent concluded that until information reached the selective filter, all messages were processed at the level of their sensory characteristics, while semantic processing only took place on selected messages. Since selection was assumed to take place early in the processing stream, before semantic processing, Broadbent's model is considered an *early* selection model. However, accumulating evidence soon started to indicate that selection might not take place in the early processing stages. For example, using the shadowing technique, Moray (1959; see Wood & Cowan, 1995 for a recent replication) found out that participants were able to recognize their own name even when it was spoken to the nonshadowed ear. Similarly, Treisman (1960) asked participants to attend to a story presented to one ear while ignoring the story presented to the other ear. However, when the story was switched to the previously unattended ear, participants switched automatically and shadowed a few words before returning to the previously attended ear. In an even more compelling example, Treisman (1964; cited in Styles, 2006) showed that the nature of the content in the nonshadowed ear interfered with shadowing (i.e., the more similar the two messages were, the more interference). This type of data prompted some researchers (most notably Deutsch & Deutsch, 1963; but see also Norman, 1968) to propose that message filtering takes place *late* in the processing stream – i.e., after semantic processing. A third version of the filter model came from Treisman (1969), who proposed that the attentional filter was not an all-or-nothing processor, but simply an *attenuating* filter. In Treisman's view, stimuli were stored for a brief period of time during which their elementary characteristics were analyzed. This pre-attentive analysis was then used by the filter to select the relevant stimuli based on their physical properties. The filter did not completely block unattended messages but simply increased the threshold for their perception. However, these messages could overcome this filtering process, provided that they were intense enough, or had a generally low detection threshold (such as one's name).

The debate regarding the locus where selection took place continued further in the field of visual processing. Some studies supported the early selection view, by showing that visual stimuli were also filtered based on their physical characteristics (e.g., Dick, 1969; Graves, 1976; Rock & Gutman, 1981; Sperling, 1960; Styles & Allport, 1986). For example, in an experiment that resembled the dichotic listening paradigm, Rock and Gutman (1981) showed that when subjects were presented with superimposed red and green outline drawings and told to attend to one set of figures, they were virtually unable to recognize figures from the unattended set. However, paralleling the evolution of the debate in the auditory domain, evidence soon emerged indicating that unattended stimuli interfered with processing of the attended ones. For example, Tipper (1985) used a variation of the paradigm employed by Rock and Guttman and showed that when an attended stimulus was related to the unattended stimulus from the previous trial, reaction times were significantly slower. Tipper interpreted this as evidence favoring the late selection view, namely that unattended stimuli underwent full perceptual processing, but were then actively inhibited.

Over time, more and more evidence began to accumulate that the cognitive system was best described as a parallel processor (instead of a limited serial communication channel), with multiple specialized modules (see Allport, 1993 for details). Additionally, a different line of research from visual spatial attention started producing evidence that selection took place even in situations where there was virtually no information load (Kahneman & Treisman, 1984; Posner, Snyder, & Davidson, 1980). Findings such as these led to the gradual abandonment of the filter as a model for attention and the emergence of different types of metaphors, such as the resource and spotlight metaphors.

4.2.1.2 Attention as a (limited) resource

As the filter metaphor was starting to lose ground, a different type of metaphor of attention emerged, namely that of attention as a limited supply, or resource, that could be allocated across different cognitive processes. Thus, selection, when it occurred, was not the result of a filter blocking irrelevant information, but of resources being allocated to one set of stimuli instead of another (see Fernandez-Duque & Johnson, 2002; Hasher & Zacks, 1979; Kahneman, 1973; Moray, 1967; Navon & Gopher, 1979; Norman & Bobrow, 1975; see Sanders, 1997 for a more recent review). This view implicitly introduced the idea of an executive controller distributing resources (Fernandez-Duque & Johnson, 2002; Sanders, 1997).

The need for a change in the way attention was conceptualized emerged from studies of dual-task performance, whose results could not be explained using the filter metaphor. For example, Posner and Boies (1971) showed that participants were capable of performing a letter matching and a tone identification task at the same time. They found that when the tone occurred during the pauses in the letter matching task (i.e., during inter-stimulus intervals), responses were faster than when the tone occurred at the same time as the presentation of a letter. Broadbent's model would have predicted that dual-task performance was impossible without serious performance impairments (the limited-capacity channel could only process *one* message at a time). However, studies such as these showed that individuals *were* capable of simultaneously performing two tasks, although performance varied depending on the difficulty of the two tasks (see also Bourke, Duncan, & Nimmo-Smith, 1996; Duncan, 1980).

While the resource metaphor did not generate one single clear model, there were three dominating versions of it. First, as the 1960s saw the increasing popularity of the computer, computer technology became the main source of theorizing for many topics in the newly emerging field of cognitive psychology (Neumann, 1996; Styles, 2006). Thus, the *computational metaphor* equated resources with the processing resources of a limited capacity central processor (see Moray, 1967 for the first proposal of this metaphor). The second version was the *energetic metaphor*, suggested by Kahneman (1973), who considered "effort" as the main resource distributed across different cognitive operations. In Kahneman's view attention was the result of allocating effort or physiological activation, in other words a kind of limited power supply (Styles, 2006). In the third version of the metaphor, resources were depicted in economic terms, as limited supplies that were demanded by different tasks – the *economic metaphor* (Navon & Gopher, 1979).

Irrespective of the type of metaphor preferred, the main assumption of the resource model was that different tasks vary in terms of the amount of resources they use. Thus, automatic, well-practiced tasks use extremely low amounts of resources, while more complex (voluntary, controlled) tasks use higher amounts of central processing resources (Hasher & Zacks, 1979; Schneider & Shiffrin, 1977). If the processing requests of a task exceed the available resources, performance decrements will result. In the case of dual-task performance, insufficient resources will result in interference between the two tasks (see Fernandez-Duque & Johnson, 2002; Sanders, 1997). Depending on the underlying assumption regarding the nature of cognitive resources, experimental tasks could manipulate motivation, task diffculty/complexity, or the priority assigned to each task (see Navon, 1984 for a review).

One of the most well-articulated resource models of attention was put forward by Norman and Bobrow (1975; see also Navon & Gopher, 1979 for a development of the methodologies proposed). Among others, they suggested methods for determining the relationship between resources and performance. The most well-known are the *performance-resource function* (modeling performance in one single task as a function of the amount of invested resources) and the *performance operating characteristics* (POC) function, which modeled dual-task interference in the form of performance in one task as a function of performance in the second task.

Despite its advantages (compared to the filter metaphor), this approach has been criticized for several reasons. One of the most important criticism aimed at it was that of circularity (and the difficulty of falsifying the concept of "resource"). Several authors noted that there was no method of assessing the amount of resources independently of performance: the amount of resources required by a task was inferred based on performance, and performance itself was explained as a function of available resources (see Fernandez-Duque & Johnson, 2002; Navon, 1984; Sanders, 1997). Other critiques were formulated on empirical grounds. For example, in some cases even combinations of relatively complex tasks resulted in little performance loss (Navon, 1984; Sanders, 1997), and some studies found that the degree of interference between two tasks depended upon the sensory/response modalities involved in them (e.g., Mcleod, 1977). This latter problem was tentatively solved by suggesting separate, specific resources for different modalities – a multiple resource theory (e.g., Allport, Antonis, & Reynolds, 1972; Sanders, 1997; see Hancock, Oron-Gilad, & Szalma, 2007 for a recent review). However, this theory was unable to offer valid answers to the other critiques (especially the one concerning circularity; see Neumann, 1996; Sanders, 1997). For all of these reasons, the resource metaphor gradually ceased from being regarded as a valid model for attention.

4.2.1.3 Attention as a spotlight/zoom lens

The increased interest in visual attention brought along a change in the way attention was construed, and the emergence of a new metaphor, that modeled attention as a *spotlight* (originally suggested by Posner et al., 1980; see also Cave & Bichot, 1999). This approach to attention was based on two main experimental paradigms, which have since become classical in the field: the *spatial cueing* paradigm (which measures differences in the speed of orienting to a target whose spatial location has been cued correctly, incorrectly or not at all; Posner, 1980; see Table 4.1 and paragraph 4.2.2 for details) and the *visual search* paradigm (which involves scanning the visual field for a certain feature or object; see e.g., Treisman & Gelade, 1980; Trick & Enns, 1998).

The spotlight metaphor meant that selectivity was a result of where the "spotlight" of attention was directed: any stimulus or mental content that was "illuminated" by the spotlight was attended, while anything that fell outside it was ignored. While the filter metaphor emphasized inhibition (or blocking) of unattended stimuli, the spotlight metaphor suggested *enhancement* of attended stimuli as a central selectivity mechanism. In addition, since one of the main characteristics of a spotlight is its ability to move across space, this approach put a research emphasis on the movement of attention (and the speed of this movement) between locations and objects in the visual field (Fernandez-Duque & Johnson, 2002; Johnston & Dark, 1986). Two of the first experiments that prompted the use of this metaphor (Shulman, Remington, & McLean, 1979; Posner, Nissen & Ogden, 1978, cited in Posner et al., 1980) showed that cueing attention to a location in space significantly improved the detection of a target, compared to reaction times to a nonattended location. This indicated that – just as a spotlight – attention moves continuously between two different locations by passing through all intermediate locations. Finally, just as spotlights tend to have a certain width, visual attention was considered to be spatially limited. For example, Eriksen and colleagues (Eriksen & Eriksen, 1974; Eriksen, Pan, & Botella, 1993) showed that efficient selectivity of target stimuli flanked by distractors was proportional to the distance of distractors from the target (thus, distractors that fell outside the "spotlight" had a lower negative impact on selectivity). A variation on the spotlight metaphor was the *zoom lens* metaphor, prompted by research showing that the width of attention could be manipulated to include more or fewer elements from the visual field (see Eriksen & Murphy, 1987; LaBerge, 1983).

The main debate associated with this model concerns the degree to which the movement of the attentional spotlight was driven mainly by the locations of stimuli or by the features of the stimuli themselves (object-based attention; see for example Treisman & Gelade's 1980 *Feature Integration Theory*; Arrington, Carr, Mayer, & Rao, 2000; Duncan, 1984; Vecera & Farah, 1994). This debate survived even after the spotlight metaphor was largely abandoned but at present it appears to be generally accepted that the two mechanisms are complementary, rather than two mutually exclusive models of attention (see Treisman, 1999; Yantis & Serences, 2003).

As attention research became increasingly complex, the spotlight metaphor was gradually abandoned. The phenomenon was also partly due to evidence showing that attention did not behave like a true spotlight in all instances. For example, there were findings indicating that distractors grouped by common motion could override spatial proximity (they impaired performance despite their high distance from the target; Driver and Baylis, 1989), or that attention could be split across different spatial locations (Castiello & Umiltà, 1992; Kramer & Hahn, 1995).

4.2.1.4 Attention as the result of competition

This model of attention was born – on the one hand – under the influence of accumulating knowledge about the neural mechanisms of attention and – on the other hand – under the influence of connectionist/computational modeling (Feldman & Ballard, 1982; Itti & Koch, 2001; Lee, Itti, Koch, & Braun, 1999; Rumelhart, McClelland, & the PDP Research Group, 1986; Tsotsos et al., 1995). Research from these fields showed that attention could be realistically and successfully modeled as an emergent property of competition (generated by local lateral inhibition) between the units of an artificial neural network. The units that "won" this competition represented attended stimuli, while those that "lost" (i.e., were inhibited), represented the unattended, ignored, stimuli (Desimone & Duncan, 1995; Fernandez-Duque & Johnson, 2002). This type of conceptualization of attentional mechanisms can still be found in current models of attention (Desimone & Duncan, 1995; Miller & Cohen, 2001; see Biased competition models discussed below). However, the modeling work conducted nowadays is based more and more on neurobiologically-plausible models (see e.g., Itti & Koch, 2001).

4.2.1.5 Summary and conclusion

Thus, early research viewed attention as a unitary phenomenon, and attempted to generate predictions based on models adopted mainly from technology. However, with the advancement of knowledge about the multiple contexts in which attention can influence performance, as well as the development of new methods for investigating cognition and the brain, two main trends of change started to appear. First, the landscape of attention research diversified, as researchers became more and more aware of the fact that attention was not a unitary function, but rather a set of functions (see e.g., Allport, 1993; Pashler, 1998a, 1998b). Second, with the advancement of methods such as EEG, PET and fMRI to complement the traditional lesion research, interest in the brain mechanisms of attention increased (see e.g., Itti, Rees, & Tsotsos, 2005; Kanwisher & Wojciulik, 2000; Parasuraman, 1998; Pessoa, Kastner, & Ungerleider, 2003; Posner, 2004; Posner & Rothbart, 2007; Shipp, 2004). These changes do not imply that attentional metaphors have died out completely. Terms like "resources", "filter" or "spotlight" are still very much used in publications, but they tend to have a descriptive – rather than a predictive – function.

4.2.2 Varieties (functions) of attention in current research

Current research acknowledges more than ever the fact that attention is not a unitary process and that attempting to formulate a single theoretical account of it is virtually impossible at this point (see Itti, Rees, & Tsotsos, 2005; Pashler, 1998b; Posner, 2004 for examples of the degree of diversity pervading the field). While this might have been a beneficial change for the progress of the field, it also had the effect of turning attention into an extremely fragmented phenomenon, with different functions and different "local" theories for them.

While identifying the main early conceptualizations of attention is a relatively straightforward task, presenting a comprehensive review of current theorizing and models is a task that goes beyond the scope of this thesis – and would probably require another entire book to be accomplished (see e.g., Pashler, 1998a; Styles, 2006 for such extensive reviews).

Therefore, we will only focus on some of the main functions that are actively investigated currently. However, even this is not an easy task, as there have been few systematic attempts to formulate taxonomies of attentional functions (see Leclercq, 2002; Neumann & Sanders, 1996; Plude, Enns, & Brodeur, 1994; Posner & Rothbart, 2007; Sturm & Willmes, 2001) and there is at present no generally agreed-upon taxonomy of attention. The issue does not seem to be of central importance to most researchers in the field, since there is no active debate concerning what the main functions of attention might be, for example like the debate that took place around the issue of how many executive functions there are, what the main ones are, etc. (see e.g., Miyake et al., 2000; Visu-Petra, 2008 for reviews).

Thus, here we present a tentative classification of attentional functions, based on sources from both the adult (e.g., Posner & Raichle, 1997; Sturm & Willmes, 2001) and developmental literature (Plude et al., 1994; Ruff & Rothbart, 1996). Sturm and Willmes (2001) distinguish between intensity aspects of attention (i.e., aspects related to its energetic basis: alertness, sustained attention), and the more complex aspects of attention, dealing with selection (i.e., focused and divided attention). Plude et al. (1994) proposed three organizing dimensions for a taxonomy of attention: sensory modality (visual, auditory, etc.), degree of distribution (focused versus divided attention), and the type of task accomplished (orienting, filtering, searching, expecting). Posner and collaborators (see e.g., Posner & Petersen, 1990; Posner & Fan, 2008; Posner & Raichle, 1997) proposed a model that includes the functions of alerting, orienting and executive attention.

Since most anxiety-related attention research, as well as most developmental research to date has been conducted from the perspective of focused (as opposed to divided) attention, we will not discuss functions associated with divided attention here. This aspect of attention has been briefly discussed above (see the limited resource metaphor of attention) but it is not relevant for the current thesis (for reviews see Braun, 1998; Pashler & Johnson, 1998). We will also avoid discussing the "expecting" function discussed by Plude et al. (1994), as it involves memory mechanisms along with the attentional ones.

Thus, in what follows, we will present and discuss functions of visual attention, taking into account the "intensive" functions of alertness and sustained attention and the selective functions of orienting, searching and filtering. To these, we have added executive attention, viewed as a function of selective attention. We also summarize these functions in Table 4.1, indicating the main experimental paradigms used to investigate them, as well as the degree to which they have been investigated in the context of anxiety.

Alertness. The basic requirement for a proper functioning of attentional mechanisms is the ability to achieve and maintain a level of arousal that is optimal for detecting and processing external stimulation (Posner & Petersen, 1990; Posner & Boies, 1971; Posner & Rothbart, 2007; Raz & Buhle, 2006). This can be accomplished either due to external sources of stimulation (for example, a sudden car horn will automatically alert a person to the proximity of a moving vehicle, and subsequently cause them to orient towards the source of the noise; see below the discussion on orienting), or endogenously (if the person had detected the approaching car due to voluntarily increasing their own level of alertness they approached the road crossing). The first type of alertness has been termed *phasic* alertness, while the second is also known as *intrinsic* (or *tonic*) alertness (Posner & Petersen, 1990; Posner, 2008; Sturm & Willmes, 2001). In most real-life situations, alertness is difficult to separate from other attentional functions (most notably from orienting). In laboratory tasks, phasic alertness is assessed by asking participants to respond to a target stimulus which is preceded by a warning signal (in the form of a visual or auditory stimulus; Callejas, Lupiáñez, & Tudela, 2004; Coull, Frith, Büchel, & Nobre, 2000; Coull, 2004; Coull & Nobre, 1998; Coull, Nobre, & Frith, 2001; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Posner & Boies, 1971; Rueda, Fan et al., 2004). In order to separate alerting from orienting, this signal contains only temporal information regarding the target stimulus, but no indication regarding its location (i.e., it informs "when" the stimulus will occur, not "where"). Typically, detection of the target is facilitated (as indicated by faster responses and fewer errors) when the warning signal is present as opposed to the situation when it is not. Intrinsic alertness is indexed by reaction times and errors in the situation when the target is presented without a previous warning (Mottaghy et al., 2006; Posner & Petersen, 1990; Posner & Raichle, 1997;

Sturm et al., 1999; Sturm & Willmes, 2001; Sturm et al., 2004). Since no warning is given, attention needs to be sustained internally and focused on the task. Most of the time, phasic and intrinsic alertness are assessed within the same task, but often intrinsic alertness is used merely as a baseline condition to determine the efficiency of phasic alertness (e.g., Fan et al., 2002).

Sustained attention. While it is rather easy to briefly increase alertness after a warning signal, it becomes relatively difficult (more effortful) to maintain this state of readiness for a long time. Sustained attention refers to the ability to maintain a state of focus/readiness to respond to infrequent stimuli occurring at unpredictable intervals over extended periods of time (Coull, Frith, Frackowiak, & Grasby, 1996; Koelega, 1996; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Parasuraman, Warm, & See, 1998; Riccio, Reynolds, Lowe, & Moore, 2002; Sarter, Givens, & Bruno, 2001). Sustained attention is also known as *vigilance* (Koelega, 1996; Oken, Salinsky, & Elsas, 2006; Parasuraman et al., 1998; Sarter et al., 2001; but see Leclercq, 2002 for a different opinion) and has often been equated with tonic alertness (Oken et al., 2006; Posner, 2008; Posner & Boies, 1971), based on evidence that they might be subserved by the same right-lateralizatied network (Posner, 2008; Posner & Petersen, 1990; but see Sturm & Willmes, 2001 for a different opinion).

Experimental paradigms used to assess sustained attention typically require simple detection of infrequent targets over a long testing session (Koelega, 1996; Parasuraman et al., 1998), but they can also involve different additional requirements (see Riccio et al., 2002 for examples). In the first sustained attention experiment, Mackworth (1950; cited in Parasuraman et al., 1998) asked participants to report unpredictable, infrequent, double jumps of a clock pointer, as opposed to more frequent single jumps; the task involved a 2-hour observation session. A more recent widely used group of experimental paradigms are the so-called Continuous Performance Tests (CPTs; DuPaul, Anastopoulos, Shelton, Guevremont, & Metevia, 1992; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956 see Riccio et al., 2002 for a review). In the classic version of this paradigm, participants are presented with letters, one at a time and required to respond by pressing a button every time an “X” appears on the screen, but to refrain from responding to any other letter (Rosvold et al., 1956, cited in Riccio et al., 2002). Many variations of this task exist, which can use numbers, words, pictures instead of letters, as well as different variations in response criteria (see Riccio, Reynolds, & Lowe, 2001 for the many possible variations, and their use in clinical/neuropsychology contexts; see Table 4.1 for some examples). Dependent variables in sustained attention research typically focus on measures of vigilance (RTs, correct detection/hit rates, misses and false positives). An additional important element constitutes the deterioration seen in all these measures as time passes – i.e., vigilance decrements (Koelega, 1996; Parasuraman et al., 1998). CPTs have been widely used as tools in the assessment of ADHD, traumatic brain injury, or other neurological problems (Riccio et al., 2002).

Selective attention: Orienting. This is one of the most investigated functions of attention (Corbetta, 1998; Posner, 1980; Posner, Walker, Friedrich, & Rafal, 1984; see Wright & Ward, 2008 for an extensive review). This function relates to the spatial aspect of selectivity. It comes into play when relevant stimuli occur outside the current focus of attention (Posner & Fan, 2008), and it allows the allocation of attentional resources (or moving of the “attentional spotlight”) to that stimulus and away from others (Corbetta, 1998; Corbetta & Shulman, 2002; Klein & Shore, 2000; Posner & Fan, 2008; Raz & Buhle, 2006). Orienting to a new stimulus can be accomplished either in an overt (accompanied by eye movements) or in a covert manner (attentional orienting takes place in the absence of eye movements) (Corbetta, 1998).

Additionally, attentional shifts can be initiated either from exogenous sources (such as the car horn in the phasic alertness example), or endogenous ones (e.g., an arrow pointing the exit of a building; Klein, 2004; Klein & Shore, 2000; Posner, 1980). The most widely used task for investigating orienting is the spatial cueing task proposed by Posner (1980). In it, participants are asked to detect the occurrence of a target stimulus that can appear in one of two symmetrical locations. The target stimulus is preceded by a cue, appearing in the same position as the target (valid cue), or in the opposite location (invalid cue). Typically, participants give slower responses (and make more errors) to targets that have been invalidly cued, because they need to disengage their attention from the invalid location and move it to the correct one. Variations of this paradigm have been used in numerous studies and have helped the increasing understanding of attention in general – at a cognitive, as well as a neurocognitive level (see Corbetta & Shulman, 2002; Wright & Ward, 2008 for reviews).

Selective attention: Searching. The searching function of attention reflects a very common situation frequently encountered in every day life, such as, for example, visually searching for a friend in a room full of people. Thus, searching helps us adapt to the fact that we cannot process large numbers of objects at the same time: it allows us to direct attention sequentially across the visual field until we reach the sought item (Sanders & Donk, 1996; Treisman & Gelade, 1980; Wolfe, 1998, 2010; see also Treisman, 2006 for a review). The classic experimental paradigm used for investigating this function is the visual search task. In it, participants are presented with displays in which several stimuli are either randomly arranged or placed in a circle. Participants are required to report on the presence or absence of a target stimulus among "distractor" stimuli, whose number can vary. When the to be found stimulus can be differentiated from the distractors based on a single feature (e.g., a red stimulus among green distractors), people tend to find the target quickly (it "pops out"), and detection speed tends to be independent of the number of distractors (something that has been classically called "parallel" search; Treisman & Gormican, 1988; Treisman & Gelade, 1980). When the stimulus is differentiated from the rest by a conjunction of two or more features (e.g., a red square among blue squares and red triangles), search is "serial"; i.e., it is more difficult, and speed is proportional to the number of distractors.

Selective attention: Filtering. Filtering is the prototypical example of selective attention, and this is probably why often it is referred to as simply "selective attention" (e.g., Desimone & Duncan, 1995; Lavie, 2005). Filtering refers to the mechanisms involved in processing certain objects or attributes at the expense of others, or, in other words, focusing on a certain task and ignoring irrelevant information (Carr, 2004; Desimone & Duncan, 1995; Driver, 2001). It is a function that comes into play when relevant and irrelevant stimuli compete for attentional resources (Desimone & Duncan, 1995). Underlying this aspect of attention is – as indicated by Myiake and collaborators (Friedman & Miyake, 2004; Miyake et al., 2000) – the executive function of "resistance to distractor interference", that is, the ability to inhibit irrelevant stimuli. An inability to do so effectively can result in increased distractibility and compromised performance. It should be noted, though, that what we understand here as filtering is often identified in the literature under the more generic name of selective attention (see e.g., Lavie, 2005).

Many examples of filtering experimental paradigms can be found in the literature concerning the filtering and the spotlight metaphors of attention. However, one of the paradigms most often used currently to study filtering is Eriksen's flanker task (Eriksen & Eriksen, 1974). In the original version of the task, participants were presented with a target letter, displayed alone or flanked on both sides by distractor letters. They were required to press one button if the target letter was an H or a K, and another button if the letter was an S or a C. The relationship between the target and the flankers was manipulated in various ways, by making distractors either identical with the target, compatible (e.g., an H flanked by Ks), incompatible (e.g., an H flanked by Cs), or completely irrelevant (an H flanked by various letter that bore no relationship with the response). The latter condition is most relevant for the filtering function of attention. There are currently several other versions of this task (e.g., Enns & Akhtar, 1989; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Ridderinkhof, van der Molen, Band, & Bashore, 1997; Rueda, Fan et al., 2004), and most have replaced Eriksen's original letter version with non-verbal stimuli. Other types of tasks used to study filtering may involve presenting the target and distractor superimposed (e.g., Rees, Russell, Frith, & Driver, 1999; Rock & Gutman, 1981; Yi, Woodman, Widders, Marois, & Chun, 2004), presenting target words or pictures accompanied by distracting words or pictures (e.g., Bishop, Duncan, Brett, & Lawrence, 2004; Eysenck & Byrne, 1992; Vuilleumier, Armony, Driver, & Dolan, 2001), or a central task accompanied by peripheral distractors (e.g., Forster & Lavie, 2008; Lavie & Cox, 1997; Schwartz et al., 2005).

Selecting responses: Executive attention. Along with the orienting and the searching functions, executive attention is among the most investigated aspects of attention. It is also strongly linked to filtering: while filtering represents the ability to focus on the target task and inhibit irrelevant stimuli, executive attention involves selecting the appropriate motor response and inhibiting the inappropriate one (Posner & DiGirolamo, 1998).

Executive attention tasks generally tap the prepotent response inhibition function (Friedman & Miyake, 2004), but most of the time, selecting the appropriate response necessarily also implies being able to inhibit irrelevant stimuli or stimulus dimensions. Tasks that assess executive attention typically create a conflict between the target dimension of the display (to which the person must respond), and the irrelevant dimension (which is associated with a response that interferes with the required response). The prototypical tasks used to measure executive attention are the Stroop task (Stroop, 1935; see also MacLeod, 1991 for a review), Simon's spatial conflict task (Simon & Berbaum, 1990) and, again, Eriksen's flanker task (Eriksen & Eriksen, 1974). In the classic version of the *Stroop task*, participants are presented with words printed in different colors and required, for each word, to name the color of its print (a baseline condition can involve reading the words). The relationship between the word and its print can be manipulated in several ways, in order to generate a "neutral" stimulus (e.g., XXXX printed in red), a "compatible" (RED printed in red) or an "incompatible" one (GREEN printed in red). In other words, what this task does is to manipulate the level of conflict between the name of the color word and the color of the print. More precisely, since most people tend to automatically read the word, in order to perform successfully in this task, they need to inhibit that response and activate the less automatic response of naming the color. Typically, participants take longer to respond and are less accurate in the incompatible condition. There are currently numerous versions of the Stroop task, including the emotional version widely used in anxiety research (e.g., Becker et al., 2001; Egner & Hirsch, 2005; Mathews & MacLeod, 1985; Williams et al., 1996), and it is possibly the most widely used executive attention task. The *spatial conflict task* (Simon & Berbaum, 1990) follows the same logic as the Stroop task. Participants are presented with stimuli on the left- or right-side of the display (letters, geometrical figures, images, etc.). The stimuli belong to two categories, each associated with a left- or right-hand response. Conflict is generated by manipulating the relationship between the side of the response and the side where that stimulus appears on the display (see Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Gerardi-Caulton, 2000; Liu, Banich, Jacobson, & Tanabe, 2004, for examples of this task). As in the Stroop task, longer reaction times and lower accuracy are typically recorded when there is a conflict between response location and stimulus location. While the *flanker task* was originally designed as an experimental tool in the early versus late selection debate (Eriksen & Eriksen, 1974), in most current research it is used as an executive attention task (see Fan et al., 2002, 2003; Ridderinkhof, 2002; Ridderinkhof, van den Wildenberg, Wijnen, & Burle, 2004; Rueda, Fan et al., 2004), with emphasis placed on the RT and accuracy differences between the compatible and incompatible conditions. Another task – less frequently used in the context of executive attention – is the *antisaccade task* (Everling & Fischer, 1998; Hallett, 1978), which consists of presenting a stimulus in a peripheral location on the display, and requiring the participant to inhibit the reflexive saccade towards that stimulus and instead initiate a saccade to the symmetrically opposite location. We have included this task here since – like the other executive attention tasks – it involves a conflict between a prepotent response and a less well-practiced one.

To conclude, attention is not a unitary phenomenon in current research, but one with many aspects and functions. Here we have attempted to briefly present the main possible varieties of attention that can be encountered in current research. However, although we have discussed these functions separately, in everyday life they greatly overlap, and function in concert to insure efficient cognitive functioning.

4.3 Development of attention

Most of the research in attentional development has focused on infancy (see Colombo, 2001; Johnson, 2002; Richards, 1998, 2003 for reviews), which is understandable considering the role of attention in early learning (e.g., Carpenter, Nagell, Tomasello, Butterworth, & C. Moore, 1998; Smith, Colunga, & Yoshida, 2010). While in infancy the scope of investigated attentional functions has been relatively wide, starting with toddlers and preschoolers, the focus has been mostly on executive attention, as a consequence of the general increasing interest in the development of executive functions (see e.g., Carlson, 2005; Davidson, Amso, Anderson, & Diamond, 2006; Gerardi-Caulton, 2000). However, based on the available literature, we will attempt to sketch the developmental path of each attentional function discussed above in the case of adults.

Alertness. It has been suggested that this attentional function is fundamental to the development of other, higher-level, more complex attentional mechanisms (Sturm & Willmes, 2001). Despite this assertion (which, it should be noted, is rooted in adult neuropsychological research – see Sturm, Willmes, Orgass, & Hartje 1997), there has been very little developmental research regarding this function. However, this suggestion is a plausible one, since neurocognitive systems that insure an (optimal) increase in arousal might support the subsequent development of orienting, sustained attention, filtering, etc. Additionally, alertness brought about by novel events in the environment might support exploration and learning (Ruff & Rothbart, 1996). Phasic alertness appears to be functional in infancy already before the age of 2-3 months, as infants' attention can be readily engaged by novel and/or salient stimuli (Colombo, 2001; Ruff & Rothbart, 1996), and there is relatively consistent evidence that these episodes of attentional engagement are also accompanied by changes in arousal (namely, heart deceleration; see Berg & Richards, 1997; Richards, 2003, 2008 for reviews). There is very little research on alertness in older children, but phasic alertness appears to improve during the preschool years (Mezzacappa, 2004) and it is relatively stable during middle childhood, with no significant differences between children and adults (Rueda, Fan et al., 2004). However, children up to the age of 10 years find it difficult to maintain attention on the task in the absence of a warning cue (i.e., intrinsic alertness), and this ability appears to continue to develop until adulthood (Berger, Jones, Rothbart, & Posner, 2000; Rueda, Fan et al., 2004).

Sustained attention. Episodes of focused, sustained attention can already be seen in infants at 3-6 months (Colombo, 2001; Richards, 2003, 2008; Ruff & Rothbart, 1996), as indicated by the marked heart rate deceleration associated with these episodes, and the indication that these deceleration episodes are associated with less distractibility (Richards, 1987, 2008; Richards & Gibson, 1997). The ability to maintain attention once engaged is important for learning, as indicated by improved recognition memory for stimuli presented during these episodes (Richards, 2008). The development of executive abilities that starts around 12-18 months insures that the child has more and more control over how long he/she maintains attention focused on a task (Richards, 2008; Ruff & Rothbart, 1996).

Sustained attention during free play makes important leaps from 2 to 5 years of age (but there's little change after 3.5 years – Ruff, Capozzoli, & Weissberg, 1998), in the sense that children are increasingly able to focus on the same toys for longer periods of time, and show fewer and fewer episodes of inattention within the same time interval (Ruff et al., 1998; Ruff & Capozzoli, 2003; Ruff, K. R. Lawson, Parrinello, & Weissberg, 1990). In laboratory tasks such as the CPT, steady improvements (improved vigilance, slower vigilance decrements) have been found from 3 to 5 years (Akshoomoff, 2002; Corkum, Byrne, & Ellsworth, 1995) and from 5 years up to around 10-12 years, when the development of sustained attention appears to reach a plateau (Betts, Mckay, Maruff, & Anderson, 2006; Curtindale, Laurie-Rose, Bennett-Murphy, & Hull, 2007; Lin, Hsiao, & Chen, 1999).

Orienting. The ability to move attention from one location to another is already functional in infancy. Around 2-3 months, children become capable of disengaging their attentional focus from an uninteresting or distressing stimulus (Johnson, McGrath, & McNeil, 2002; Richards, 2003; Ruff & Rothbart, 1996). Orienting is probably one important component in the development of joint attention. In older children, most evidence to date indicates that – at least in the 3-11 year interval – there are some developments in orienting (especially when it comes to endogenous – as opposed to exogenous – orienting), but in general orienting performance is comparable to that of adults (Akhtar & Enns, 1989; Brodeur & Enns, 1997; Enns, Brodeur, & Trick, 1998; Iarocci, Enns, Randolph, & Burack, 2009; Lane & Pearson, 1983; Pearson & Lane, 1990; Ristic & Kingstone, 2009).

Searching. Infants as young as 3 months can successfully perform parallel (feature) searches (Colombo, Ryther, J. E. Frick, & Gifford, 1995), and it seems that infants and toddlers up to 3 years present search patterns analog to the ones found in adults, with relatively flat slopes for feature searches and linear increases with distractors for conjunction searches (Gerhardstein & Rovee-Collier, 2002). However, there is also evidence for age-related improvements in visual search (Donnelly et al., 2007; Enns & Cameron, 1987; Hommel, Li, & Li, 2004; Plude et al., 1994). For example, Trick and Enns (1998) found that compared to adults, children aged 6-10 years were slower for conjunction search, indicating that moving their attention voluntarily from one target to another was more difficult for them. More recent research (e.g., Donnelly et al., 2007; Hommel et al., 2004) tends to confirm these findings: speed of search tends to increase from 6 years on until young adulthood, and the tendency of children to be slower is more pronounced in conjunction search. Additionally, the mere presence of distractors appears to affect children negatively, whereas adults are more affected by their number.

Filtering. The development of the ability to filter out distracting stimuli has been investigated in relation with sustained attention in infants and preschoolers. As already mentioned, infants are less likely to be distracted during episodes of sustained attention – as described by Richards (2003, 2008), and more distractible once their heart rates start returning to baseline. However, until around 12-18 months, focused attention is mostly under the influence of automatic mechanisms, as it tends to manifest maximally in the presence of novel objects, and it disappears after 2-3 minutes (Ruff & Rothbart, 1996). After 12-18 months, executive (top-down) control systems start to come into play gradually (Ruff & Rothbart, 1996) making toddlers and preschoolers increasingly able to resist distraction: during free play, children of 2-5 years show fewer and fewer episodes of distraction within the same time interval – i.e., looking or moving away from toys (Ruff et al., 1998; Ruff & Capozzoli, 2003; Ruff & K. R. Lawson, 1990). However, until the end of middle childhood, the ability to focus attention and ignore distractors is still undergoing development (Akshoomoff, 2002; Enns & Akhtar, 1989; Enns & Girgus, 1985; Pastò & Burack, 1997; Plude et al., 1994; Roebers, Schmid, & Roderer, 2010). Laboratory tasks (such as variations on the flanker task) indicate that compared to adults, children are significantly more affected by the mere presence of visual distractors (Akshoomoff, 2002; Enns & Akhtar, 1989; Pastò & Burack, 1997; Plude et al., 1994), and 4-5-year-olds are especially vulnerable to distraction (Akshoomoff, 2002; Pastò & Burack, 1997). However, the age at which the efficiency of filtering is similar to that of adults is not clear. One influence on improved distractor filtering is likely to be the ability to control the dimensions of the attentional "spotlight" or "zoom lens". This ability is underdeveloped in children aged 4-5 years, who tend to be distracted by irrelevant stimuli placed close as well as far from the target stimuli. However, children above the age of five appear to posses this control ability: just like adults, they are only affected by distractors placed close to the target stimulus (Enns & Girgus, 1985; Pastò & Burack, 1997; Ridderinkhof et al., 1997).

Executive attention. The development of executive attention is often confounded with the development of executive functions (see e.g., Rothbart, Posner, & Kieras, 2006). While this is not necessarily wrong, it does complicate things for someone attempting to treat executive attention as a separate (legitimate) attentional function. Compared to the other attentional functions, executive attention is probably the most investigated in children, especially in preschoolers. As already stated, its development parallels the development of executive functions linked to the prefrontal cortex (Colombo, 2001; Luciana, 2003; Posner & Rothbart, 1998; Rothbart et al., 2006; Zelazo et al., 2008) and it is assumed to continue until adolescence. However, as will be discussed in more detail in Chapter 5, there is some evidence that – at least in the flanker task – behavioral performance reaches adult levels around the age of 7 years (Rueda et al., 2004), while other studies, using a variety of tasks (Davidson et al., 2006; Huizinga, Dolan, & van der Molen, 2006; Ridderinkhof & van der Molen, 1995; Simonds & Rothbart, 2006), have found performance improvements up to age 13.

To conclude, it appears that for most attentional functions development begins in early infancy. However, the first signs of filtering, sustained attention, etc. are largely automatic, since they are driven mostly by characteristics of the external stimuli, and less by internal, voluntary control mechanisms. The development of more effortful (i.e., top-down) forms of attentional modulation begins after the age of 12 months – when the first signs of executive control start to emerge (Diamond, 1991; Wellman, Cross, & Bartsch, 1987) – and appears to continue until at least early adolescence (Davidson et al., 2006; Huizinga et al., 2006). These two aspects of attentional modulation – the automatic, effortless one, and the controlled one – have a great tradition in research on adult attentional functioning (although, as usually, there seems to be little overlap between the developmental and adult literatures). They are also the mechanisms that the ACT suggests might be out of balance in anxiety. Therefore, we next review the most important models of top-down and bottom-up attentional regulation.

4.4 Models of top-down and bottom-up attentional modulation

What we perceive as well as what we react to depends critically on what we pay attention to. However, our attention can be engaged in different ways. On the one hand, attention can be drawn to external stimuli due to the fact that they "pop out" from their background (e.g., a red poppy flower in a grass field), due to their novelty, due to the fact that they appear suddenly, or due to well-learned associations (e.g., a spider can automatically draw the attention of a spider-phobic) (Corbetta & Shulman, 2002; Desimone & Duncan, 1995; Yantis, 1998). This occurs when attention is modulated by *bottom-up* or *stimulus-driven* processes. These processes are assumed to be automatic, i.e., they do not require voluntary control, and they almost invariably lead to the activation of certain cognitions or behaviors in response to certain stimuli or their characteristics (Schneider & Shiffrin, 1977; see also Schneider & Chein, 2003). In other words, stimulus-driven processes are reflex-like.

On the other hand, attentional resources can be allocated to external stimuli based on the person's conscious goals (e.g., a child focusing his/her attention on the homework and filtering out the sound of TV coming from the other room). In such situations, attention is regulated by *top-down* or *goal-driven* processes. These are considered controlled processes, i.e., voluntary, flexible, and resource-limited (Schneider & Shiffrin, 1977; Schneider & Chein, 2003). Most models of top-down control assign the PFC a key role in this type of processing (Duncan, 2001; Miller, 2000; Miller & Cohen, 2001; Ridderinkhof, Vandenwildenberg, Segalowitz, & Carter, 2004; Ridderinkhof et al., 2004; Wood & Grafman, 2003 for reviews). This assertion is based on essential characteristics of the structure and connectivity of the PFC. First, it has rich interconnections (feed-forward and feed-back) with sensory, limbic and motor areas (allowing for both integration of multimodal information as well as top-down modulation) (Fuster, 2008; Miller & Cohen, 2001). Second, there are rich interconnections between the subdivisions of the PFC, allowing for the intermixing of information. Third, PFC neurons are highly adaptive to behaviorally relevant features in the environment (Duncan, 2001; Miller & Cohen, 2001), which allow it to encode the task set (task requirements), but also to actively maintain them "on-line" – even across delays – for as long as it is needed (Fuster, 2008; Goldman-Rakic, 1996; Miller & Cohen, 2001).

There are several models of bottom-up and top-down modulation of attention. In what follows we review some of them. Our choice is based on their relevance for attention research in general (the fact that they have generated clear lines of research and that they are frequently cited), and for ACT in particular (i.e., they have been cited by Eysenck et al., 2007, as essential for the way they conceptualize top-down and bottom-up processing).

4.4.1 The contention scheduler/supervisory attentional system model

Norman and Shallice's (1986) model is one of the classic models in cognitive psychology. According to the terminology used by the authors, any behavioral or cognitive act is the result of the activation of a certain “action schema”. Action schemas can be either inhibited or activated, and when their level of activation exceeds a certain threshold, they are executed. Norman and Shallice’s model (see also Shallice, 1988) states that there are two mechanisms that govern the manner in which action schemas are executed, and, therefore, the automatic or controlled nature of thought and action. The first such mechanism is the *contention scheduler* (CS), which deals with routine, automatic behavior and cognition. It activates certain action schemas or their sub-components and inhibits others, but this activation/inhibition is triggered automatically, based on the person’s prior learning history with external stimuli or sequences of mental operations or actions. In other words, the contention scheduler is responsible for decentralized, peripheral control of behavior. Its function is similar to that of the lateral inhibition present in connectionist models, in the sense that it occurs between units present at the same level and it is triggered by direct input from the environment and associations between units.

However, there are situations in which deliberate control of action is necessary, such as in tasks that involve planning or decision making, tasks that involve elements of troubleshooting, activities that are not well learned or contain new action sequences, difficult or dangerous actions, or activities that require overcoming strong automatic responses or resisting temptation (Norman & Shallice, 1986). In such situations, a second system – the *Supervisory Attentional System* (SAS), which has access to the intentions and goals of the organism – intervenes to modulate the selection of action schemas, by overriding the influence of the CS. Shallice (1988) suggests that the primary function of the SAS is to help generate planned (as opposed to impulsive, automatic) responses in novel situations. As a consequence, an impairment in the operation of the SAS would result in a dominance of the CS over behavior, manifesting in two apparently contradictory behavioral tendencies: perseveration (due to the CS’s rigid dependence on environmental triggers and its tendency to carry out routine operations in a routine fashion) and increased distractibility (in the absence of modulatory influences from the SAS, the CS would be easily “captured” by irrelevant stimuli in the environment). Based on evidence from human patients and monkeys with frontal lesions, Norman and Shallice suggested the frontal lobes as the most likely location for the SAS. Later, Shallice, Burgess, and Robertson (1996) suggested fractionating the SAS into different sub-mechanisms (strategy generation, episodic memory retrieval, error monitoring, problem solving and intention generation) corresponding to different PFC areas. However, the nature and location of these functions were never clearly specified.

While Norman and Shallice’s model is still often cited (especially the SAS component), it has been criticized for its emphasis on novel situations as the most relevant context for the intervention of the SAS, as well as for its failure to sufficiently specify the components of the model on a neurofunctional level (see Wood & Grafman, 2003 for such a critique).

4.4.2 Posterior / Anterior attention systems

While the previously presented model lacked clear hypotheses about the localization of its component systems, Posner and Petersen's (1990) model was built specifically on such research, taking into account both lesion studies (Posner & Dehaene, 1994; Posner & Petersen, 1990) and neuroimaging research (Posner & Dehaene, 1994; Posner & Fan, 2008). In its early version, this model proposed that attention was modulated by two different systems with relatively well-defined neurofunctional underpinnings. The first system – the *posterior attention system* (composed of the superior parietal cortex, pulvinar, and superior colliculus) – was postulated as responsible for responding to cues that increase readiness to detect and process sensory events in the environment either because they signal the spatial location of the event or because they signal when the event will occur, without indicating where. The second system – the *anterior attention system* – was associated primarily with the anterior cingulate cortex. It was initially suggested that the anterior attention system was involved in target detection under conditions of focused attention, for the purposes of conscious, active processing (e.g., processing of the significance of words; Posner & Petersen, 1990). However, later accounts (e.g., Posner & Dehaene, 1994; Posner & DiGirolamo, 1998) linked this attentional system to selective attention, conflict managing, error detection and generally to cognitive control.

As more research evidence accumulated, this initial model was expanded, and a new model emerged. In this latter model there is less explicit emphasis on the top-down/bottom-up aspects of attentional modulation, and more on three different functions/networks of attention: alerting, orienting and executive attention. These three attention networks were presented in Posner and Petersen's (1990) initial model, but they were less clearly delineated (but see, e.g., Fernandez-Duque & Posner, 1997 for a clearer presentation of the alerting and orienting networks and their interaction; Posner & Rothbart, 2007 for a recent review of the main evidence accumulated regarding the three attentional networks). This latter version of the model will be reviewed in more detail in the next chapter.

4.4.3 Biased competition models

This approach to the problem of top-down and bottom-up modulation has its roots in the "competition" metaphor of attention, and it is represented by two strongly related models.

Desimone and Duncan (1995, see also Desimone, 1998) proposed that stimuli present in the visual field tend to compete for representation (i.e., neural responses) in the visual cortex. At the same time, adjacent stimulus representations tend to inhibit each other. Representations that "win" the competition remain active, while those that do not tend to be suppressed. However, if attention were modulated only by competition between stimuli, coherent behavior would be virtually impossible. Therefore, these competitive interactions can be biased in favor of one stimulus representation or the other through the intervention of different mechanisms (Desimone, 1998). *Bottom-up biases* represent "the intrinsic or learned biases of the perceptual system towards certain types of stimuli" (Desimone & Duncan, 1995; p. 201). Bottom-up biases most often reflect the sensory distinctiveness of certain stimuli in comparison with the visual context where they appear, or their novelty (Desimone & Duncan, 1995). Such stimuli tend to have a larger neural signal in the visual cortex, this giving them a processing advantage over other stimuli in gaining control over attentional and orienting systems. On the other hand, *top-down biases* derive from what the authors have termed the "attentional template", resulting from the individual's goals/intentions or what the task instructions prescribe as being relevant. The authors proposed that the attentional template is likely stored in the PFC, but they left the mechanisms through which the PFC contributes to the top-down bias unspecified.

A solution to this latter problem was proposed by Miller and Cohen (2001, see also Miller, 2000). Their model focuses on the PFC and its role in cognitive control in general (not just attention). They argue that one of the fundamental characteristics of top-down control relies in the ability to select a weaker response (or stimulus) relevant to the task, in the face of competition from stronger, but task-irrelevant ones. It is proposed that the PFC plays an essential part in this process, by biasing neural activity so that certain neural populations/pathways are more activated than others. Without its influence, behavior would be dominated by automatic reactions, subserved by the most frequently used neural pathways. However, Miller and Cohen (2001) state that the role of the PFC is only *modulatory*, not transmissive. In other words, no information pathway is assumed to run through the PFC. Rather, it acts more like a switch operator on railroad tracks, favoring certain neural pathways over others.

As already mentioned, the structure and functionality of the PFC indicates that it is capable of representing and actively maintaining current task goals even in the face of delays. Moreover, due to its feedback connections, it is capable of sending excitatory signals to stimulus processing or motor areas, based on these actively maintained representations. It is through these excitatory feedback signals that the PFC is presumed to bias the competition in favor of the weaker (but more task-relevant) stimulus-response mappings. At the level of the visual cortex, some of the effects attributed to directing attention in a top-down manner include enhancement of cell activations corresponding to the attended stimulus, filtering out or eliminating the suppressive effects of competing (but task-irrelevant) stimuli, and enhancing baseline neural activity in processing areas even in the absence of a stimulus (e.g., when the individual expects a stimulus to occur) (Kastner & Ungerleider, 2000; Kastner, De Weerd, Desimone, & Ungerleider, 1998; Kastner, Pinsk, De Weerd, Desimone, & Ungerleider, 1999). In other words, according to biased competition models, the PFC controls behavior by enhancing the relevant representations/responses, *not* by inhibiting the irrelevant ones. Inhibition only takes place between stimuli or responses represented at the same level in the neural architecture.

Direct evidence for biased competition models is thus far limited. However, the development of new statistical methods for determining coupling between brain areas ad assessing causal directionality look promising (see Miller & D'Esposito, 2005 for a review). Recently, Buschman and Miller (2007) – using a visual search paradigm in monkeys – were able to bring more direct evidence in support of biased competition. More precisely, when the task involved top-down control, the PFC was activated first, while an area of the monkey parietal cortex (the lateral intraparietal area) was activated first during the bottom-up condition. Thus, it appears that activation was driven by different areas depending on the degree of cognitive control required by the task.

4.4.4 Attentional capture models

Within this approach – as in most models discussed above – attention is considered *goal-driven* (or “active”) when it is controlled by the person’s current plans, goals and intentions (Yantis, 1998). However, this line of research focuses mostly on stimulus-driven/bottom-up modulation of attention, and its relationship with goal-driven/top-down attention.

One of the central attentional phenomena assumed to be (mostly) under bottom-up control is *attentional capture*, reflected in involuntary, automatic, shifts of spatial attention, elicited by the sensory features of external stimuli (Egeth & Yantis, 1997; Remington, Folk & McLean, 2001; Yantis, 1998), or more precisely, the sensory distinctiveness of a stimulus within its spatial or temporal context. This distinctiveness can be represented by salient differences between the stimulus and its surroundings, abrupt luminance transients, abrupt occurrence and/or novelty (Pashler, Johnston & Ruthruff, 2001). Thus, attentional capture is a form of *stimulus-driven* (or “passive”) attention, since it is controlled by some salient attribute of the stimuli the person is viewing, an attribute that is not necessarily relevant to the person’s goals (Yantis, 1998). In other words, stimulus-driven attention provides a mechanism through which cognitive resources can be reallocated irrespective of task goals. While this mechanism may appear non-adaptive, it is very useful in situations that require fast redirecting of attention (e.g., situations involving sudden danger) as it allows the organism to engage attentional resources without the need to monitor for important unexpected events in a deliberate manner (Remington et al., 2001).

Most research on attentional capture has used visual search or spatial orienting experimental paradigms. Early evidence and theory appeared to indicate that the phenomenon was influenced exclusively by stimulus characteristics: the time necessary to locate a target decreased when the target was perceptually distinctive, and it increased when the distractors were perceptually distinctive (see Treisman & Gormican, 1988 for an example). However, at the beginning of the 1990s contradictory evidence started to emerge. More precisely, Folk and collaborators (Folk, Remington, & Johnston, 1992; Folk, Remington, & Wright, 1994) were the first to show that attentional capture by distracting stimuli tends to occur only if these stimuli share certain properties with the target. For example, distractors represented by red bars tend to capture attention when the target is a red "X", but not when the target is an "X" that appears suddenply. Thus, completely irrelevant distractors (that do not share any property with the target) appear to be less successful in capturing attention (see e.g., Connor, Egeth & Yantis, 2004; Remington et al., 2001;Yantis & Egeth, 1999 for more recent similar results). Based on these results, Folk et al. (1992) concluded that even involuntary attentional capture is under some degree of top-down control, and proposed a new theory of attentional capture – the *contingent orienting theory* – reflecting the fact that attentional capture is contingent upon the top-down goals of the task.

However, in parallel with evidence supporting the contingent orienting theory, some laboratories found data indicating that, in fact, irrelevant stimuli *can* capture attention in a completely bottom-up manner, especially in the early stages of attentional processing (see Theeuwes, 2005; Theeuwes, Kramer, Hahn, & Irwin, 1998 for the most important evidence supporting this view). While the debate is still ongoing, recent research has brought even stronger evidence showing that purely stimulus-driven attentional capture is possible (Beck & Kastner, 2005; Lamy & Zoaris, 2009).

4.4.5 Top-down and bottom-up modulation of (spatial) attention

This model was proposed by Corbetta and collaborators (see Corbetta, Patel, & Shulman, 2008; Corbetta & Shulman, 2002 for reviews). Although it can be extended to a wide range of attentional phenomena (see the ones discussed in Corbetta & Shulman, 2002), most of the evidence discussed and generated within the context of this model reflects an emphasis on spatial attention.

Corbetta and Shulman (2002) defined *top-down processing* as referring to attentional responses influenced by "cognitive" factors (knowledge, expectations, goals) rather than sensory stimulation and represented at a neural level as the flow of information from higher- to lower-order centers. Based on lesion, neuroimaging, and more recent methods for inferring causality at the neural level, they proposed that top-down attentional processing is modulated by a dorsal frontoparietal network (the dorsal posterior parietal and frontal cortex), whose activity was recently shown to modulate activity in the visual cortex in a top-down manner (Bressler, W. Tang, Sylvester, Shulman, & Corbetta, 2008). The second type of modulating influence on attention – *bottom-up processing* – refers to information flowing from neural sites recording sensory inputs to the motor output, without involving any feedback information flow. As in other models discussed above, this type of processing reflects sensory stimulation, and it is involved in detecting especially events/stimuli that are "new and unexpected" (Corbetta & Shulman, 2002).

Bottom-up processing is regulated by a ventral frontoparietal network (involving the temporoparietal junction and the ventral frontal cortex).

Corbetta and collaborators suggest that the main function of the bottom-up, ventral network is to act as a "circuit breaker", interrupting allocation of attentional resources to the task at hand and redirecting them towards the new, unexpected stimuli (Corbetta et al., 2008; Corbetta & Shulman, 2002). In other words, this network accomplishes a function similar to the attentional capture phenomenon described in the previous approach. Recent experimental and computational research has suggested a similar function for Posner's posterior attentional system (Aston-Jones & Cohen, 2005; Posner & Fan, 2008; Posner, Petersen, Fox, & Raichle, 1988). However, while Posner's model would predict that the main activator of the bottom-up system is the mere salience of external events, recent research suggests otherwise (Corbetta et al., 2008; Kincade, Abrams, Astafiev, Shulman, & Corbetta, 2005). More precisely, in line with the contingent orienting theory, a sensory salient stimulus appears to activate the ventral network when it is also relevant to the task, but not when it is completely irrelevant (Kincade et al., 2005). While the previously discussed approach emphasized situations when attentional capture does take place, Corbetta et al. (2008) focused also on situations when salient stimuli fail to activate the ventral network (and to distract attention). They hypothesized that the individual's focusing on the task is probably associated with a *suppression* of the ventral network through a sustained top-down signal (however, it is not clear whether this signal originates in the dorsal network or some other part of the frontal cortex). It is noteworthy that, contrary to the predictions of biased competition models (i.e., that top-down control *enhances* task-relevant content), Corbetta's model predicts that top-down control is involved in the suppression of irrelevant content.

4.4.6 Summary and conclusion

The models discussed above share many commonalities, but also have some differentiating aspects. First, from a neurophysiological (or implementational – see Miclea, 1999) point of view, most models identify the PFC (or at least some of its structures) as a key element in generating top-down control signals (see Desimone & Duncan, 1995; Miller & Cohen, 2001; Norman & Shallice, 1986; Posner & Petersen, 1990). As discussed previously, there is evidence that the structure and functionality of the PFC might justify such an assumption, although other research and models indicate that the issue of top-down control might be more complex (e.g., Corbetta et al., 2008; Corbetta & Shulman, 2002; Lauritzen, D'Esposito, Heeger, & Silver, 2009). On the other hand, sources of bottom-up signals seem to derive either from the visual cortex (Desimone & Duncan, 1995) or from more clearly specified neural networks (Corbetta et al., 2008; Posner & Petersen, 1990). However, it is likely that these are linked to the type of attentional function investigated within that model. One point where models do not seem to agree is the exact influence on top-down modulation over lower-order representations. More precisely, while some models suggest that the function of top-down signals is to enhance task-relevant representations in the face of competition from distractors, which would implicitly result in inhibition at the lower level (see the biased competition models of Desimone & Duncan, 1995 and Miller & Cohen, 2001), other models propose that top-down signals actively suppress processing of distracting stimuli (Corbetta et al., 2008).

Second, from a cognitive and behavioral perspective, all these models tend to agree that top-down modulation of attention derives from the person's ability to maintain active the goal(s) of the task and act accordingly, while bottom-up allocation of attention can take place when external stimuli have certain characteristics that make them distinct. Thus, at this level of description, intervention of top-down or bottom-up mechanisms can be inferred from the task requirements, the characteristics of the stimuli, and the individual's performance. For example, if the task is to respond to centrally presented stimuli and ignore any peripheral distractors, attention to central stimuli is considered a top-down phenomenon, and any consistent performance decrements registered in the presence of distractors can be considered an effect of bottom-up mechanisms and/or a failure of top-down regulation (Frith, 2005). However, in this case, it is not clear whether such distractors might always be effective: some authors suggest that they need to share some characteristics with the target stimuli in order to disrupt performance (Folk et al., 1992; Remington et al., 2001), while others maintain that sufficiently distinctive stimuli can capture attention even when they are completely irrelevant to the task (Theeuwes, 2005). On the other hand, bottom-up attentional modulation need not always be disruptive. When stimuli with attentional capturing properties are the target stimuli themselves, or signals for the occurrence of the target stimuli, performance can be facilitated (compared to the situation when top-down control is employed). In fact, several authors suggest that the role of the bottom-up system is highly adaptive (e.g., Corbetta et al., 2008; Remington et al., 2001; Yantis, 1998): reallocating attention to potentially important events in a quick, effortless manner. However, when such attentional capturing properties are absent, optimal performance can be sustained through the intervention of voluntary, effortful mechanisms.

Very likely, most attentional functions discussed above are modulated by both bottom-up and top-down influences, although perhaps in different proportions (see Corbetta et al., 2008; Desimone & Duncan, 1995; Sarter et al., 2001; Theeuwes, Atchley, & Kramer, 2000; Wilson, Smith, & Holmes, 2007 for such discussion regarding the functions of searching, filtering, orienting and sustained attention). While these modulating influences are no yet clearly understood for all attentional functions, approaching these functions from the perspective of top-down/bottom-up mechanisms, might facilitate their investigation from the perspective of anxiety.

4.5 Attentional functions, top-down/bottom-up modulation and anxiety

In Table 4.1, we have summarized – for each attentional function – the research that has investigated it in anxiety, using emotional or non-emotional stimuli, in adults and children (see the last two columns of the table). The first aspect that can be noticed from inspecting the table is the almost complete lack of research in children, at the level of almost every function. Searching and executive attention are the most well represented, but even here, there is less research than in the case of adults. However, even in the case of adults, with the exception of searching and executive attention which have been investigated in the context of threat-related attentional biases (see paragraph 4.1.1), research is relatively scarce and present mostly in the context of emotional stimuli.

Of course, lack of research on a topic does not necessarily represent a valid reason to start investigating it. However, we believe that better knowledge of the way attention works in anxious persons might help increase understanding of the threat-related bias phenomenon, as well as, possibly, other cognitive phenomena associated with anxiety (such as, for example, WM deficits; Ashcraft & Kirk, 2001; Hadwin, Brogan, & Stevenson, 2005; Visu-Petra, 2008). Additionally, knowing whether attentional development follows a different path in anxious individuals, might help us understand how some of these phenomena emerge, and might help design interventions for preventing them.

The few studies investigating general attentional mechanisms that have started to appear recently (e.g., Dennis & Chen, 2007, 2009; Moriya & Tanno, 2009), have focused on a triad of attentional functions – alerting, orienting and executive attention – proposed by Posner and collaborators (Posner & Boies, 1971; Posner & Fan, 2008; Posner & Petersen, 1990; Posner & Raichle, 1997; Posner & Rothbart, 2007). This is the model we will focus on in the next chapter[12]. We chose it because it allows the assessment of all three attentional functions within one testing session. Additionally, it has received plenty of research interest in recent years (from outside anxiety research), and therefore there is a lot of evidence that can aid in data interpretation. Apart from this model, in Chapter 6 we chose to investigate the problem of distractibility in anxiety from the perspective of the filtering function, and we chose one of the most prominent current models for this function – namely Lavie's (Lavie, 2005; Lavie & Tsal, 1994) perceptual load theory. In both cases, we kept the developmental, cross sectional approach we used in Chapter 3, by including samples of both children and adults.

The investigations presented in the following two chapters are largely exploratory (especially the studies included in Chapter 5). However, we tried to approach them – as much as possible – from the perspective of ACT, and the hypothesized imbalance between bottom-up and top-down attentional mechanisms. This implies that we started out with a general expectation of finding executive attention deficits, as well as deficits wherever attentional performance depended upon top-down control (in either emotional or non-emotional contexts). On the other hand, we expected that stimuli with characteristics that elicit bottom-up responses due to their salience would be detected faster and would interfere with performance more in participants with higher anxiety levels. While we define "salience" in accordance with the way it is understood in models of bottom-up/top-down processing (as sensory distinctiveness due to contrast, abrupt occurrence, novelty, etc.), in the context of anxiety salience also means "threat". We therefore consider both aspects of salience as being relevant for attentional performance in anxiety.

4.6 Chapter summary

In the present chapter, we started out by discussing the most robust attentional phenomenon associated with anxiety (at least in adults; the data is less clear in children), namely threat-related attentional biases and some of the theoretical models associated with it. We then discussed the recent Attentional Control Theory (Eysenck et al., 2007), which offers a more general perspective on the anxiety-attention relationship, by suggesting (among other hypotheses) a possible imbalance in bottom-up versus top-down attentional processing. Due to what we perceived as a limited interest in general attentional mechanisms from the anxiety research community, we then turned to fundamental attention research. We reviewed some of the early definitions of attention, as well as some of the main functions of attention investigated in current literature (in adults as well as children; see Table 4.1), and then focused on some of the most relevant models of bottom-up (stimulus-driven) and top-down (goal-driven) attentional modulation. Finally, we showed (Table 4.1) that most of the main attentional functions have been underinvestigated in anxiety – especially in the case of children. In the following two chapters, we focus on two different models of attentional functioning, namely Posner's (see Posner & Petersen, 1990; Posner & Petersen, 1990) triadic model of attention (combining

[12] Most of the research using this model has been published while we were gathering the data presented in Chapter 4.

alerting, orienting and executive attention), and Lavie's (see Lavie, 2005) perceptual load theory (a model of the filtering function).

Table 4.1

A summary of the main attentional functions, tasks used to asses them, and research that has investigated these functions in anxiety.

	Function	Main experimental paradigm(s)	Investigated in anxiety?	
			Adults	**Children**
Intensive aspects of attention	**Alertness** (intrinsic and phasic)	Detection of a target stimulus (either its spatial location or some other attribute) presented at variable intervals, in the absence of a warning signal (intrinsic alertness). *Warning task*: Detection of a target stimulus (spatial location or some other attribute) proceeded by a warning signal (phasic alertness). (In both cases, the target stimulus is presented in each trial). *Adults:* Posner & Boies (1971); Fan et al. (2002); Coull & Nobre (1998); Callejas et al. (2004); Sturm et al. (1999); Mottaghy et al. (2006) etc. *Children:* Berger et al. (2000); Rueda, Fan et al. (2004).	*Non-emotional stimuli:* Yes- • Null findings (Moriya & Tanno, 2009a). *Emotional stimuli:* Yes- • Higher phasic alertness linked to high state anxiety (Dennis et al., 2008)* • Null findings (Dennis & Chen, 2007, 2009; Finucane & Power, 2010)*	*Non-emotional stimuli:* No *Emotional stimuli:* No
	Sustained attention/ Vigilance	*Continuous Performance Tests (CPTs):* Detection of infrequent target stimuli, occurring at unpredictable intervals among other, non-target stimuli. Stimuli are presented sequentially, one at a time. They can be letters, numbers, geometric figures, etc. Examples: X-type CPT: Respond to “X”; ignore any other letter. AX-type CPT: Respond to “X”, but only when it is preceded by “A”. XX-type CPT: Respond to “X”, but only when it is preceded by itself. *Adults:* DuPaul et al. (1992); Parasuraman et al. (1998); Riccio et al. (2002); Koelega (1996) etc. *Children:* Laurie-Rose et al. (2005); Lin et al. (1999); Llorente et al. (2008) etc.	*Non-emotional stimuli:* No *Emotional stimuli:* No	*Non-emotional stimuli:* No *Emotional stimuli:* No

	Function	Main experimental paradigm(s)	Investigated in anxiety? Adults	Investigated in anxiety? Children
Selective aspects of attention	**Orienting**	*Spatial cueing task:* Detection of the location (up-down/left-right) of a target stimulus, preceded by an exogenous or endogenous, valid or invalid cue. (Usually, valid cues are more frequent than invalid ones; e.g., 80:20 %). *Adults:* Posner (1980, 1984); Corbetta (1998); Fan et al. (2002); Raz & Buhle (2006); Corbetta et al. (2000); Kincade et al. (2005) etc. *Children:* Pearson & Lane (1990); Berger et al. (2000); Rueda, Fan et al. (2004); Brodeur & Enns (1997); Ristic & Kingstone (2009) etc.	*Non-emotional stimuli:* Yes- • Slow orienting after a valid, exogenous cue (Moriya & Tanno, 2009b). *Emotional stimuli:* Yes- • Slow disengagement when angry or fearful faces are used as cues (Fox et al., 2001; Giorgiou et al., 2005) • Faster orienting after a valid, exogenous cue, after intertrial presentation of a sad or fearful face (Dennis & Chen, 2007)* • Null findings (Dennis & Chen, 2009; Dennis et al., 2008; Finucane & Power, 2010)*	*Non-emotional stimuli:* No *Emotional stimuli:* No
	Searching	*Visual search task:* Detection of the presence or absence of a target stimulus in a "crowd" of distractors. The target stimulus can be characterized by a single feature or a conjunction of features, and most often is present in 50% of trials. *Adults:* Treisman and Gormican, (1988); Wolfe (1998, 2010); Theeuwes, 2004; Leber & Egeth (2006); Lamy & Zoaris (2009) etc. *Children:* Trick & Enns (1998); Donnelly et al. (2007); Hommel et al. (2004); Booth et al. (2003) etc.	*Non-emotional stimuli:* No *Emotional stimuli:* Yes • Faster search for threatening stimuli (angry/fearful faces, spiders, etc.) versus neutral or positive ones (e.g., Öhman et al., 2001; Miltner et al., 2004**; Rinck et al., 2005** etc.). • Slower search for neutral targets among threatening distractors (e.g., Byrne & Eysenck, 1995; Gerdes et al., 2008**; Rinck et al., 2005** etc)	*Non-emotional stimuli:* Yes- • Null findings (Lubow et al., 2000**). *Emotional stimuli:* Yes- • Faster detection of presence (Waters & Lipp, 2008) or absence (Hadwin et al., 2003) of angry faces among neutral or happy distractors (7-11 years)

	Function	Main experimental paradigm(s)	Investigated in anxiety?	
			Adults	**Children**
Selective aspects of attention	**Filtering**	*Flanker task:* Detection of a target characteristic of a central stimulus (identity, direction, etc.), flanked by distractors. The relationship between the target and flankers can be manipulated in various ways. Any paradigm that requires the participant to focus on a target stimulus/task and ignore distracting stimuli. *Adults:* Lavie & Cox (1997); Schwartz et al. (2005); Reed et al. (1999); Eriksen & Eriksen (1974); Palmer & Moore (2009) etc. *Children:* Ridderinkhof et al. (1997); Enns & Akhtar (1989); Pastó & Burack (1997); Akshoomoff (2002); Roebers et al., 2010 etc.	*Non-emotional stimuli:* Yes- • Impaired frontal recruitment (activation) in the presence of distractors, but null behavioral findings (Bishop, 2009). *Emotional stimuli:* Yes- • Impaired frontal recruitment (activation) in the presence of fearful face distractors, but null behavioral findings (Bishop, 2004; Bishop et al., 2007). • Null findings (Peers & Lawrence, 2009; this study used only behavioral measures).	*Non-emotional stimuli:* No *Emotional stimuli:* No

	Function	Main experimental paradigm(s)	Investigated in anxiety?	
			Adults	Children
Selective aspects of attention	**Executive attention**	*Stroop task:* Naming the color of words that represent color names. *Spatial conflict task:* Responding (by pressing a left-hand or right-hand button) to the identity of a stimulus presented on the left or right side of the display. *Flanker task:* Detecting the target characteristic of a central stimulus (identity, direction, etc.), flanked by distractors. Distractors can be congruent (associated with the same response) or incongruent (associated with the opposite response) with the target stimulus. *Antisaccade task:* A target stimulus is presented in a peripheral location on the display. The requirement is to make a saccade to the opposite side of the display. *Adults:* Stroop (1935); Pardo et al. (1990); Bush et al. (1998); Botvinick et al. (1999); Ursu et al. (2009); van Veen et al. (2001); Eriksen & Eriksen (1974); Simon & Berbaum (1990); Fan et al. (2002, 2003); Hallett (1978); Everling & Fischer (1998) etc. *Children:* Davidson et al. (2006); Huizinga et al. (2006); Gerardi-Caulton (2000); Gerstadt et al. (1994); Carlson et al. (2005); Berger et al. (2000); Rueda, Fan et al. (2004); Ridderinkhof et al. (1997) etc.	*Non-emotional stimuli:* Yes- • Stroop task: - • Spatial conflict task: - • Flanker task: Null findings (Moriya & Tanno, 2009b; Reinholdt-Dunne et al., 2009). • Antisaccade task: Longer saccade latencies in high anxiety (Derakshan et al., 2009). *Emotional stimuli:* Yes+ • Stroop task: Longer latencies to name the color of threatening words/faces/images (e.g., Mathews & MacLeod, 1985; Williams et al., 1996; Becker et al., 2001**; Ruiter & Brosschot, 1994; Reinholdt-Dunne et al., 2009 etc.) • Spatial conflict task: - • Flanker task: Better executive attention in participants with high state anxiety following intertrial fearful faces (Dennis et al., 2008) or threatening images (Finucane & Power, 2010)* • Flanker task: Null findings (Dennis & Chen, 2007, 2009)* • Antisaccade task: Longer saccade latencies in high anxiety; more pronounced with angry (vs. happy/neutral) faces used as cues (Derakshan et al., 2009).	*Non-emotional stimuli:* No *Emotional stimuli:* Yes • Stroop task: Longer latencies to name the color of threatening words/faces/images (e.g., Taghavi et al., 2003**; Richards et al., 2000; Heim-Dreger et al., 2006 etc.) • Stroop task: Similar latencies to name the color of threatening words/faces/images (e.g., Kindt et al., 1997; Kindt & Brosschot, 1999**; Benoit et al., 2007** etc.)

Note: Yes- = We were only able to identify a limited number of studies, and all of them are mentioned in the table; Yes = We were able to find a relatively high number of studies (a few examples are included in the parentheses); Yes+ = There is a very large number of studies on this topic (a few examples from this larger pool are included in the parentheses); No = We were unable to identify any published study on this topic. These estimates were based on searches carried within several scientific databases (PsycInfo, PubMed, SpringerLink, ScienceDirect and Ebsco).

*Emotional stimuli – faces or scenes – inserted between trials containing non-emotional stimuli.
**Study with clinical participants (The unmarked references represent studies that have only measured trait anxiety).

Chapter 5.
Attentional networks, anxiety and self-regulation

As a means of investigating general attentional functioning in anxiety in contexts that do not require emotional processing, we decided to focus on the three attentional networks initially postulated by Posner and Petersen (1990), and described in later research as the alerting, orienting and executive attentional networks. As mentioned in the previous chapter, we chose this model because it allows us to focus simultaneously on three different attentional functions, belonging to the intensive and selective aspects of attention. Thus, in this chapter we present three studies (focusing, as before, on three developmental samples: preschool, middle childhood and young adulthood) in which we are attempting to determine whether attentional functioning in these three networks is altered as a function of anxiety, whether EC moderates anxiety-related attentional performance, or whether these attentional mechanisms are linked to self-regulatory skills (EC and ER).

5.1 The model

Reviewing data from animal studies, human neuropsychological studies and imaging in healthy participants, Posner and Petersen (1990) have outlined three neuroanatomical networks that subserve three different functions of attention. Posner and Raichle (1997) have further described these three attentional networks as accomplishing the functions of alerting (or vigilance), orienting and executive attention. The three attentional networks have been characterized at behavioral, neurofunctional, neuropharmacological and (especially in the case of the executive attention network) genetic level. The functions associated with these three attentional networks have been discussed briefly in Chapter 4, but here we will describe each network and we will review the evidence related to its functioning in more detail. Most research to date has focused on the orienting and executive attention network; therefore our presentation will start with them.

5.1.1 The orienting network

The attentional network with the longest research tradition is the orienting network. It modulates the selection of specific information from among multiple sensory inputs by allocating attentional resources to specific regions in (external) space and thus giving them preferential access to visual and cognitive routines that control behavior (see Corbetta & Shulman, 2002; Klein & Shore, 2000; Posner & Fan, 2008; Raz & Buhle, 2006 for reviews). The orienting function comes into play when relevant stimuli occur outside the current focus of attention (Posner & Fan, 2008).

Efficient orienting relies on the proper functioning of three component mechanisms: *disengagement* of attention from the current focus, *shifting* attention to a new location and *engaging* attentional resources at the new focus (Posner, 1980; Posner, Walker, Friedrich, &

Rafal, 1984). In ecological contexts, orienting is most often associated with head movements and/or ocular saccades to the target stimulation, i.e., *overt* orienting. However, attention can also be shifted in a *covert* manner, in other words in the absence of eye or posture changes. The neural areas associated with the two types of orienting are largely overlapping (Corbetta, 1998). Whether overt or covert, attentional shifts can be initiated either from *exogenous* sources, thus external to the individual, or *endogenous* ones – initiated by the individual. Exogenous orienting is considered a reflexive, automatic or bottom-up process, while endogenous orienting is a voluntary or top-down process (Klein, 2004; Klein & Shore, 2000; Posner, 1980).

As already discussed, the classic experimental paradigm for investigating visual orienting is the well-known Posner spatial cueing task (Posner, 1980). Participants are asked to detect a target stimulus presented in one of two possible symmetrical positions in the visual field. The target is preceded by a cue signaling its location either correctly (valid cue) or incorrectly (invalid cue). Responses are typically facilitated after valid cues compared to invalid cues. Thus, orienting efficiency is measured as the *cost* in reaction time associated with the invalid cue. Other versions of the task (e.g., Fan, McCandliss, Sommer, Raz, & Posner, 2002; Thiel, Zilles, & Fink, 2004) use only valid cues and measure orienting as the difference between a spatial (100% valid) cue and a central one (which has only an alerting function, thus providing no spatial information). The main difference between the two versions of the task is that while the validity manipulation allows for the assessment of global orienting efficiency (i.e., disengaging + shifting + engaging) the latter version captures mostly the shifting and engaging aspect. Another common variation across orienting paradigms is related to the exogenous/endogenous orienting distinction. This aspect is measured by manipulating the manner in which the location of the target is signaled. More precisely, in the case of exogenous orienting the spatial cue is presented peripherally, at the location where the target is expected (see Raz & Buhle, 2006 for examples), while for endogenous orienting the cue is presented centrally, and the potential target location is signaled through the cue's meaning – e.g., an arrow pointing right or left (see Coull, Nobre, & Frith, 2001; Posner, 1980 for two different versions).

The neurofunctional substrate of attentional orienting is relatively well understood. Several lesion and neuroimaging studies have contributed to clarifying the areas involved in disengaging (superior parietal lobe and the temporoparietal junction), shifting (frontal eye fields, superior colliculus), and engaging attention (the pulvinar and reticular nuclei of the thalamus) (Corbetta, Kincade, Ollinger, McAvoy, & Shulman, 2000; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Posner & Petersen, 1990; Posner et al., 1984; Raz & Buhle, 2006; Wojciulik & Kanwisher, 1999). Because the frontal and parietal areas are the most prominent structures involved in orienting, the entire network is often termed the "fronto-parietal" network. This network tends to activate even when variations are made to the classic cueing task. For example, Fan et al. (2005) found activations in these areas even when comparing the spatial (fully valid) cue with a centrally presented cue (i.e., in the absence of the validity manipulation). Moreover, a series of recent studies suggest that the fronto-parietal network involved in visual orienting to locations in external space might be involved in orienting in general (i.e., orienting attention to different mental contents, and orienting to different moments in time; Coull & Nobre, 1998; Griffin & Nobre, 2003; Nobre et al., 2004 see Nobre, 2004, for a review).

From a pharmacological point of view, orienting is modulated by the cholinergic system arising in the basal forebrain (see Beane & Marrocco, 2004; Coull, 2005 for reviews). This fact was demonstrated in studies showing that increasing acetylcholine levels in the brain, for example through administration of nicotine (an ACh agonist) speeds up orienting after an invalid cue (because it facilitates disengagement) (Murphy & Klein, 1998; Thiel, Zilles, & Fink, 2005; Witte, Davidson, & Marrocco, 1997). Decreasing ACh through administration of antagonist drugs such as scopolamine typically has an impairing effect: it increases response times and the validity effect (Davidson & Marrocco, 2000; Stewart, Burke, & Marrocco, 2001).

There is little evidence for heritability within this attentional network (Fan, Wu, Fossella, & Posner, 2001). However, a recent study by Parasuraman et al. (2005) shows the association of specific alleles of the CHRNA4 (a subunit controlling the nicotinic acetylcholine receptor polymorphism – nAChRs) with reduced validity costs.

5.1.2 The executive attention network

The executive control function of attention comes into play in situations requiring planning or decision making, situations that require making novel or not well-learned responses, detecting and correcting errors, potentially difficult or dangerous situations, and overcoming habitual behaviors (Fan et al., 2009; Norman & Shallice, 1986; Posner & Fan, 2008; Posner & DiGirolamo 1998). While this account of executive attention includes a rather diverse range of situations, what they have in common is the occurrence of conflicts between computations in different neural areas (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Bush, Luu, & Posner, 2000; Posner & DiGirolamo, 1998).

Executive attention has been traditionally assessed using tasks that capture the ability to detect and resolve conflict between stimuli, between stimuli and responses or between different motor responses (see van Veen, Cohen, Botvinick, Stenger, & Carter, 2001 for an example of how the different levels at which conflict arises can be manipulated and assessed). The prototypical tasks used to measure executive attention are the Stroop task (Stroop, 1935; see also MacLeod, 1991 for a review), Eriksen's flanker task (Eriksen & Eriksen, 1974), and Simon's spatial conflict task (Simon & Berbaum, 1990), which have been discussed in Chapter 4.

Performance in tasks tapping executive attention is associated with the function of the anterior cingulate cortex (ACC) and the lateral prefrontal cortex, most notably the dorsolateral part (DLPFC) (Fan, Flombaum, McCandliss, Thomas & Posner, 2003; Bush et al., 2000; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Fan et al., 2005). The ACC in particular is seen as playing a central role in executive attention. There is a widely accepted view of the structure and function of the different ACC subdivisions, indicating that the dorsal "cognitive" part consistently activates in cognitive conflict tasks, while the rostral-ventral "affective" part is more involved in affect-related tasks and in error detection (Bush et al., 2000; Carter & van Veen, 2007). Early perspectives on the involvement of the ACC in cognitive control viewed this structure as directly responsible for implementing top-down control/attentional selection (see e.g., Posner & DiGirolamo, 1998). More recently however, Botvinick and collaborators (Botvinick et al., 2001; see also Botvinick, Cohen, & Carter, 2004; Botvinick & Plaut, 2004) have suggested that the function of the ACC is merely to detect and signal the presence of conflict (most notably response conflict – see van Veen et al., 2001). This conflict signal then triggers compensatory top-down control mechanisms implemented by other neurofunctional sites, such as the DLPFC. This *conflict-monitoring hypothesis* has met with widespread support as several studies have found evidence for higher ACC activation in conflict versus non-conflict situations(Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Fan, Fossella, Sommer, Wu, & Posner, 2003; MacDonald, Cohen, Stenger, & Carter, 2000; Ursu, Clark, Aizenstein, Stenger, & Carter, 2009; van Veen et al., 2001). For example, MacDonald et al. (2000), manipulated instructions within the Stroop task ("read the word", or "name the color") and found that the

ACC was significantly more activated during the conflict (i.e., color naming) condition. The DLPFC was more active during response preparation in the high conflict condition. Botvinick et al. (1999; see also Casey et al., 2000 for a similar study) showed that the ACC is responsive to trial-by-trial changes in conflict and top-down control. By manipulating the sequentiality of congruent and incongruent trials, they were able to investigate the activation of the ACC in a situation involving high conflict with low top-down control, versus a condition involving low conflict with high top-down control. In line with the conflict detection hypothesis, the authors found significantly higher activation associated with high conflict situations rather than top-down control. Furthermore, a recent study (Ursu et al., 2009) showed that the ACC activates in high conflict situations even in the absence of awareness.

Moving beyond simple localization, a number of studies were able to identify some of the mechanisms behind conflict monitoring and the implementation of top-down control. For example, using the Stroop paradigm, Kerns et al. (2004) found that higher conflict-related ACC activation predicted higher DLPFC activity. Going one step further, Egner and Hirsch (2005) showed that while the ACC is indeed involved in detecting conflict, the DLPFC implements top-down control by amplifying the signal in the neural system primarily involved in processing the attended stimuli. They used a version of the Stroop task with name and face stimuli and manipulated the sequence of congruent and incongruent trials like in Botvinick et al.'s (1999) study. When participants were asked to attend to the faces (instead of the names) under conditions of high top-down control, there was a higher coupling between the DLPFC activation and that of the fusiform gyrus than in conditions involving low top-down control. On a functional level, conflict monitoring is also associated with a specific ERP component – the N2, a frontocentral potential having its most likely source in the ACC, and whose amplitude is larger in high-conflict situations (Nieuwenhuis, Yeung, Van Den Wildenberg, & Ridderinkhof, 2003; van Veen & Carter, 2002).

Pharmacologically, the executive function of attention is regulated by the dopaminergic system of the brain arising in the ventral tegmental area and projecting to the ACC and the LPFC (Fosella et al., 2002; Posner & Fan, 2008; Robbins et al., 2004). Deficits in this system have been associated with deficits in executive attention, most notably with ADHD symptoms (e.g., Grady, Moyzis, & Swanson, 2005; Swanson et al., 2000).

Compared to the other two attentional networks, the executive network appears to be associated with the highest degree of heritability (Fan et al., 2001). Moreover, in line with its modulation by dopamine, studies have found associations between better executive performance in the flanker task (Fossella et al., 2002), higher activation of the ACC (Fan et al., 2003) and polymorphisms of the dopamine D4 receptor (DRD4) gene and the monoamine oxidase (MAOA) gene.

5.1.3 The alerting network

The neural network subserving this function modulates the allocation of attentional resources in preparation for detecting and processing impending stimuli (Posner & Petersen, 1990; Posner & Rothbart, 2007; Raz & Buhle, 2006). In other words, as discussed in Chapter 4, alerting involves the ability to achieve and maintain a state of high sensitivity/readiness to incoming stimuli. Alerting is considered one of the more basic aspects of attention, and probably constitutes a prerequisite for the more demanding aspects, such as executive attention (Sturm & Wilmes, 2001).

As mentioned before, several authors distinguish between two types of alertness states: *intrinsic* (or *tonic*) *alertness* and *phasic alertness* (see e.g., Posner & Petersen, 1990; Posner & Boies, 1971; Sturm & Willmes, 2001). Intrinsic alertness has been equated to general wakefulness or arousal level (Sturm & Wilmes, 2001), but other authors indicate that this type of alertness might be more similar to sustained attention (the ability to maintain attentional focus on a task over an extended period), only assessed over a shorter time span (Oken, Salinsky, & Elsas, 2006). As discussed in Chapter 4, phasic alertness arises in situations when a warning stimulus temporally precedes the occurrence of the target stimulus, but without giving any information regarding the location where that stimulus will occur. In other words, intrinsic alertness is necessary in situations when stimuli need to be detected and processed in the absence of any attention-capturing warning cue, while phasic alertness represents short-term increases in attention and cognitive processing following a signal to attend. Intrinsic alertness is regulated endogenously whereas phasic alertness can be seen as extrinsically (or exogenously) regulated (Mottaghy et al., 2006; Sturm et al., 1999, 2004). This point of view has some support in the neurofunctional mechanisms underlying the two attentional states (see below). Viewed from the perspective of this distinction, Posner's (Posner & Petersen, 1990; Posner & Raichle, 1997) *alerting network* is assumed to be involved in regulating phasic alertness (Fan et al., 2009), with intrinsic alertness serving mostly as a baseline state. However, since both attentional states are relevant to our interest in anxiety, we will continue to discuss both.

Behaviorally, intrinsic alertness is operationalized as simple or choice reaction time (and/or accuracy) to the (un-warned) occurrence of a stimulus (e.g., Smith & Nutt, 1996; Sturm et al., 1999). By contrast, phasic alertness is measured using warning cues that signal the impending occurrence of the target stimulus without signaling *where* that stimulus will occur. Such warning cues are often visual (e.g., Coull et al., 2001; Fan et al., 2002; 2005; 2009; Périn, Godefroy, Fall, & Marco, 2009) or auditory (Callejas, Lupiáñez, & Tudela, 2004; Callejas, Lupiàñez, Funes, & Tudela, 2005), but in principle can belong to any sensory modality. Usually, in the assessment of phasic alertness the cued condition is compared with the uncued (intrinsic alertness) condition, and the *gain* associated with the warning cue (in terms of response speed or accuracy) is computed (e.g., Coull & Nobre, 1998; Fan et al., 2002).

Alerting is modulated by the noradrenergic system of the brain originating in the locus coeruleus and has been associated with the function of brainstem, thalamic, frontal and parietal regions (Fan et al., 2009; Raz & Buhle, 2006). Evidence suggests that while strongly related, intrinsic and phasic alertness have somewhat separate underlying neural mechanism. Thus, the network regulating phasic alertness is right lateralized, while intrinsic alertness appears to be associated mostly with the left hemisphere, as indicated by early studies of patients with unilateral lesions to the parietal and frontal lobes (see Posner & Petersen, 1990; Sturm & Willmes, 2001 for reviews). More recent neuroimaging research tends to support this lateralization, but it also confirms that the two networks are largely overlapping (Coull et al., 2001; Fan et al., 2005; Sturm et al., 1999; Thiel & Fink, 2007). In line with the idea that intrinsic alertness is probably regulated endogenously and subject to top-down control, some studies have found ACC and/or DLPFC activation during tasks assessing short-term sustained attention (Fan et al., 2007; Mottaghy et al., 2006; Sturm et al., 1999; see Singh-Curry & Husain, 2009 for a review). For example, Mottaghy et al. (2006) used structural equation modeling (SEM) to investigate network connectivity in an intrinsic alertness task, and found that the traditional fronto-parietal-thalamic-brainstem network activated in such tasks had as its main coordinating structure the ACC, namely its "cognitive division" (according to the terminology used by Bush et al., 2000). Based on their results, Mottaghy and collaborators suggested that endogenous (intrinsic) control of alertness might be seen as the most basic aspect of executive attention. Data from a study by Fan et al. (2007) appears to confirm this. While Mottaghy's study only included an intrinsic alertness condition (compared with two resting baseline conditions), Fan et al. compared uncued and cued conditions and found greater activation in the ACC and PFC associated with the former. This data indicates that intrinsic alertness is potentially a "top-down" process. However, a more recent study (Périn et al., 2009) appears to contradict Fan et al.'s findings. Perin and collaborators found strong correlations between the activations of the ACC and DLPFC and the gain in response speed induced by a warning cue as compared to an uncued condition. In other words, the structures involved in regulation of top-down control were more active in the phasic alertness state in Perin's study, in contrast to Fan et al. (2007), who found the opposite pattern. It is impossible to formulate a clear conclusion at this point, as the evidence regarding the neurofunctional operation of the alerting network is extremely scarce. From a behavioral/cognitive point of view, it is likely, as Fan et al. (2005) point out, that in situations when target stimuli are presented without warning, fast and accurate responding requires the endogenous (i.e., voluntary, top-down) maintenance of attentional focus on the task at hand.

Pharmacologically, alertness is modulated by noradrenaline, as indicated by the effects of noradrenergic α2 agonists such as clonidine and guanfacine (Coull, Frith, Frackowiak, & Grasby, 1996; Coull et al., 2001; Smith & Nutt, 1996; Witte & Marrocco, 1997). These drugs decrease arousal and thus have a general slowing effect on reaction time. They affect both intrinsic and phasic alertness responses, but tend to affect phasic alertness (especially clonidine) more (Coull et al., 2001). However, both clonidine and guanfacine affect alertness in a selective manner, with little impact on the behavioral correlates of orienting (Beane & Marrocco, 2004; Witte & Marrocco, 1997). Studies indicate that in humans the effects of these drugs can be reversed by increasing arousal through methods such as adding white noise in the person's environment (Coull, Jones, Egan, Frith, & Maze, 2004; Smith & Nutt, 1996). There are two other types of noradrenaline receptors that mediate the action of noradrenaline upon brain and behavior (α1 and β; Arnsten, 2007), but their involvement in intrinsic and phasic alertness is less clearly understood. Research on the effects of *high* arousal on intrinsic and phasic alertness is extremely limited, although there is evidence to suggest that dysregulation of the noradrenergic system might be involved in the pathogenesis of anxiety and depression (see Goddard et al., 2009 for a review).

Finally, at the genetic level there is some evidence for moderate heritability for the alerting network (Fan et al., 2001), but to our knowledge no study has looked for candidate genes associated with modulation of intrinsic or phasic alertness.

5.2 The independence and interaction of the three attentional networks

Based on this triadic model of attention, Posner and collaborators (see Fan et al., 2002) have designed the *Attention Network Test* (ANT), which allows for the simultaneous assessment of the efficiency of all three attentional networks (see Figure 5.1 for an illustration of the conditions involved in ANT). The task combines elements from Posner's cueing task (Posner, 1980) and Eriksen's flanker task (Eriksen & Eriksen, 1974) with elements introduced to assess alertness (see Fernandez-Duque & Posner, 1997 for an earlier version of the alerting manipulation). The ANT requires participants to respond to the orientation (left/right) of a target arrow presented centrally, above or below fixation, by pressing a button corresponding to it (e.g., the left or right mouse button). The target display is preceded by one of four types of cueing conditions: No Cue (the target stimulus appears without prior warning), Center Cue (an asterisk presented at fixation), Double Cue (two asterisks presented above and below fixation, at the levels where the target would normally appear), and Spatial Cue (an asterisk is presented above or below fixation, at the location where the target will appear). The cueing conditions are combined with three conditions of the target display: Neutral Flankers (the target arrow is presented alone), Congruent Flankers (the target arrow is flanked by two arrows on each side, pointing all in the same direction), and Incongruent Flankers (the target and flanking arrows point in opposite directions).

Based on these task conditions, performance indexes can be computed for each of the three attentional networks. An *alerting score* is obtained by subtracting the reaction times obtained in the Double Cue condition (i.e., phasic alertness) from reaction times obtained in the No Cue condition (i.e., intrinsic alertness). The *orienting score* results from the difference between reaction times in the Center Cue condition (which has only an alerting value) and reaction times in the Spatial Cue condition (in which the cue is always valid). The *conflict score* (corresponding to the efficiency of the executive attention network) is computed as the response time difference between the Incongruent Flanker and Congruent Flanker conditions. These scores can also be computed using accuracy data (rate of errors or correct responses). In short, the ANT allows for the measurement of alertness (both intrinsic and phasic), exogenous orienting, and executive attention. Fan and collaborators (Fan et al., 2002; 2005) showed that the ANT reliably measured the three attentional networks at the behavioral level (Fan et al., 2002), and had adequate validity in neurofunctional terms, as the areas activated in association with ANT task manipulations were largely similar to the activations traditionally associated with the three neural networks (Fan et al., 2005). Other versions of the ANT were further developed by Fan and collaborators (Fan et al., 2009; Fan et al., 2005) or by other research groups (e.g., Callejas et al., 2004; 2005).

Despite early suggestions for possible interactions between alerting, orienting and executive attention (Posner, 1994; Posner & Petersen, 1990), the idea that the three attentional networks are structurally and functionally independent gained prominence in the literature. This was probably due to the fact that early studies including simultaneous measures of at least two attentional networks (most frequently alerting and orienting) found no evidence for interactions between them, either behavioral (e.g, Fernandez-Duque & Posner, 1997), neurofunctional (Casey et al., 2000) or pharmacological (e.g., Beane & Marrocco, 2004; Casagrande, Martella, Di Pace, Pirri, & Guadalupi, 2006; Murphy & Klein, 1998). These results were largely replicated using the ANT, as Fan and collaborators found limited evidence for correlation or interaction between the three attentional networks at the behavioral level (Fan et al., 2002), and showed that the neural areas associated with the three functions were distinct, with little overlap between them (Fan et al., 2005). Additionally, the three attentional networks even appeared to have distinct patterns of EEG band oscillatory activity (Fan et al., 2007).

However, it is hard to believe that everyday attention involves the three functions in isolation. In fact, even Fan et al.'s (2002) original ANT study found a small interaction between the alerting and conflict networks, manifested as enhanced flanker interference after the presentation of an alerting cue. In line with this result, Fosella et al. (2002) found a correlation between the alerting and conflict networks. The initial interpretation offered by the authors pointed to a methodological explanation, pertaining to the design of the ANT. However, this interaction had in fact been predicted by Posner in an earlier review (Posner, 1994). More precisely, Posner had suggested that since the function of the alerting network is to speed up reaction to the target stimulus, this might be accomplished at the cost of detailed stimulus processing, thus resulting in a disruption of executive function. Additionally, Posner and collaborators (Fernandez-Duque & Posner, 1997; Posner & Petersen, 1990; Posner & Fan, 2008) also suggest that the alerting system acts upon the orienting system. Namely, phasic alertness (and activation of its neural network) is usually associated with co-activation of the orienting system. In an attempt to probe this and other potential interactions between the three attentional networks, Callejas and collaborators (Callejas et al., 2004; 2005) modified the ANT to allow for more independent measurement of the three attentional networks. Namely, they used a tone as the (phasic) alerting cue, and used both valid and invalid visual cues for the assessment of the orienting network. Their studies replicated the alerting × conflict interaction (i.e., the alerting cue disrupted responding to the conflict situation), but revealed two additional interactions: an interaction between orienting and conflict (valid cues facilitate responding to conflict, while invalid cues impair it), and an interaction between alerting and orienting, indicating that alerting enhances orienting, i.e., alerting induces a higher validity effect by speeding up responses to valid cues (Fuentes & Campoy, 2008). Fan et al. (2009), using a revised version of the ANT, recently replicated the alerting × conflict and the orienting × conflict interactions. There is some additional indication of more subtle interactions coming from pharmacological studies. Namely, it appears that while administration of nicotine does not affect alerting performance behaviorally (or has very subtle behavioral effects), it does however modulate BOLD responses in areas associated with alertness – mostly by increasing activation in areas associated with intrinsic alertness and decreasing it in areas associated with phasic alertness (Lawrence, Ross, & Stein, 2002; Rezvani & Levin, 2001; Thiel & Fink, 2007; Thiel et al., 2005).

5.3 Development of the three attentional networks

Three studies (Berger, Jones, Rothbart, & Posner, 2000; Rueda, Posner, Rothbart, & Davis-Stober, 2004; Rueda, Fan et al., 2004) demonstrated that the efficiency of attentional networks could be reliably measured in children aged 4-10 years. While Berger et al. assessed the efficiency of the three attentional networks using three separate tasks, (Rueda, Fan et al., 2004) developed a child-friendly version of the ANT. The child ANT is virtually identical to the adult version, except for the fact that the original arrow stimuli were replaced with yellow fish "swimming" to the right or to the left.

Using this version of the ANT, Mezzacappa (2004) found steady age-related improvements in all three attentional networks, from 4 to 7 years. However, across middle childhood (i.e., in 6- to 10-year-olds) Rueda, Fan et al. (2004) found that the alerting network was relatively stable, but it was significantly improved in young adults, indicating that the alerting network continues to develop into adulthood. Rueda et al. noted that in children with higher scores, these were mostly generated by the children's difficulty in the intrinsic alertness (i.e, No Cue) condition. This effect might be due to the low probability of occurrence of the No Cue condition (75% trials are cued, 25% are not). However, Berger et al. (2000) showed (in an alerting task with an equal number of cued and uncued trials) that in 5-year-olds even the efficiency of the alerting cue tends to wane if the interval between cue and target is above 500 ms, while the opposite effect is present in adults (Coull, 2009). This indicates that during childhood, the ability to endogenously maintain attention on the task at hand is still developing. On the other hand, phasic alertness can already be triggered in infants (see Colombo, 2001; Ruff

& Rothbart, 1996 for reviews). It is difficult, however, to clearly describe the normative development of alerting, as research focusing on children is very limited. This is unfortunate, since alerting mechanisms are probably fundamental in the development of "higher", more complex attentional mechanisms (Sturm & Willmes, 2001).

Far more research has been conducted on the development of visual orienting. Thus it is relatively well established that while reflexive (exogenous) orienting is already present in infants (see Colombo, 2001; Johnson, McGrath, & McNeil, 2002 for reviews) and appears to undergo little change over the lifespan, endogenous cueing is still developing during preschool and middle childhood. For example, Ristic and Kingstone (2009) showed that children aged 3-6 years had validity scores comparable to those of adults only when exogenous cues were used. This result was replicated in different samples of children with ages ranging from 5 to 11 years (Akhtar & Enns, 1989; Brodeur & Enns, 1997; Enns, Brodeur, & Trick, 1998; Iarocci, Enns, Randolph, & Burack, 2009; Lane & Pearson, 1983; Pearson & Lane, 1990). Most importantly, the similarity between child and adult performance was also found using the child ANT (Rueda, Fan et al., 2004). In line with this developmental constancy present at the behavioral level, evidence suggests that brain areas involved in exogenous orienting are almost fully functional by 6 months of age (Johnson et al., 2002). However, despite these similarities between children and adults, evidence suggests that a fully adult pattern of attentional orienting does not develop until around the age of 10-11 years (Brodeur & Enns, 1997; MacPherson, Klein, & Moore, 2003; Pearson & Lane, 1990).

The executive attention network is generally expected to develop throughout childhood and into adulthood, in accordance with the protracted structural and functional development of the prefrontal cortex and ACC in particular (Giedd et al., 1999; Lenroot & Giedd, 2006). However, on a behavioral level, performance in conflict tasks depends much on the interaction between a child's developmental level and the complexity of the conflict he/she has to monitor and resolve. For example, the type of conflict involved in the A-not-B task can already be solved by most children aged 12 months or older (Wellman et al., 1987). However, the type of conflict we are interested in was assessed in children mostly using tasks adapted from adult versions of the Stroop, spatial conflict (Simon), or flanker task. For example, in the spatial conflict task, conflict can already be reliably measured by the age of 2 (Gerardi-Caulton, 2000; see also Benga, 2004), and appears to reach a plateau in terms of accuracy (but not RT) around the age of 5 (Berger et al., 2000). Similar results have been found using versions of the Stroop task, with accuracy reaching high or ceiling levels around the age of 5 (Berger et al., 2000; Carlson, 2005; Gerstadt, Hong, & Diamond, 1994). However, the ability to resolve the type of conflict involved in the ANT is improving steadily from 3-4 years to around 7 years (Rueda, Fan et al., 2004) and possibly later (Simonds, Kieras, Rueda, & Rothbart, 2007). For example, Benga (2004) showed that clear performance improvements were present between age 3 and 7 in children's performance in the Day/Night Stroop (a task in which the child is asked to say "day" when shown a black card depicting the moon and the stars and "night" when shown a white card depicting the sun; Gerstadt et al., 1994) and in Luria's tapping task (in which the child is asked to tap once when the experimenter taps twice, and to tap twice when the experimenter taps once; Diamond & Taylor, 1996). However, most of the improvement in Luria's tapping task appears to occur by the age of 6 years, after which there is little change in children's performance (Diamond & Taylor, 1996). The ANT shows a similar picture: while 4-year-olds had clearly large conflict scores when compared to adults (Rueda, Fan et al., 2004), children's performance improved until around 7-8 years, after which it reached a plateau (Mezzacappa, 2004; Rueda, Fan et al., 2004). In fact, when Rueda and collaborators directly compared 10-year-old children with adults, they found no conflict score differences either in the child or adult versions of the ANT. However, a more recent study did find age-related improvements between 7 an 10 years (Simonds, Kieras, Rueda, & Rothbart, 2007) and there is considerable evidence that executive attention continues to develop at least until early adolescence, as indicated by research using more complex tasks (e.g., Davidson et al., 2006; Huizinga et al., 2006; Ridderinkhof & Molen, 1995; Simonds & Rothbart, 2006).

On a neurofunctional level, even after the age of 7, children appear to use different mechanisms to reach the same level of performance as adults in executive attention tasks. This was indicated in fMRI studies which showed that children aged between 7 and 12 activated different brain areas compared to adults in response to conflict (Booth et al., 2004; Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; Casey, Thomas, Davidson, Kunz, & Franzen, 2002; Durston et al., 2002; Konrad, Günther, Heinzel-Gutenbrunner, & Herpertz-Dahlmann, 2005). It is also likely that children rely on different mechanisms since a recent study has shown that functional connectivity within the ACC is reduced in children and adolescents compared to adults (Kelly et al., 2009).

As already mentioned, adult studies indicate that a certain degree of interaction exists between the three attentional networks. Until now, there appears to be little evidence of interaction in children (Konrad, Günther, Heinzel-Gutenbrunner, & Herpertz-Dahlmann, 2005; Rueda, Fan et al., 2004) – at least as far as middle childhood is concerned (we are not aware of any studies reporting on such interactions in other child/adolescent age groups). However, as pointed out by Rueda, Fan et al. (2004a), it is unreasonable to assume that the three attentional networks operate completely independently, and it is likely that the null results obtained in children are due to the small sample sizes used in both studies.

Thus, apart from one study indicating age-related improvements in all three attentional networks in preschoolers (Mezzacappa, 2004), most research indicates that the alerting network is stable in middle childhood but then develops until adulthood, reflexive orienting is relatively stable throughout the lifespan, and executive attention develops until around 7 years and possibly later. The developmental evidence regarding network interactions is at this point unclear.

5.4 Attentional networks and individual differences in self-regulation

The development of attention has been linked to the development of self-regulation both in terms of EC and ER (see Berger, Kofman, Livneh, & Henik, 2007; Posner & Rothbart, 2007; Rueda, Posner, & Rothbart, 2005 for reviews). These hypothesized links were founded on the assumption that self-regulatory abilities are behavioral reflections of the development of attention (Posner & Rothbart, 2007). Most research to date has focused on the relationship between executive attention and EC, generally indicating that children with better executive attention skills are also characterized by better EC abilities. This pattern was confirmed across different childhood developmental stages: in toddlers aged 2-3 years using the spatial conflict task (Gerardi-Caulton, 2000; Rothbart, Ellis, Rueda, & Posner, 2003), in preschoolers using Berger et al.'s (2000) methodology for assessing attentional networks (Chang & Burns, 2005), or Luria's tapping task (Blair & Razza, 2007) and in middle childhood using the child ANT (Simonds, Kieras, Rueda, & Rothbart, 2007). While there is general agreement regarding this link, at least one study failed to find a clear relationship between inhibition measured by a "Simon Says" type of task (in which children are presented with two toy animals and asked to do what one of them says, but not what the other animal says) and EC in 3- to 4-year-old children (Jones, Rothbart, & Posner, 2003).

It is reasonable to expect that attentional mechanisms contribute to the development of at least some ER strategies (e.g., avoidance, distraction). However, little research has examined the relationship between attentional networks and ER, despite some indications that this connection might begin early. For example, in infants aged 3 to 6 months of age, distress can be down-regulated by orienting the child's attention to a visual stimulus (Harman, Rothbart, & Posner, 1997). Thus, exogenous orienting might constitute a precursor to the more advanced distraction and/or avoidance strategies. Another study has recently shown that low conflict scores in the ANT (i.e., good executive attention) predict the ability to regulate the expression of disappointment in the disappointing gift paradigm in children aged 7-10 (Simonds, Kieras, Rueda, & Rothbart, 2007). Finally, some recent research points to the possibility that even other elements of emotional competence might be linked to the development of attentional networks. Thus, Geangu, Benga and Ionescu (2009) have found that the efficiency of alerting and orienting (as measured with the child ANT) were related to the ability to correctly identify and label emotional expressions of fear, sadness and anger in preschool children.

5.5 Attentional networks and anxiety

Apart from their normative functioning and development, the three attentional networks have also been investigated in disorders such as schizophrenia (Gooding, Braun, & Studer, 2006; Wang et al., 2005) and borderline personality disorder (Posner et al., 2002) in adults, ADHD in children (Konrad, Neufang, Hanisch, Fink, & Herpertz-Dahlmann, 2006) and adults (Oberlin, Alford, & Marrocco, 2005), and the 22q11 deletion syndrome in children (Sobin et al., 2004). In general, these studies have mostly found executive attention deficits associated with the disorders of interest.

The question of whether high levels of trait anxiety are associated with alterations in any of the three attentional networks has recently gained interest. Only a handful of studies have been published thus far and we are not aware of any research investigating these mechanisms in children. In addition, there is little theoretical background to support any specific hypotheses regarding basic attentional mechanisms that might be affected (or at least working differently) in anxiety. As already mentioned in the previous chapter, the Attentional Control Theory (ACT; Derakshan & Eysenck, 2009; Eysenck, Derakshan, Santos, & Calvo, 2007) is the only current theory attempting to describe the way attention functions in persons with high trait anxiety in general, not just in emotionally laden environments. One of the main hypotheses of this theory states that anxiety is associated with a dominance of bottom-up (stimulus-driven) attentional mechanisms to the expense of top-down (goal-driven, voluntary) ones. This indicates that – depending on how they are assessed – we might expect to find deficits associated with anxiety in all three attentional functions: (1) impaired ability to maintain intrinsic alertness and/or faster responding after a warning cue (phasic alertness), i.e., higher alerting scores; (2) faster reactions to exogenous orienting cues, and possibly higher validity scores; (3) impaired executive attention (although this might be true only in emotional contexts).

However, studies conducted thus far offer a rather mixed picture. For example, Moriya and Tanno (2009a) investigated both exogenous and endogenous orienting, using both valid and invalid cueing, in relation to social anxiety. They found that participants with high social anxiety had higher validity scores, but only in the exogenous orienting condition, which corresponds to our previous prediction. However, this was only true for accuracy, not RT scores. In a previous study using the classic version of the ANT (i.e., only exogenous valid cueing for orienting) Moriya and Tanno (2009b) found moderate *negative* correlations between measures of anxiety and depression and the orienting score. This finding indicates either a reduced facilitating effect of the spatial cue in capturing attention or possibly the presence of a delayed disengagement from fixation in participants with higher levels of anxiety/depression. The second interpretation would be in line with the slow disengagement hypothesis put forward by E. Fox (Fox, Russo, Bowles & Dutton, 2001; Fox, Russo & Dutton, 2002; Georgiou et al., 2005) in the context of threat-related attentional biases. In an earlier study, Compton et al. (2004) found that lower positive affect was associated with an increased validity effect but only at short (100 ms) cue-stimulus intervals (stimulus onset asynchrony - SOA). Compton and collaborators also found a link between high negative affect and high alerting scores (slower RTs to uncued trials and faster RTs to cued trials) at long (500 ms) SOAs, a finding that partially matches our previous predictions. As far as executive attention is concerned, there seems to be no clear relationship with anxiety, as indicated by a recent study (Reinholdt-Dunne, Mogg, & Bradley, 2009) that used the ANT.

Apart from this research measuring attentional functions with a relatively traditional methodology, a few recent studies have tested the potentially disruptive effects of inserting emotional stimuli (faces or scenes) between the trials of the ANT, and the potential interactions of these effects with state/trait anxiety. Dennis and collaborators (Dennis & Chen, 2007, 2009; Dennis, Chen, & McCandliss, 2008) used task-irrelevant fearful, sad or neutral faces as the inter-trial stimuli. They found an association between higher state anxiety and higher alerting scores irrespective of face valence, but reduced alerting (due to impaired phasic alertness) after the presentation of fearful faces in all participants (Dennis et al., 2008). They also found faster orienting to the spatial cue after the presentation of sad or fearful faces in participants with high trait anxiety (Dennis & Chen, 2007), and *better* executive attention in participants with high state anxiety following the presentation of fearful faces (Dennis et al., 2008). This latter finding was replicated in a similar experiment using fearful versus neutral images as the inter-trial stimuli (Finucane & Power, 2010). Here, both higher state and trait anxiety were linked to decreased interference from incongruent flankers in the fear-eliciting condition. ERP recordings during the ANT revealed that participants with high trait anxiety had a reduced modulation of the N2 potential as a function of flanker condition (Dennis & Chen, 2007, 2009). This indicated that high anxiety participants were characterized by inefficient use of conflict monitoring resources, or, in other words, an overactive conflict monitoring system (even during congruent trials). Interestingly, N2 modulation as a function of flanker condition was also related to improved alerting and executive attention, but this relationship was much weaker in highly anxious participants, due to their reduced N2 modulation.

It is reasonable to conclude at this point that research regarding the three attentional functions and their potential involvement in anxiety presents a somewhat confusing picture. However, we might try to sum up the studies reviewed above, while keeping in mind that the relationship between exogenous orienting and anxiety in adults might depend on task factors such as the SOA or presentation of emotional stimuli. Thus, improved executive attention appears to be linked to high anxiety but only in emotional contexts (Dennis et al., 2008; Finucane & Power, 2010; Reinholdt-Dunne, Mogg, & Bradley, 2009), and adults with high trait anxiety tend to over-monitor conflict (Dennis & Chen, 2009). The relationship between orienting and anxiety seems to depend on whether emotional cues are used or not [orienting is slow in neutral contexts (Moriya & Tanno, 2009b), but fast when the cue is preceded by an emotionally negative stimulus (Dennis & Chen, 2007)] and possibly on SOA manipulations. Lastly, there is some limited indication of a link between alerting and anxiety/negative affect, irrespective of emotional/neutral context (Compton et al., 2004; Dennis et al., 2008).

5.6 The present research

As already mentioned, we were unable to identify any published research investigating the three attentional functions in anxiety from a developmental point of view, and, as discussed in the previous chapter, research approaching attention and anxiety in non-emotional contexts from a developmental perspective is also rather scarce. However, such an approach is relevant for understanding the degree to which basic attentional mechanisms are altered as a function of anxiety symptoms. Since these mechanisms are used in everyday life, it is possible that subtle modifications in the way they work will affect everyday performance at least in tasks such as learning/studying and working. Our main objective was to investigate the links between anxiety and the three attentional networks in preschoolers, school age (middle childhood) children and adults. We were interested whether anxiety would be *directly* associated with functional alterations in attention, but also whether such a link would be moderated by EC (or any of its sub-dimensions). Second, since previous research suggests a relationship between attentional mechanisms and self-regulation, we looked at whether the functioning of the three attentional networks is related in any way with EC or ER strategies. Here we expected that high EC would be linked to good executive attention performance at all ages, but we were unable to make any other specific predictions due to the lack of previous research. As a third and minor objective, we were also interested in the pattern of ANT performance (including network interactions) specific for each age sample.

Since our objectives are largely exploratory in nature (due to the limited amount of previous research), on a methodological level we preferred to assess the three attentional networks using the original child and adult ANT tasks, without any major alterations. Additionally, in order to test the degree of specificity of the anxiety–attention relationship, along with measures of self-regulation we also included measures of temperamental NA and depression (as before, the latter measure was only available in the middle childhood and adult sample). In each of the three studies presented below, we first looked at the pattern of ANT performance, then at attention–self-regulation links, and finally at the relationships between anxiety and attention. Due to the high number of analyses, we preferred to focus primarily on reaction times as the dependent measure.

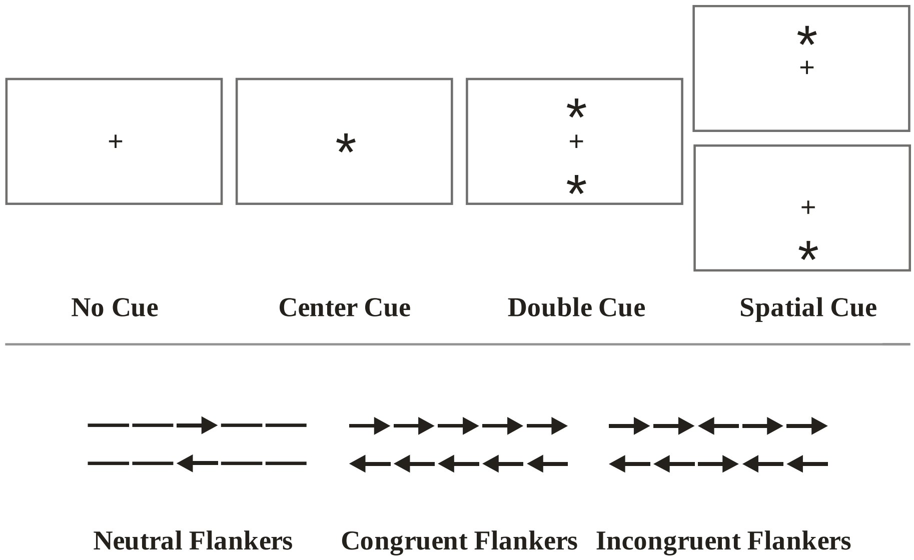

Figure 5.1. Illustration of the cue and flanker conditions involved in ANT (figure reconstructed after Fan et al., 2002).

5.7 Study 2A: Attentional networks and anxiety in preschoolers

5.7.1 Method

5.7.1.1 Participants

Children between four and seven years of age from two kindergartens in Cluj-Napoca were selected based on informed consents given by parents and child verbal assent. The children included in this study are a sub-sample of the preschool group included in Study 1A (Chapter 3). A total number of 225 parents were contacted initially with the aid of kindergarten staff. Out of 119 children whose parents consented to take part in the study and filled in questionnaires, a total of 18 children were eliminated from the main analyses presented here due to missing at least one of the variables of interest (N = 16) or child unwillingness to participate in ANT testing (N = 2). Additionally, one child was eliminated from the final analysis due to having a disproportionately high error rate (i.e., 97%). The final sample consisted of 97 children (48 girls) aged 4-7 years (M = 67.28 months; SD = 9.97; range = 50-86 months).

5.7.1.2 Measures

Anxiety

The Romanian version of the *Spence Preschool Anxiety Scale* (SPAS) was used as a measure of anxiety symptoms (Spence, Rapee, McDonald, & Ingram, 2001; see Benga, Ţincaş, & Visu-Petra, 2010 for the Romanian version). A detailed description of the SPAS can be found in Chapter 3, Study 1A. In the current sample, Cronbach's α coefficient for the total scale was .86.

Temperament

Parents were administered the Romanian version of the *Children's Behavior Questionnaire* (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001; see Benga, 2004 for the Romanian version; see Chapter 3, Study 1A for a detailed description of the questionnaire). For the purposes of the present study, we selected the sub-scales measuring Fearfulness (α = .67), Sadness (α = .60), Attentional control (α = .62) and Inhibitory control (α = .80), as well as the higher-order dimensions NA (α = .80) and EC (α = .82).

Emotion regulation

Children's ER strategies were assessed using Eisenberg's *Children's Coping Styles Questionnaire* (CCSQ; Eisenberg et al., 1993, 1995), described in more detail in Chapter 3, Study 1A. ER strategies were grouped here exactly as in Chapter 3, but we decided to include only the first three strategies from the previous study: (1) Active ER (Cognitive restructuring, Distraction, Instrumental coping; α = .79); (2) Passive ER (Emotional intervention, Avoidance, Venting; α = .82); (3) Aggressive ER (Emotional aggression, Instrumental aggression; α = .85).

Attentional networks

The child version of the Attention Network Test (Rueda, Fan et al., 2004) was used to assess the efficiency of the three attentional networks. The task is an adaptation of the adult ANT (Fan et al., 2002; see Figure 5.1). Rueda, Fan et al. (2004) replaced the arrows with yellow fish pointing right or left. The child is told that his/her task is to "feed" the target fish by pressing the mouse button corresponding to the direction in which the target fish "swims". Each trial starts with a central fixation cross (presented for 400-1600 ms), followed by a warning cue (an asterisk displayed for 150 ms), present in 75% of the trials, and then the target display (presented 450 ms after the offset of the warning cue). The target display consists of the target fish, presented centrally above or below fixation, alone or flanked by two other fish on each side. The child must respond within 1700 ms by pressing the left or right mouse button. The response is followed by a positive or negative visual and sound feedback.

Two variables are manipulated within the task: the type of warning cue given and the type of flankers used. The *cue conditions* are as follows: (1) No Cue; (2) Center Cue (one asterisk is displayed in the center of the screen); (3) Double Cue (two asterisk are displayed – one below, one above fixation) and (4) Spatial Cue (one asterisk, presented either above or below fixation, signaling the location of the target stimuli). The *target display* can be composed of either (1) the target fish presented alone (Neutral Flanker condition) or the target fish flanked by other fish (2) pointing in the same direction (Congruent Flankers), or (3) in the opposite direction (Incongruent Flankers).

The efficiency of the three attentional networks is determined by taking into account children's median RTs from correct trials and computing the differences between the different task conditions. More precisely, the scores for the three attentional networks are computed as follows:

Alerting = $RT_{No\ Cue} - RT_{Double\ Cue}$

Orienting = $RT_{Center\ Cue} - RT_{Spatial\ Cue}$

Conflict (executive attention) = $RT_{Incongruent\ Flanker} - RT_{Congruent\ Flanker}$

5.7.1.3 Procedure

Parents were contacted with the help of teachers. Each parent received a set of three questionnaires (SPAS, CBQ, and CCSQ) and an informed consent letter. Children whose parents agreed to take part in the study and returned all three questionnaires filled-in were further selected for testing with the child ANT.

Each child was tested individually by a female experimenter, in a quiet room inside the kindergarten. The task was administered using a laptop computer with a 15-inch display, with the screen resolution set to 1024 × 768. The left and right buttons of the mouse pad were used to collect responses. Children placed the index finger of each hand on the corresponding button. They were allowed to use more than one finger on each button if it was more comfortable for them. Instructions were given before the start of the task using cards depicting the possible target displays. The task started with a practice block consisting of 24 trials, during which each child received feedback and encouragement from the experimenter. The practice block was followed by three blocks consisting of 48 trials each. The entire task lasted approximately 30 minutes (including instructions and breaks). Upon task completion, each child received three stickers.

5.7.2 Results

5.7.2.1 Preliminary analyses

Before addressing the main research questions, we verified the presence of gender differences and correlations with age for Anxiety, temperament dimensions, and ER strategies. In addition, we conducted a separate analysis on the ANT data. Descriptive statistics for all measures of interest, for the entire sample and separated by gender, are presented in Table 5.1.

Gender and age

Girls and boys had similar levels of Anxiety: $t(95) = 1.06$, *ns*. Among the temperament variables of interest, girls had higher scores than boys for EC and Attentional control, and there was a tendency for them to also have higher scores for Sadness [$t(95) = 1.85$, $p = .07$]. No differences were found for any of the ER strategies (see Table 5.1 for further details).

Age was negatively related with Attentional control ($r = -.24$, $p < .05$) and positively with Anxiety ($r = .41$, $p < .001$). No other correlations were found.

Table 5.1
Descriptive statistics for the entire preschool sample, and separated by gender

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)	**df**	**t-test**
Anxiety (SPAS)	22.36 (12.92)	21.00 (11.71)	23.75 (14.05)	95	-1.05
Temperament (CBQ)					
Negative Affect (NA)	3.97 (0.54)	3.90 (0.49)	4.04 (0.59)	95	-1.28
Fear	3.82 (0.92)	3.72 (0.87)	3.91 (0.96)	95	-1.02
Sadness	3.90 (0.65)	3.78 (0.66)	4.02 (0.62)	95	-1.84
Effortful Control (EC)	4.46 (0.50)	4.36 (0.45)	4.57 (0.53)	95	-2.01*
Attentional control	4.39 (0.50)	4.27 (0.43)	4.51 (0.54)	95	-2.38*
Inhibitory control	4.62 (0.67)	4.55 (0.65)	4.68 (0.69)	95	-0.92
Emotion regulation (CCSQ)					
Active ER	4.02 (1.08)	4.00 (1.14)	4.04 (1.02)	95	-0.16
Passive ER	3.55 (1.25)	3.41 (1.26)	3.70 (1.23)	95	-1.15
Aggressive ER	2.45 (1.35)	2.68 (1.32)	2.22 (1.35)	95	1.68
Attention (Child ANT)					
Overall RT (ms)	973.22 (149.59)	925.39 (141.21)	1022.04 (143.25)	95	-3.35**
Accuracy (% errors)	13.11 (14.63)	10.52 (11.08)	15.76 (17.26)	95	-1.78
ANT Alerting	72.90 (100.61)	75.00 (114.66)	70.75 (85.08)	95	0.21
ANT Orienting	25.25 (84.20)	22.62 (78.80)	27.93 (90.15)	95	-0.31
ANT Conflict	104.49 (84.23)	99.64 (71.08)	109.45 (96.34)	95	-0.57

$*p < .05$; $**p < .01$

Child ANT

In order to include age as a factor in the ANT data, we grouped children into three age groups: 4-year-olds (N = 27; M = 54.89, SD = 2.61), 5-year-olds (N = 36; M = 66.06, SD = 2.91), and 6-7-year-olds (N = 34; M = 78.41, SD = 4.49).

We conducted a 2 (gender) × 3 (age group) × 4 (cue) × 3 (flanker) mixed ANOVA with RT as the dependent variable. Main effects were found for gender [$F(1, 87) = 5.20$, $p < .05$, $\eta_p^2 = .06$], age [$F(2, 87) = 20.34$, $p < .001$, $\eta_p^2 = .32$], cue type [$F(3, 261) = 44.00$, $p < .001$, $\eta_p^2 = .34$] and flanker type [$F(2, 174) = 127.06$, $p < .001$, $\eta_p^2 = .59$]. More precisely, girls had significantly longer RTs than boys (see Table 5.1). Further, as indicated by a Bonferroni post-hoc test, 4-year-olds were significantly slower than 5-year-olds and 6-7-year-olds, respectively (no other significant differences were found between age groups). In addition, children had significantly longer RTs in the No Cue condition compared to all other cue conditions, and longer RTs in the Center Cue condition compared to the Double Cue and Spatial Cue conditions. In the case of flanker conditions, the longest RTs were recorded for trials presenting Incongruent Flankers, while the shortest RTs were obtained in the Neutral Flanker condition (all comparisons were statistically significant; see also Table 5.2 and Figure 5.2). No interaction effects were found.

Table 5.2
Mean ANT RTs (in ms) and SDs as a function of cue and flanker conditions for each age group in the preschool sample; the last two columns include means and SDs of overall RT and accuracy (% errors) for each age group.

Age	Flanker type	Cue type				Overall RT	Overall error %
		No cue	*Center cue*	*Double cue*	*Spatial cue*		
4	*Neutral*	1113.41 (164.49)	1047.22 (182.16)	1051.50 (197.97)	1041.02 (190.26)		
	Congruent	1150.22 (152.58)	1096.71 (201.34)	1054.30 (189.07)	1002.54 (174.20)	1096.59 (144.44)	23.05 (17.11)
	Incongruent	1273.75 (173.05)	1174.29 (188.07)	1179.64 (178.93)	1195.24 (198.01)		
5	*Neutral*	948.03 (146.16)	896.64 (129.65)	877.74 (160.31)	897.26 (149.26)		
	Congruent	987.63 (166.25)	917.39 (143.98)	920.44 (135.22)	905.79 (150.23)	944.86 (131.19)	11.55 (11.47)
	Incongruent	1062.32 (182.96)	1027.89 (156.20)	1011.92 (168.08)	990.17 (175.99)		
6-7	*Neutral*	913.35 (141.43)	856.07 (119.89)	834.47 (126.15)	813.35 (129.97)		
	Congruent	948.59 (127.98)	900.03 (157.88)	863.72 (120.04)	840.10 (106.07)	905.27 (110.97)	6.88 (11.36)
	Incongruent	1049.88 (117.17)	1008.01 (152.70)	969.35 (129.93)	951.44 (121.55)		

In order to determine further the degree of independence of the three attentional networks we computed zero-order correlations between the three attention network scores and overall RT. All correlations were small (all $|rs| < .15$) and none of them was statistically significant, thus further indicating the independence of the three attentional networks in preschoolers.

For each attention network score, we additionally carried out a separate 2 (gender) × 3 (age group) ANOVA with attention score as the dependent variable. We found a significant effect of age on the Orienting score: $F(2, 91) = 4.18$, $p < .05$, $\eta_p^2 = .08$. As indicated by post-hoc pairwise comparisons with Bonferroni correction, this effect was due to the presence of a significantly larger orienting effect in the 6-7-year-old group ($M = 56.07$, $SD = 64.87$) compared to the 5-year-old group ($M = 8.43$, $SD = 76.86$), but not the 4-year-old group ($M = 8.85$, $SD = 104.75$). These results indicate that while Orienting scores increased until 6-7 years, there was a tendency for individual variability to drop. No other effects were found.

In order to determine whether overall accuracy differed as a function of children's gender and age, we conducted a 2 (gender) × 3 (age group) univariate ANOVA with overall error percentage as the dependent variable. While there was no difference in error rates between boys and girls, we found significant age differences: $F(2, 91) = 10.12$, $p < .001$, $\eta_p^2 = .18$. More precisely, 4-year-olds had significantly higher error rates compared to both 5- and 6-7-year-olds (see Table 5. for descriptive statistics). No interaction effects were found.

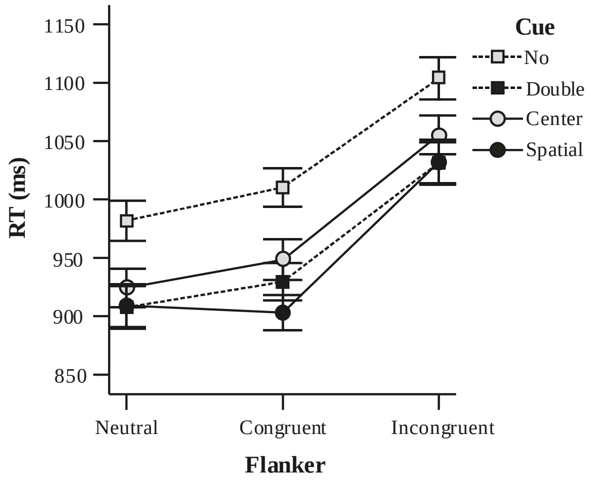

Figure 5.2. Mean RT (± 1 SE) in the preschool sample, plotted as a function of flanker and cue conditions.

5.7.2.2 Attentional networks, EC and ER

We first investigated whether children's self-regulatory characteristics were related to their overall performance in the ANT (i.e., overall RT and error rates). Subsequently, we tried to determine whether self-regulation was related to functioning in any of the three attentional networks.

We carried out zero-order correlations between measures of self-regulation and overall indices of ANT performance. We found a significant negative relationship between Active ER and overall RT (r = -.21, p < .05), indicating that higher Active ER was associated with faster responses. Additionally, in the case of boys, high Inhibitory control and high Active ER were associated with reduced error rates: r = -.34, p < .05 and r = -.40, p < .01, respectively. The Inhibitory control–low error rate relationship was partially explained by children's age, as it was reduced when we controlled this factor (r = -.26, p = .07). Overall however, these results indicate that children with better self-regulatory abilities tend to be both more efficient and more accurate in their general ANT performance.

As the correlations presented in Table 5.3 indicate, higher EC and Inhibitory control scores were linked to higher Conflict scores in girls (r = .30, p < .05 and r = .34, p < .05, respectively). However, the EC–Conflict score relationship was partially explained by age variation as the correlation became non-significant when controlling for age (r = .25, p = .10). We further explored these correlations through a series of mixed ANOVAs, attempting to determine, in each case, whether the relevant self-regulatory dimension interacted with the Conflict score, or, in other words, whether children high or low in self-regulatory abilities reacted differently to the two conditions of the task. Each continuous self-regulatory variable was transformed into a nominal (high vs. low) variable by conducting a median-split across it.

Table 5.3
Correlations between study variables and attention network scores for the entire preschool sample and separated by children's gender

	Total sample			Boys			Girls		
	A	O	C	A	O	C	A	O	C
Anxiety (SPAS)	.04	.06	-.13	-.01	-.01	.03	.10	.12	-.23
Temperament (CBQ)									
Negative Affect (NA)	.00	.01	-.01	-.20	-.05	.10	.24	.05	-.10
Fear	.03	.10	-.03	-.22	-.04	-.02	.34*	.21	-.04
Sadness	-.07	.09	.08	-.25+	.18	.18	.19	.00	-.02
Effortful Control (EC)	-.06	-.01	.19	-.01	.00	.00	-.12	-.04	.30*
Attentional control	-.07	.02	.15	.06	.01	.00	-.20	.02	.22
Inhibitory control	-.04	-.06	.19	-.10	-.01	-.01	.05	-.11	.34*
Emotion regulation (CCSQ)									
Active ER	-.16	-.10	.06	-.16	.13	.30*	-.17	-.33*	-.15
Passive ER	.08	-.03	.04	.00	.07	.03	.21	-.14	.03
Aggressive ER	.14	-.12	-.22*	.16	-.14	-.23	.13	-.10	-.20

Note: A = Alerting; O = Orienting; C = Conflict.
**p* < .05; +*p* < .10

In order to investigate the relationship between Inhibitory control and the Conflict score in the girls sub-sample we carried out a 2 (high vs. low Inhibitory control) × 2 (Congruent vs. Incongruent Flanker) mixed ANOVA with RT as the dependent variable. This analysis revealed a statistically significant Inhibitory control × Flanker interaction effect: $F(1, 46) = 4.52$, $p < .05$, $\eta_p^2 = .09$. Post-hoc pairwise comparisons were not statistically significant. However, as can be seen in Figure 5.3, the interaction effect we obtained was due to the fact that girls with high Inhibitory control responded faster than those with low Inhibitory control in the Congruent Flanker condition, but slower in the Incongruent Flanker condition.

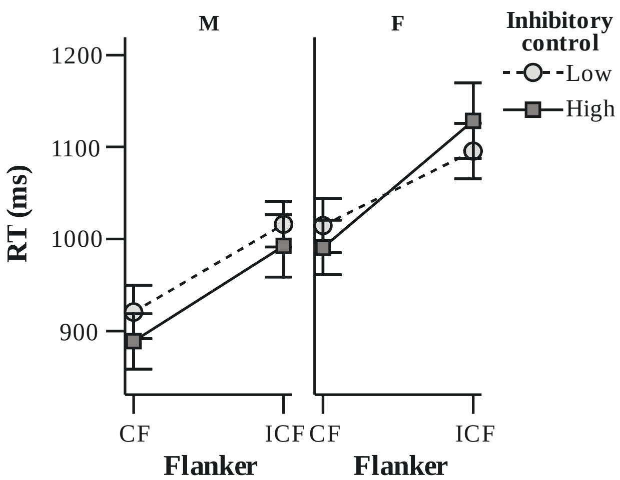

Figure 5.3. Mean RT (± 1 SE) plotted separately for boys (left panel) and girls (right panel) as a function of Flanker type and Inhibitory control.
Note: CF = Congruent Flanker; ICF = Incongruent Flanker.

Among ER strategies, high Active ER was related to higher conflict scores in boys ($r = .31$, $p < .05$) and to a reduced Orienting effect in girls ($r = -.33$, $p < .05$). Within the entire sample, Aggressive ER was associated with lower Conflict scores ($r = -.22$, $p < .05$).

The high Active ER–high Conflict score relationship found in boys was further investigated through an ANOVA similar to the analyses described above, revealing a statistically significant interaction effect: $F(1, 47) = 6.16$, $p < .05$, $\eta_p^2 = .12$. Post-hoc comparisons were not significant, but the correlation and the interaction effect were determined by the fact that boys with better Active ER strategies were faster in the Congruent Flanker condition ($M = 882.82$, $SD = 142.75$) than their less well-regulated peers ($M = 927.73$, $SD = 147.45$). At the same time, RTs were almost identical in the Incongruent Flanker condition ($M = 1005.92$, $SD = 136.92$ for high Active ER; $M = 1002.94$, $SD = 155.72$).

Investigating the Active ER–Orienting correlation in girls revealed only a marginally significant interaction effect: $F(1, 46) = 3.93$, $p = .05$, $\eta_p^2 = .08$. However, a closer look at attentional networks and the specific strategies of Active ER – Cognitive restructuring and Distraction, as well as Avoidance, revealed that higher Alerting scores were linked to low Cognitive restructuring in the entire sample ($r = -.20$, $p < .05$; interaction $F < 1$, *ns*); see Figure 5.4A. High Orienting scores were linked to high Cognitive restructuring in boys ($r = .28$, $p < .05$; $F < 1$, *ns*), but low in girls [$r = -.32$, $p < .05$; $F(1, 46) = 3.22$, $p = .08$, $\eta_p^2 = .07$]; see Figure 5.4B. High Conflict scores were related to high Avoidance in the entire sample [$r = .25$, $p < .05$; $F(1, 95) = 3.36$, $p = .07$, $\eta_p^2 = .03$; Figure 5.4C] and marginally in boys ($r = .27$, $p = .06$; $F < 1$, *ns*), but also with high Distraction tendencies in boys [$r = .44$, $p < .01$; $F(1, 47) = 5.44$, $p < .05$, $\eta_p^2 = .10$; Figure 5.4D].

Lastly, the investigation of the negative relationship between Aggressive ER and the Conflict score found no significant interaction effect: $F(1, 95) = 1.61$, $p = .21$, $\eta_p^2 = .02$. Children with low Aggressive ER scores tended to have overall higher RTs compared to their more aggressive peers ($M = 982.46$, $SD = 158.75$ and $M = 963.78$, $SD = 140.67$, respectively). They also had a higher increase in RT in response to the Incongruent Flanker when compared to children with high Aggressive ER, as indicated by their higher Conflict score ($M = 115.19$, $SD = 158.75$ vs. $M = 93.57$, $SD = 81.35$). However, these differences were not large enough to become statistically significant.

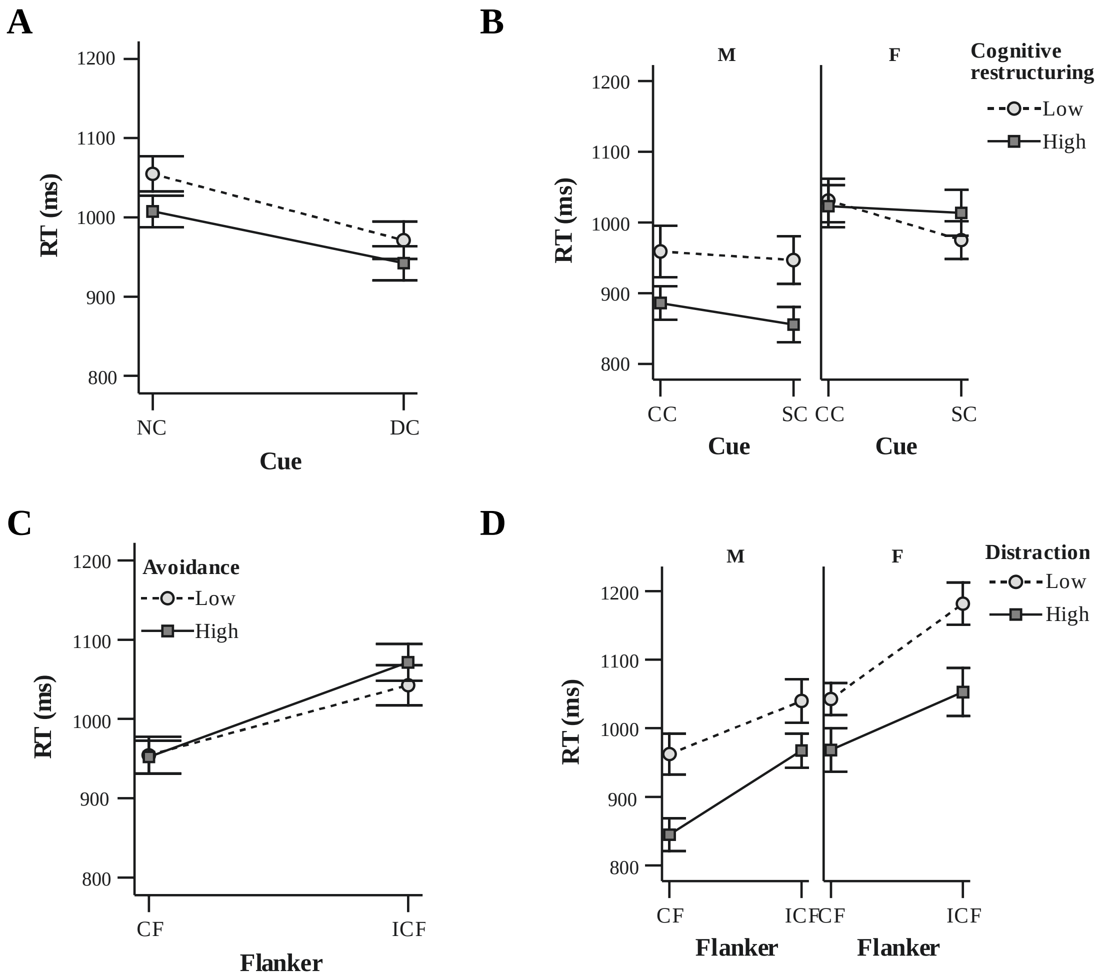

Figure 5.4. Plots for the preschool sample representing relationships between (A) Cognitive restructuring and the Alerting effect in the entire sample; (B) Cognitive restructuring and the Orienting effect in boys and girls; (C) Avoidance and the Conflict score in the entire sample; (D) Distraction and the conflict score in boys and girls. Each plot depicts the mean RT (± 1 SE) as a function of cue/flanker type and high/low groups within each ER strategy.
Note: NC = No Cue; DC = Double Cue; CC = Center Cue; SC = Spatial Cue; CF = Congruent Flanker; ICF = Incongruent Flanker.

5.7.2.3 Anxiety, attention and EC

As the results summarized in Table 5.3 indicate, we found no direct relationship between attention network scores and intensity of Anxiety symptoms.

We next investigated whether EC or its sub-dimensions had any moderating contribution to the Anxiety–attention link. For each attention score, we tested the moderating role of each variable in a separate hierarchical regression analysis, conducted according to the guidelines put forward by Aiken and West (1991; see also Cohen, Cohen, West, & Aiken, 2003; Sava, 2004).

Table 5.4
Hierarchical multiple regression predicting the Alerting effect in preschoolers, with Anxiety as a main predictor and Inhibitory control as a moderator.

	Total sample			Boys			Girls		
	B	SE B	β	B	SE B	β	B	SE B	β
Step 1	R^2 = .01			R^2 = .00			R^2 = .01		
(Constant)	153.21	61.76		70.03	112.78		2.03	87.82	
Gender	7.20	17.44	.04	-	-	-	-	-	-
Age	-0.78	0.88	-.09	0.07	1.62	.01	1.05	1.33	.12
Step 2	ΔR^2 = .01			ΔR^2 = .00			ΔR^2 = .00		
(Constant)	122.27	69.05		65.42	121.48		19.50	104.90	
Gender	10.72	17.79	.06	-	-	-	-	-	-
Age	-0.34	0.98	-.04	0.14	1.75	.01	0.78	1.59	.09
Anxiety	-0.75	0.75	-.12	-0.17	1.54	-.02	0.33	1.06	.05
Step 3	ΔR^2 = .04*			ΔR^2 = .01			ΔR^2 = .00		
(Constant)	121.62	67.90		47.91	124.71		8.25	110.01	
Gender	7.98	17.54	.05	-	-	-	-	-	-
Age	-0.31	0.96	-.04	0.39	1.79	.04	0.95	1.67	.11
Anxiety	-0.92	0.74	-.14	-0.13	1.55	-.01	0.23	1.11	.04
Inhibitory control	26.13	12.77	.21*	-18.68	26.75	-.11	7.26	19.20	.06
Step 4	ΔR^2 = .01			ΔR^2 = .03			ΔR^2 = .09*		
(Constant)	126.50	68.02		53.00	124.23		33.54	106.54	
Gender	7.99	17.53	.05	-	-	-	-	-	-
Age	-0.37	0.96	-.04	0.29	1.79	.03	0.62	1.61	.07
Anxiety	-0.83	0.75	-.13	0.02	1.55	.00	0.74	1.09	.12
Inhibitory control	25.45	12.78	.20*	-12.95	27.06	-.07	8.04	18.48	.07
Anxiety × Inhibitory control	-1.02	0.97	-.11	2.48	2.09	.18	-3.06	1.44	-.31*

$*p < .05$

Predictor variables were first centered to reduce multicollinearity, and two-way interaction terms were computed as the multiplicative products of these centered variables. Each analysis was conducted both at the level of the entire sample, as well as separately for boys and girls. Gender and age in months were first entered into each equation in order to partial out their effects (in the case of the gender-split analysis only age was entered in the first step). Anxiety was entered in the second step, followed in the next step by the potential moderator (i.e., EC, Inhibitory control or Attentional control). The interaction term was entered in the last (fourth) step. As before, effect sizes were computed according to Cohen's f^2 formulas for multiple regression and hierarchical multiple regression, respectively (Cohen, 1992). As there were three attention network scores and two potential moderators, this resulted in six separate sets of equations. In order to avoid overloading the text with too many tables, we only present the parameters of the analysis where the moderating effect was statistically significant here, namely the one including Inhibitory control as a moderator of the relationship between Anxiety and the Alerting score.

The Alerting effect was significantly predicted by the interaction of anxiety and inhibitory control in girls (see Table 5.4 for results). The entire model predicted 8% (f^2 = 0.09) of the variance in alerting scores in the case of the total sample, 4% (f^2 = 0.04) in the case of boys and 11% (f^2 = 0.12) in the case of girls. Inhibitory control was a direct predictor of Alerting at the level of the entire sample (β = .20, p < .05). The interaction effect added 9% of explained variance (f^2 = 0.10) and it significantly predicted the Alerting score (β = -.31, p < .05) in the girls sample. As Figure 5.5 indicates, while at lower levels of Inhibitory control high Anxiety is associated with a high Alerting score, high Inhibitory control tends to attenuate (and indeed even reverse) this relationship. Post-hoc probing (using ModGraph; Jose, 2008) indicated, however, that none of the three slopes was significantly different from zero: $t(44)$ = 1.75, p = .09; $t(44)$ = 0.18, p = .86; $t(44)$ = -1.06, p = .29 for low, medium and high Inhibitory control, respectively.

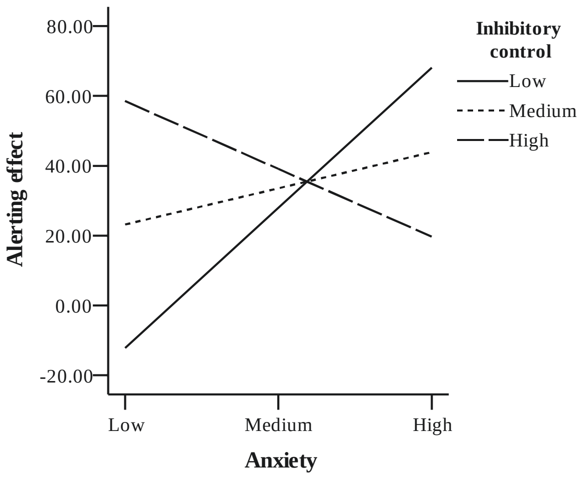

Figure 5.5. Interaction between Anxiety and Inhibitory control in predicting the Alerting effect in girls.

As the data included in Table 5.3 indicates, we found a significant relationship between temperamental Fear and the Alerting score (r = .33, p < .05) in the case of girls. A 2 (high vs. low fearfulness) × 2 (No Cue vs. Double Cue) mixed ANOVA with RT as the dependent variable found a marginally significant effect: $F(1, 46)$ = 3.98, p = .05, η_p^2 = .08. Pairwise comparisons were not statistically significant, but, as can be seen in Figure 5.6, compared to their less fearful peers, highly fearful girls tend to have slower responses in the absence of a warning cue, and faster responses when the cue is present. Sadness was only marginally linked to Alerting in boys (r = -.25, p = .08). Note that the Fear–Alerting relationship is an incidental finding.

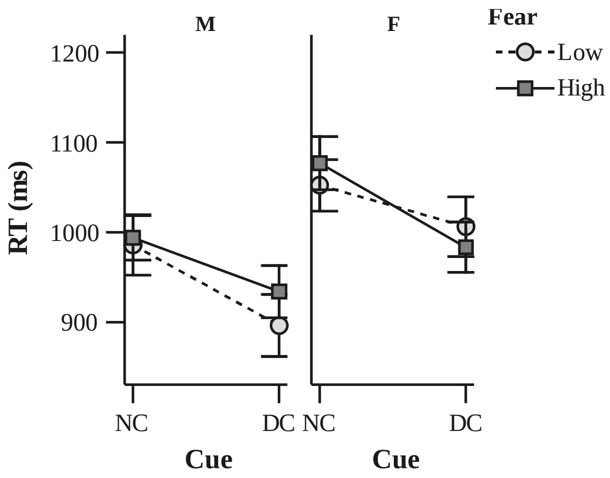

Figure 5.6. Mean RT (± 1 SE) plotted separately for boys (left panel) and girls (right panel) as a function of cue type and Fear. *Note:* NC = No Cue; DC = Double Cue.

5.7.3 Discussion

The present study aimed to investigate the links between attentional networks and anxiety in preschool children, as well as the degree to which EC affected these potential links. As secondary objective, we were interested whether attentional network performance was related to EC and ER.

In order to better understand these relationships, it was important to first to look at the general development of attentional networks in this age sample. As expected, across the preschool years, general performance in the child ANT improved, with children responding increasingly faster and more accurately; this improvement was more notable after the age of 4 years. With respect to the development of the three attentional networks, our results indicate no change in alertness and executive attention throughout the preschool years, but they indicate significantly improved orienting during this developmental stage and a decrease in the individual variability of orienting scores as children get older. In other words, from 4 to 7 years children are increasingly more efficient in taking advantage of the spatial (orienting) cue. These results are somewhat at odds with previous research indicating, on the one hand, similar exogenous orienting in children and adults (e.g., Brodeur & Enns, 1997; Rueda, Fan et al., 2004), and, on the other hand, continued improvements in executive attention at least until around the age of 7 (Rueda, Fan et al., 2004). However, a few aspects of previous research differentiate it from the present study. On the one hand, most developmental studies using the ANT have focused on middle childhood and beyond, or have directly compared 4-year-olds with adults (Rueda, Posner, Rothbart, & Davis-Stober, 2004). A similar observation can be made about developmental research involving only orienting: it is also predominantly focused on middle childhood and comparisons of children with adults. Failure to include a large enough preschool sample (4-, 5- and 6-year-olds), and to look at age-related variability *within* that sample can result in possibly missing potential changes that arise within that developmental stage. In fact, Mezzacappa (2004), who investigated the three attentional networks in an age sample similar to ours found age-related improvements in *all* three attentional networks, but the largest changes were present in orienting.

A surprising null finding regarded the absence of an age-related improvement in executive attention, as would have been expected based on previous research (Benga, 2004;

Berger et al., 2000; Carlson, 2005; Gerardi-Caulton, 2000; Gerstadt et al., 1994; Jones, Rothbart, & Posner, 2003). However, again this previous research differs from ours in some respects, as it includes 3-year-olds or younger children, or uses either the Stroop or the spatial conflict task (but not Eriksen's flanker task) to asses executive attention. This latter distinction is important since, as Fan et al. (2003) have shown, although these three tasks activate overlapping brain areas in adults, they do not correlate very well behaviorally. In developmental studies that did include the flanker task comparisons were performed between groups of 6-, 7-, 8- and 9-year-olds (Rueda, Fan et al., 2004), or between a group of 5-7 year-olds and older children (Ridderinkhof, van der Molen, Band, & Bashore, 1997). Therefore, it is possible that in the age sample included in our study, if there is any change using the flanker task, it is too small to be detected with our sample size, and more significant changes occur from around 6 years on. A similar interpretation can be made regarding the lack of change in alerting performance, but here research is even more limited, with virtually no developmental study (to our knowledge) involving preschoolers (Berger et al., 2000 did focus on 5-year-olds, but they included no other sample of older children or adults). A last aspect worth mentioning was the lack of an interaction between the three attentional networks. This finding is in line with Rueda, Fan et al.'s (2004) results in older children. Thus, it appears that attentional networks function relatively independently (at least as far as behavioral performance is concerned) during this developmental stage.

With respect to attention–self-regulation links, our results show that in general children with higher self-regulatory abilities (both in terms of temperamental self-regulation, and in terms of ER strategies) tend to perform better (i.e. faster responses and lower error rates). However, our results also indicate that good self-regulatory skills (high inhibitory control in girls, high Active ER in boys – especially distraction, and to a lesser degree low aggressive regulation in all children) are associated with *higher* conflict scores and therefore possibly deficits in executive attention. On first look, this result contradicts our expectations and previous research showing higher EC associated with better executive performance (e.g., Gerardi-Caulton, 2000; Simonds et al., 2007). While it is still possible that in this developmental stage children who are perceived by parents as being better regulated actually have difficulties in managing interference, at least two other alternative interpretations are plausible. First, our results indicate that children who are better regulated respond slightly faster in the Congruent Flanker condition compared to their less well-regulated peers; their slower responses only appear in reaction to the conflict condition (the Incongruent Flanker). This indicates that this response pattern might in fact be not so much a sign of poor conflict resolution but might have a different source. It is possible that well-regulated children are more cautious in the conflict condition (since they generally also tend to have lower error rates). This is even more plausible considering the fact that the same pattern was seen in relation to several self-regulatory dimensions, some of which are not even correlated with each other, but capture different aspects of self-regulation (i.e., inhibitory control and active ER). On the other hand, if we take into account the interpretation of inhibitory control in preschoolers as a combination of genuinely controlled inhibition and automatic inhibition, this strengthens our interpretation of higher conflict scores as increased cautiousness on the part of these children. However, this interpretation is somewhat speculative and further studies are needed to clarify it. Second, these results must also be placed in a developmental context. It is possible that the pattern we see in this sample is characteristic for this stage of development and that we have captured a phase in the development of executive attention when good inhibition (suppressing an inappropriate response) is not yet coupled with activating the alternative, appropriate response. If this is the case, then we should see a reversal of the correlation between the conflict score and inhibitory control in older children.

The links between attentional networks and ER strategies were rather interesting. More precisely, in all children low cognitive restructuring was associated with high alerting scores due to somewhat higher RTs in the intrinsic alertness (i.e., No Cue) condition. This relationship indicates that the ability to reinterpret a negative situation is related to the ability to maintain attention focused on the task even in the absence of a warning stimulus. At the same time, cognitive restructuring was also linked to orienting: higher cognitive restructuring scores were associated with higher orienting scores in boys, but lower orienting scores in girls. While these two correlations are difficult to interpret, this potential link is worthy of further exploration, especially in the light of recent research by Nobre and collaborators (Griffin & Nobre, 2003; Nobre et al., 2004) showing that orienting in internal mental space is regulated by a similar neural network as orienting in extra-personal space. It is possible that shifting attentional focus between two different interpretations of the same situation might involve something akin to orienting in one's mental space. Taken together, these correlations indicate that cognitive restructuring is linked to the ability to focus and to shift attention. The fact that we found these links in children so young is even more remarkable. However, these results and their interpretation must be regarded with caution, as it is unclear to what extent preschoolers really use this ER strategy, and how much insight parents have into children's cognitive reframing. The exact nature of this relationship, and the role of gender in it remains to be established in future research. Further, avoidance was linked to higher conflict scores in the entire sample, indicating that children with higher avoidant tendencies took somewhat longer to resolve conflict.

Turning to our main objective, while we did not find any direct links between anxiety and efficiency of the alerting, orienting or executive attention networks in this age sample, we did find an anxiety–alerting relationship that was moderated by inhibitory control in girls. More precisely, high anxiety was associated with high alerting scores at low levels of inhibitory control. Although the effect was small, this finding indicates that girls with high anxiety and low inhibitory control tend to have deficits in maintaining intrinsic alertness but are more reactive when it comes to phasic alertness. Thus, it seems that a potential impairment in top-down modulation of alertness can be compensated by good inhibitory control abilities. Our findings are partially in line with Dennis et al. (2008) and Compton et al. (2004), who found associations between high anxiety/negative affect and high alerting in adults. However, they differ from other research (e.g., Moriya & Tanno, 2009b), indicating a relationship between slow orienting and high trait anxiety in adults. The discrepancy between our results and those of Moriya and Tanno is probably developmental in nature, and the next two studies included in this chapter should clarify this.

Incidentally, we also found a positive correlation between temperamental fearfulness and alerting in girls. A closer inspection of our results indicated that the larger alerting scores found in highly fearful girls were due to their tendency to respond to the presence of the warning cue faster than girls with low levels of fearfulness, and to respond slower when no warning cue was given. Thus, high fearfulness in girls is associated with somewhat reduced intrinsic alertness, but enhanced phasic alertness. If we take into account research suggesting a top-down regulation of intrinsic alertness in adults (i.e., Fan et al., 2007; Mottaghy et al., 2006; Sturm et al., 1999), these findings are congruent with ACT, since they suggest impaired top-down control on alertness in highly fearful girls (or those with high anxiety and low inhibitory control) and an overactive bottom-up system. The response pattern found in highly fearful girls in our study is indicative of precisely a dominance of the stimulus-driven attentional system overriding the goal-driven system. It is possible that during trials when there is no warning cue to draw their attention to the task, fearful girls' attention "wanders off", delaying their reaction to the target stimulus when it appears. In fact, there is already evidence in adults showing that mind wandering episodes can be reliably measured, and they can best be captured using a sustained attention task. These episodes tend to be associated with reduced processing of task stimuli and are associated with reduced activation in the right inferior frontal gyrus, the middle frontal gyrus and the ACC (Smallwood, Beach, Schooler, & Handy, 2008). Another (complementary) interpretation is that highly fearful girls are more distractible by exogenous stimuli since they react faster when the exogenous warning cue is present. This interpretation is consistent with previous research showing higher levels of distractibility in adults with high levels of trait anxiety (e.g., Eysenck & Byrne, 1992).

While these results regarding the alerting network raise some intriguing possibilities for future research, the reader should keep in mind that effects were small and should therefore be replicated to determine their reliability. It is, however, tempting to speculate on the role of noradrenaline in generating a pattern of intrinsic-phasic alertness like the one discussed above, especially considering the involvement of this neurotransmitter in anxiety and depression (Goddard et al., 2009). For example, Aston-Jones and collaborators (Aston-Jones & Cohen, 2005) have described two modes of functioning of the cells in the locus coeruleus in monkeys during a task resembling go/no-go: "tonic" and "phasic" mode (the terms are not directly related to tonic/intrinsic and phasic alertness). High phasic activation is usually accompanied by moderate tonic activation and good task performance, while high tonic functioning is associated with impaired performance and high distractibility. Another line of research (see Arnsten, 2007 for a review) shows that noradrenaline acts as a "chemical switch", determining which brain areas dominate in controlling behavior and cognitive/emotional processing. This switching effect results from the interaction between noradrenaline levels and the three types of noradrenergic receptors present in the brain ($\alpha 1$, $\alpha 2$ and β). This interaction causes enhancement of PFC control (i.e., improved attentional focus, working memory, etc.) at moderate noradrenaline levels, but a dominance of processing in posterior cortical areas, the amygdala and the hippocampus at high noradrenaline levels. This latter effect can result in high distractibility, vivid sensory processing and enhanced memory for emotional events (Arnsten, 2007). Thus, dysregulation in the two mechanisms described here might constitute neurofunctional and neuropharmacological bases for the anxiety-related attentional functioning described by the ACT.

In summary, with respect to our objectives, the present study showed that in preschool children the relationship between good self-regulatory abilities and executive attention might not be as straightforward as previously thought and that the anxiety-related imbalance in bottom-up versus top-down processing postulated by the ACT might already be present in preschoolers (at least in girls), at the level of alerting mechanisms. However, both aspects need further studies to be fully clarified.

5.8 Study 2B: Attentional networks and anxiety in middle childhood

The present study had the same main objectives as the ones stated in section 5.6. Namely, we were interested to understand the links between self-regulation and attention (and in particular to determine whether our previous findings related to executive attention were likely to be of a developmental nature or not), anxiety and attention, and whether EC moderated any potential anxiety-attention relationship.

Since research presented in Chapter 3 indicated that after the preschool stage EC is more important as a predictor/moderator than its sub-dimensions, here only EC as a whole was used as a potential moderator.

5.8.1 Method

5.8.1.1 Participants

Children who attended first to fourth grade at a school in Cluj-Napoca were selected based on informed consents given by parents, child verbal assent, and teacher informal agreement. These children are a sub-sample of the group included in Study 1B (Chapter 3). A total number of approximately 230 parents were contacted initially with the aid of the school principal and teachers. Out of the total number of contacted parents 139 (60.43%) consented to take part in the study and filled in questionnaires (described below). A number of 108 children were assessed using the ANT, but two children were eliminated from the final analysis due to technical difficulties resulting in data loss. This resulted in a final sample of 106 children (55 girls) aged 6-11 years (M = 105.69 months; SD = 14.03; range = 81-135 months).

Additionally, we managed to obtain self-report data for two of the questionnaires from a number of 66 children aged 8-11 years. Among them, a number of 46 children (23 girls; M = 118.72 months; SD = 8.24; range = 98-135 months) were tested using the child ANT.

5.8.1.2 Measures

Anxiety and depression

The Romanian version of the *Revised Child Anxiety and Depression Scales* (RCADS; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000) was used to assess anxiety and depression symptoms in the middle childhood sample (see Chapter 3, Study 1B for details). In our current sample, internal consistency indices for the Anxiety sub-scales of the RCADS-P ranged between α = .60 and α = .81, while the full Anxiety scale had a Crombach's α of .89. The internal consistency of the Depression scale was α = .77.

The child self-report version (RCADS) was administered to the older children in our sample (i.e., third and fourth graders). Internal consistency indices computed over the 66 children who were assessed with this version of the scale ranged between .63 and .83 for anxiety sub-scales. Crombach's α for the entire anxiety scale was .92, while the depression scale had an α = .71.

Temperament

Parents were administered the Romanian version of the *Temperament in Middle Childhood Questionnaire* (TMCQ; Simonds, 2006; Simonds & Rothbart, 2006; see Chapter 3, Study 1B for details). For the purposes of the present study, we selected sub-scales for Fear (α = .78), Sadness (α = .78), Attentional focusing (α = .77), and Inhibitory control (α = .67), as well as the higher-order dimensions of NA (α = .79) and EC (α = .82).

Emotion regulation

The Romanian, parent version of the *Children's Coping Strategies Checklist, Revised version* (CCSC-R1; Ayers et al., 1996; Program for Prevention Research, Arizona State University, 1999; see Chapter 3, Study 1B for details) was administered to parents. For the current sample, CCSC-R1-P internal consistency indices were as follows: α = .93 for Active coping strategies, α = .75 for Distraction, α = .73 for Avoidance and α = .90 for Support seeking.

As in the case of RCADS, the CCSC-R1, self-report version was administered to 3rd and 4th graders. For this version, internal consistency indices were .92 for Active coping strategies, .88 for Distraction, .79 for Avoidance and .90 for Support seeking.

Attentional networks

As in our previous study, the child version of the Attention Network Test (Rueda, Fan et al., 2004) was used to assess the efficiency of the three attentional networks. However, since pilot testing indicated that the task was extremely simple for the children in our sample, and most perceived it as being relatively unchallenging and boring, we made a slight alteration to the task so as to make it more challenging. Namely, while we kept all parameters as in the original task, we limited the amount of time available for the child's response to 1000 ms (from the original 1700). This manipulation made the task more engaging while still maintaining the error rates relatively low and comparable to the ones reported by Rueda, Fan et al. (2004). Additionally, a similar interval was previously used without difficulty in 5-year-old children by Berger et al. (2000). Apart from this modification, everything was kept as in the original task; and attention network scores were computed exactly as in the previous study.

5.8.1.3 Procedure

Permission for conducting the study inside the school was obtained from the school principal. Parents were contacted with the help of teachers. Each parent received an informed consent letter and three questionnaires assessing child characteristics (RCADS-P, TMCQ and CCSC-R1-P). Children whose parents agreed to take part in the study and returned the questionnaires were further selected for testing with the child ANT.

Additionally, children from 3rd and 4th grade whose parents had consented to involve them in the study were also asked to complete the RCADS and CCSC-R1 questionnaires. Each questionnaire was administered in a separate session to the whole class. The teacher was present throughout each assessment. Before handing out the questionnaires, children were informed that their participation was voluntary and that they did not have to participate if they did not want to. Children for whom there was no parental consent were allowed to participate if they wished to, but their data was not used. The experimenter read the instructions and the items aloud to the children and explained them when necessary.

The child ANT was administered as already described in the previous study. Each child was tested individually by a female experimenter, in a quiet room inside the school. The entire task lasted approximately 20-25 minutes (including instructions and breaks). Upon task completion, each child received a colored badge.

5.8.1.4 Missing data

In the parent-report sample, one child missed data on the TMCQ, while more data was missing for the following CCSC-R1-P ER strategies: Active coping (N = 17), Distraction (N = 3), Avoidance (N = 10), Support (N = 3). Due to the high amount of items missing in the incomplete protocols, we decided it was safer to eliminate all participants missing data on at least one ER strategy from all analyses involving ER. This resulted in a number of 84 children (39 boys, 45 girls) with complete ER information. In the child self-report dataset, five children lacked the CCSC-R1 and two did not complete the RCADS questionnaire.

5.8.2 Results

5.8.2.1 Preliminary analyses

Before addressing the main research questions, we verified the presence of gender differences and correlations with age for Anxiety, Depression, temperament dimensions, and ER strategies.

In addition, as in the previous study involving preschoolers, we conducted a separate analysis on the ANT data. In order to include age as a factor in the analysis of the ANT data, we grouped children into four age groups: 6-7 years (N = 30; M = 89.57, SD = 4.12), 8 years (N = 29; M = 100.48, SD = 3.89), 9 years (N = 26; M = 113.42, SD = 3.24) and 10-11 years (N = 21; M = 126.33, SD = 4.45). Descriptive statistics for all measures of interest, for the entire sample and separated by gender, are presented in Table 5.5. Descriptive statistics for child-report data can be found in Table 5.10.

Table 5.5
Descriptive statistics for the entire middle childhood sample, and separated by gender

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)	**df**	**t-test**
Anxiety (RCADS-P)	20.75 (13.02)	20.00 (12.02)	21.45 (13.97)	104	-0.57
Depression (RCADS-P)	5.25 (3.58)	5.35 (3.40)	5.16 (3.77)	104	0.27
Temperament (TMCQ)					
Negative Affect (NA)	2.98 (0.61)	2.97 (0.60)	3.00 (0.62)	103	-0.23
Fear	2.90 (0.81)	2.77 (0.85)	3.02 (0.76)	103	-1.62
Sadness	2.81 (0.61)	2.83 (0.58)	2.80 (0.63)	103	0.30
Effortful Control (EC)	3.22 (0.44)	3.12 (0.39)	3.32 (0.47)	103	-2.33*
Attention focusing	2.95 (0.66)	2.80 (0.61)	3.08 (0.68)	103	-2.21*
Inhibitory control	3.42 (0.57)	3.31 (0.58)	3.53 (0.55)	103	-1.98*
Activation control	3.30 (0.43)	3.25 (0.42)	3.35 (0.44)	103	-1.08
Emotion regulation (CCSC-R1-P)					
Active coping	2.73 (0.46)	2.76 (0.45)	2.71 (0.48)	84	0.44
Distraction	2.90 (0.54)	2.99 (0.57)	2.81 (0.51)	84	1.66
Avoidance	2.63 (0.47)	2.70 (0.36)	2.57 (0.55)	84	1.26
Support seeking	3.17 (0.68)	3.13 (0.67)	3.21 (0.69)	84	-0.63
Attention (Child ANT)					
RT (ms)	632.22 (54.04)	628.93 (52.85)	635.27 (55.44)	104	-0.60
Accuracy (% errors)	6.79 (4.55)	7.69 (4.49)	5.95 (4.49)	104	1.99
ANT Alerting	67.13 (40.07)	66.22 (44.81)	67.98 (35.51)	104	-0.23
ANT Orienting	25.34 (33.89)	27.89 (35.67)	22.97 (32.31)	104	0.74
ANT Conflict	72.83 (33.63)	83.34 (35.68)	63.09 (28.62)	104	3.23**

$^*p < .05$; $^{**}p < .01$

Gender and age

The parent-report data revealed no statistically significant differences between girls and boys in Anxiety or Depression scores. Among the temperament variables of interest, girls had higher scores than boys for Attention focusing [$t(103) = 2.21$, $p < .05$] and overall EC [$t(103) = 2.33$, $p < .05$]. No differences were found for ER strategies. In the child self-report data, girls had significantly higher Anxiety scores than boys [$t(42) = 2.22$, $p < .05$], but there were no gender differences in Depression scores: $t(43) = 0.48$, *ns* (see Table 5.10 for descriptive statistics). We found no gender differences in ER strategies.

Significant correlations were found only between age (in months) and Inhibitory control ($r = .24$, $p < .05$), indicating that Inhibitory control was higher in older children. Anxiety, Depression, or ER strategies were not correlated with age. No correlations were found for the child self-report data.

Child ANT

Table 5.6 presents RTs by cue, flanker condition and age group, along with overall RT and error percentage for each age group.

Table 5.6
Mean ANT RTs (in ms) and SDs as a function of cue and flanker conditions for each age group in the middle childhood sample; the last two columns include means and SDs of overall RT and accuracy (% errors) for each age group

Age	**Flanker type**	**Cue type**				**Overall RT**	**Overall error %**
		No cue	*Center cue*	*Double cue*	*Spatial cue*		
6-7	*Neutral*	683.68 (52.05)	621.63 (56.44)	597.55 (58.35)	605.82 (53.96)	662.22 (43.46)	9.33 (4.68)
	Congruent	685.74 (72.58)	625.98 (65.27)	613.79 (59.18)	609.57 (62.29)		
	Incongruent	709.73 (73.82)	670.12 (58.80)	655.21 (68.67)	653.85 (75.03)		
8	*Neutral*	702.95 (58.48)	641.95 (52.76)	619.70 (52.89)	617.10 (59.37)	642.17 (56.25)	7.95 (4.35)
	Congruent	733.29 (72.03)	711.05 (84.27)	693.40 (74.87)	678.88 (64.39)		
	Incongruent	629.10 (67.63)	574.40 (67.80)	555.17 (58.35)	535.76 (66.84)		
9	*Neutral*	762.63 (58.98)	725.22 (61.07)	719.83 (65.36)	697.72 (75.28)	609.52 (45.92)	4.99 (3.77)
	Congruent	630.58 (49.32)	559.02 (57.66)	555.13 (53.85)	543.15 (50.25)		
	Incongruent	646.31 (70.72)	590.74 (57.00)	571.60 (62.01)	557.86 (59.96)		
10-11	*Neutral*	661.10 (61.60)	608.43 (75.29)	594.09 (67.07)	571.31 (74.02)	603.74 (50.16)	3.79 (2.79)
	Congruent	658.65 (62.51)	585.37 (51.46)	578.50 (53.04)	568.29 (58.40)		
	Incongruent	681.83 (70.37)	662.88 (53.43)	651.57 (52.39)	626.90 (55.58)		

We conducted a 2 (gender) × 4 (age group) × 4 (cue) × 3 (flanker) mixed ANOVA with RT as the dependent variable. Main effects were found for age [$F(3, 98) = 8.79$; $p < .001$; $\eta_p^2 = .21$], cue type [$F(3, 294) = 173.21$; $p < .001$; $\eta_p^2 = .64$] and flanker type [$F(2, 98) = 470.40$; $p < .001$; $\eta_p^2 = .83$]. As indicated by post-hoc pairwise comparisons using Bonferroni correction, 6-7-year-olds were overall significantly slower to respond than 9-year-olds and 10-11-year-olds, respectively, and 8-year-olds were significantly slower than 10-11-year-olds (see Table 5. for descriptive statistics). In addition, all pairwise comparisons between cue conditions were statistically significant, with the longest RTs in the No Cue condition, followed by the Center Cue, Double Cue, and Spatial Cue conditions, respectively. We found a similar pattern in the case of flanker conditions, with all pairwise comparisons significant (i.e., Neutral Flanker < Congruent Flanker < Incongruent Flanker). See Figure 5. for descriptive statistics. We found a significant cue × flanker interaction [$F(6, 588) = 5.98$; $p < .001$; $\eta_p^2 = .06$] and a gender × flanker interaction [$F(2, 196) = 9.34$; $p < .001$; $\eta_p^2 = .09$]. As Figure 5.7 indicates, all conditions containing a form of cueing are associated with higher conflict scores, as cues appear to have a disruptive effect on conflict processing. In order to further determine the nature of this interaction, we carried out correlations between all three attention network scores and found a statistically significant correlation between Alerting and Conflict: $r = .27$, $p < .01$.

We additionally carried out a 2 (gender) × 4 (age group) multivariate analysis of variance (MANOVA) with network scores as the dependent variables. This analysis revealed that boys had significantly higher Conflict scores than girls [$F(1, 98) = 9.54$; $p < .01$; $\eta_p^2 = .09$] but there were no gender effects on the Alerting and Orienting scores, and no age effects on any of the three attentional networks.

In order to determine the effect of child gender and age upon overall accuracy, we conducted a 2 (gender) × 4 (age group) one-way ANOVA with error rates as the dependent variable. This analysis showed main effects of both variables [$F(1, 98) = 4.65$, $p < .05$, $\eta_p^2 = .05$ for gender; $F(3, 98) = 11.86$, $p < .001$, $\eta_p^2 = .27$ for age], but no interaction effect. More precisely, boys had significantly higher error rates than girls (see Table 5.5 for descriptive statistics). Additionally, post-hoc pairwise comparisons with Bonferroni correction indicated that both 6-7 and 8-year-olds had significantly higher error rates than 9- and 10-11 year-olds, respectively (see Table 5.6).

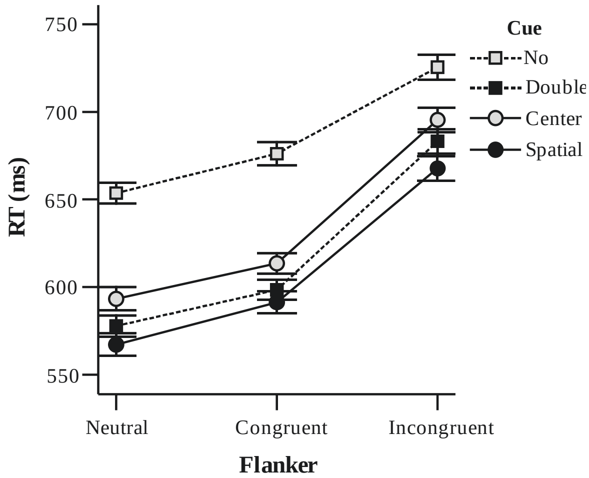

Figure 5.7. Mean RT (± 1 SE) in the middle childhood sample, plotted as a function of flanker and cue conditions.

5.8.2.2 Parent-report data: Attentional networks, EC and ER

As in our previous study, we first investigated the relationships between self-regulation measures and overall ANT performance indicators (overall RT and error rates), and then focused on the more specific relationships with attention network scores.

Among the temperament variables of interest, RT and/or error rates were correlated with overall EC (r = -.23, p < .05 for RT; r = -.24, p < .05 for errors) and Inhibitory control (r = -.21, p < .05 for RT; r = -.28, p < .01 for errors). However, only the links with EC (r = -.20, p < .05 for RT; r = -.21, p < .05 for errors) held when controlling for age, indicating that independent of the effect of age on performance higher levels of EC are associated with both faster and more accurate performance. Additionally, higher levels of Activation control are associated with faster performance. No statistically significant correlations were found between ER strategies and overall ANT performance.

Table 5.7

Correlations between study variables and attention network scores for the entire middle childhood sample and separated by children's gender

	Total sample			Boys			Girls		
	A	**O**	**C**	**A**	**O**	**C**	**A**	**O**	**C**
Anxiety	.14	-.15	.14	.22	-.32*	.15	.06	.01	.18
Depression	-.01	-.08	.06	-.14	-.13	-.05	.12	-.03	.18
Temperament									
Negative Affect (NA)	.05	-.06	.07	.12	-.22	.14	-.01	.10	.07
Fearfulness	.14	-.03	.01	.22	-.07	.13	.04	.03	-.03
Sadness	.00	-.08	.18	.04	-.29*	.21	-.04	.10	.15
Impulsivity	-.06	-.21*	.11	-.03	-.24	.14	-.10	-.20	-.02
Effortful Control (EC)	.14	.10	-.13	.13	.18	-.06	.14	.07	-.06
Attention focusing	.10	.06	-.07	.11	.05	-.06	.10	.11	.05
Inhibitory control	.11	.20*	-.23*	.07	.28*	-.21	.15	.15	-.15
Activation control	.11	-.04	.03	.12	.05	.20	.11	-.12	-.08
Emotion regulation									
Active coping	.11	.19	.09	$.31^{+}$	.26	.06	-.10	.13	.11
Distraction	-.09	.08	.15	.10	$.28^{+}$	.11	$-.27^{+}$	-.11	.01
Avoidance	-.16	.08	.03	.04	.19	-.04	-.33*	.01	.03
Support seeking	.09	.05	.04	.12	.08	-.05	.07	.02	.18

Note: A = Alerting; O = Orienting; C = Conflict.
*$p < .05$; $^{+}p < .10$

Correlations between self-regulation measures and the three attention network scores are displayed in Table 5.7. While overall EC was not linked to any of the three network scores, Inhibitory control was significantly correlated with the Orienting effect in the total sample (r = .20, p < .05) and in boys (r = .28, p < .05). However, both correlations became non-significant when age was controlled for (r = .18, *ns* in the total sample; r = .23, *ns* in the boys sub-sample). Most importantly, high Inhibitory control was also linked with low conflict scores in this age sample (r = -.23, p < .05; r = -.19, *ns* when controlling for age).

At the level of the entire sample, there was no relationship between any of the ER strategies and attention network scores. However, in the gender-split analysis, we found a significant correlation between Avoidance and Alerting in the case of girls (r = -.33, p < 05), and a marginally significant correlation between Active coping and Alerting in the case of boys (r = .31, p = .05).

In order to clarify the nature of these relationships, we proceeded in a manner similar to the approach taken in the previous study. Each self-regulatory characteristic that had a significant link with one of the attention network scores was transformed into a nominal dichotomous (i.e., high vs low) variable through a median split. For the optimism/positivity – alerting relationships found in the case of boys we only selected optimism, as it correlated more strongly with alerting and we assumed the pattern would be similar – only probably weaker – for positivity. For each relationship we carried out a 2 × 2 mixed ANOVA on RTs, with the self-regulatory trait as a between-subjects factor and the two conditions generating the attentional score as the within-subjects factor.

For the Inhibitory control–Conflict score relationship we found no statistically significant interaction with flanker type: $F(1, 104) = 1.05$, $p = .31$, $\eta_p^2 = .01$. However, the previously found correlation genuinely reflected lower executive attention performance in children with lower Inhibitory control, as this group had slower responses than children with high inhibitory control abilities in both flanker conditions: $t(104) = 2.01$, $p < .05$ for the Congruent Flanker condition; $t(104) = 2.38$, $p < .05$ for the Incongruent Flanker condition.

Regarding ER strategies, the 2 (high vs. low Avoidance) × 2 (No Cue vs. Double Cue) mixed ANOVA conducted with the purpose of exploring the Avoidance–Alerting relationship found in girls revealed a statistically significant interaction effect: $F(1, 43) = 5.98$, $p < .05$, $\eta_p^2 = .12$. Post-hoc t-tests showed that while there was no statistically significant difference between girls with high versus low Avoidance in the No Cue condition [$t(43) = 1.04$, *ns*], girls with low Avoidance were significantly faster in the Double Cue condition: $t(43) = 2.46$, $p < .05$; see Figure 5.8.

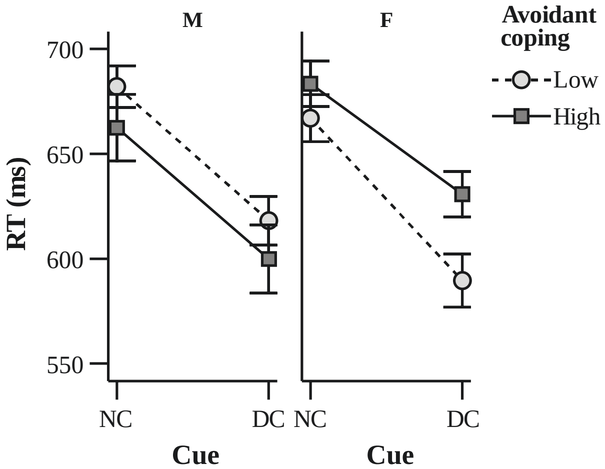

Figure 5.8. Mean RT (± 1 SE) for the middle childhood sample, plotted separately for boys (left panel) and girls (right panel) as a function of (A) cue type and avoidant strategies and (B) cue type and optimism.
Note: NC = No Cue; DC = Double Cue.

5.8.2.3 Parent-report data: Anxiety / Depression, attention and EC

In a manner similar to the analysis presented in the previous paragraph, we started out by investigating the correlations between Anxiety / Depression and indicators of overall ANT performance. This analysis revealed that both RT and error rates were significantly correlated with Anxiety (r = .22, p < .05 for RT; r = .28, p < .01 for errors), but not with Depression. However, when controlling for age only the correlation between Anxiety and error rates remained significant: r = .17, *ns* for RT; r = .25, p < .05 for errors. This indicated that the relationship between Anxiety and RT was partially explained by children's age, and that higher levels of Anxiety are related with higher error rates.

As can be seen in Table 5.7, there were no significant correlations between Anxiety or Depression and attention network scores at the level of the entire sample. In the gender-split analysis we found statistically significant results only for the boys' group, where high Anxiety was related to a low Orienting score (r = -.32, p < .05). We carried out two more correlational analyses between anxiety and Orienting in the case of boys: once controlling for Sadness (since, as the data in Table 5.7 indicates, it was also significantly correlated with Orienting) and once for Depression. When we controlled for Sadness, the relationship between Anxiety and Orienting disappeared (r = -.18, *ns*); when controlling for Depression it became marginally significant (r = -.27, p = .06). These results indicate that the relationship between Anxiety and Orienting in the case of boys is at least in part explained by the negative emotionality that is common to Anxiety, Sadness and Depression.

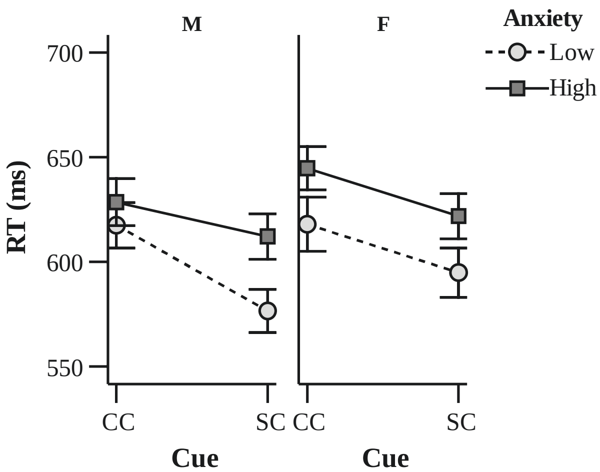

Figure 5.9. Mean RT (± 1 SE) plotted separately for boys (left panel) and girls (right panel) as a function of cue type and anxiety. *Note:* CC = Center Cue; SC = Spatial Cue.

We further explored the Anxiety–Orienting correlation found in boys through a 2 (high vs. low Anxiety) × 2 (Center Cue vs. Spatial Cue) mixed ANOVA with RT as a dependent variable. This analysis revealed a statistically significant Anxiety × Cue type interaction: $F(1, 49) = 6.67$, $p < .05$, $\eta_p^2 = .12$. Post-hoc t-tests found no significant differences between boys with high versus low Anxiety in the Center Cue condition: $t(49) = .70$, *ns*. However, boys with high Anxiety were significantly slower compared to their less anxious peers in response to the Spatial Cue: $t(49) = 2.35$, $p < .05$ (see Figure 5.9).

Since our preliminary analyses indicated the presence of an interaction between Alerting and Executive attention, we investigated whether this interaction was influenced by Anxiety. We carried out a 4 (cue) × 3 (flanker) ANCOVA with Anxiety as a covariate and RT as the dependent variable, but found no cue × flanker × Anxiety effect: $F(6, 624) = 1.37$, $p = .22$, η_p^2 =

.01. However, when looking at correlations between the three attentional networks in children with high versus low Anxiety, we found that the Alerting–Conflict correlation was present in high Anxiety (r = .32, p < .05), but not low Anxiety (r = .19, *ns*).

The next step in our analysis was to determine whether EC moderated the relationship between Anxiety and attention network scores. As in the preschool study, we carried out a series of hierarchal regression analyses according to the guidelines put forward by Aiken and West (1991) and Cohen et al. (2003). We first centered each predictor variable (i.e., anxiety and EC) and computed the interaction terms as the arithmetic product of the two centered variables. Gender and age were introduced first to partial out their effects. Anxiety was entered in the second step, EC was entered in the third step, and the interaction term was entered in the last step. In each case, the analysis was repeated as a gender-separate analysis (entering only age in the first step). Significant results were found only when the Orienting effect constituted the outcome variable. Therefore, we only present these results here.

Table 5.8
Hierarchical multiple regression predicting Orienting efficiency in middle childhood, with anxiety as a predictor and EC as a moderator

	Total sample			**Boys**			**Girls**		
	B	SE B	β	B	SE B	β	B	SE B	B
Step 1	R^2 = .02			R^2 = .03			R^2 = .00		
(Constant)	0.26	25.54		-17.91	39.75		10.10	32.54	
Gender	-4.94	6.66	-.07	-	-	-	-	-	-
Age	0.26	0.24	.11	0.43	0.37	.17	0.12	0.31	.05
Step 2	ΔR^2 = .02			ΔR^2 = .09*			ΔR^2 = .00		
(Constant)	4.74	25.66		-6.84	38.56		9.49	33.21	
Gender	-4.45	6.65	-.07	-	-	-	-	-	-
Age	0.22	0.24	.09	0.33	0.36	.13	0.13	0.31	.06
Anxiety	-0.34	0.26	-.13	-0.91	0.41	-.30*	0.04	0.32	.02
Step 3	ΔR^2 = .01			ΔR^2 = .01			ΔR^2 = .01		
(Constant)	7.38	25.91		4.61	41.31		7.32	33.58	
Gender	-5.82	6.86	-.09	-	-	-	-	-	-
Age	0.20	0.24	.08	0.22	0.39	.08	0.15	0.31	.07
Anxiety	-0.29	0.27	-.11	-0.88	0.41	-.30*	0.12	0.35	.05
EC	6.61	8.04	.09	10.88	13.69	.12	6.48	10.27	.09
Step 4	ΔR^2 = .08**			ΔR^2 = .01			ΔR^2 = .12*		
(Constant)	15.36	25.01		2.34	41.68		16.97	31.96	
Gender	-8.70	6.66	-.13	-	-	-	-	-	-
Age	0.11	0.23	.05	0.24	0.39	.09	0.02	0.30	.01
Anxiety	-0.61	0.27	-.23*	-0.80	0.43	$-.27^+$	-0.57	0.42	-.25
EC	7.51	7.73	.10	9.08	14.01	.10	7.41	9.72	.11
Anxiety × EC	-1.91	0.62	-.32**	-1.01	1.47	-.10	-1.92	0.73	-.46*

**p* < .05; ***p* < .01; $^+$ *p* < .10

As the data included in Table 5.8 indicates, the Orienting effect was significantly predicted by Anxiety and its interaction with EC. The complete model explained 12% (f^2 = 0.14) of the variance in Orienting scores when the entire sample was included, 14% (f^2 = 0.16) when only boys were included in the analysis and 13% (f^2 = 0.15) when only girls were included. In the case of boys, Anxiety was a significant direct predictor of the Orienting effect even when taking age into account (β = -.30, p < .05). EC significantly moderated the relationship between Anxiety and Orienting in the total sample (β = -.32, p < .01; ΔR^2 = .08, f^2 = 0.09) and in the case of girls (β = -.46, p < .05; ΔR^2 = .12, f^2 = 0.14). Thus the effect of the added variance was relatively small in the case of the total sample and moderate in the girls' sub-sample.

The plots for the interaction between anxiety and EC in predicting the orienting score are displayed in Figure 5.10. As can be seen, the relationship between Anxiety and Orienting is strongest at *high* levels of EC. The model predicts that children with high levels of Anxiety but also high levels of EC will have the lowest Orienting scores. Probing the interaction (using ModGraph; Jose, 2008) indicated that for the overall sample the slope was statistically significant only at high levels of EC [t(101) = -3.19, p < .01], but not medium [t(101) = -1.71, p = .09] or low levels [t(101) = 0.77, *ns*]. A similar pattern emerged in the case of the girls sub-sample: the slope for high EC was statistically significant [t(51) = -2.15, p < .05], while the slope for medium and low EC were not: t(51) = -0.95, p = .35 and t(51) = -0.98, p = .33, respectively.

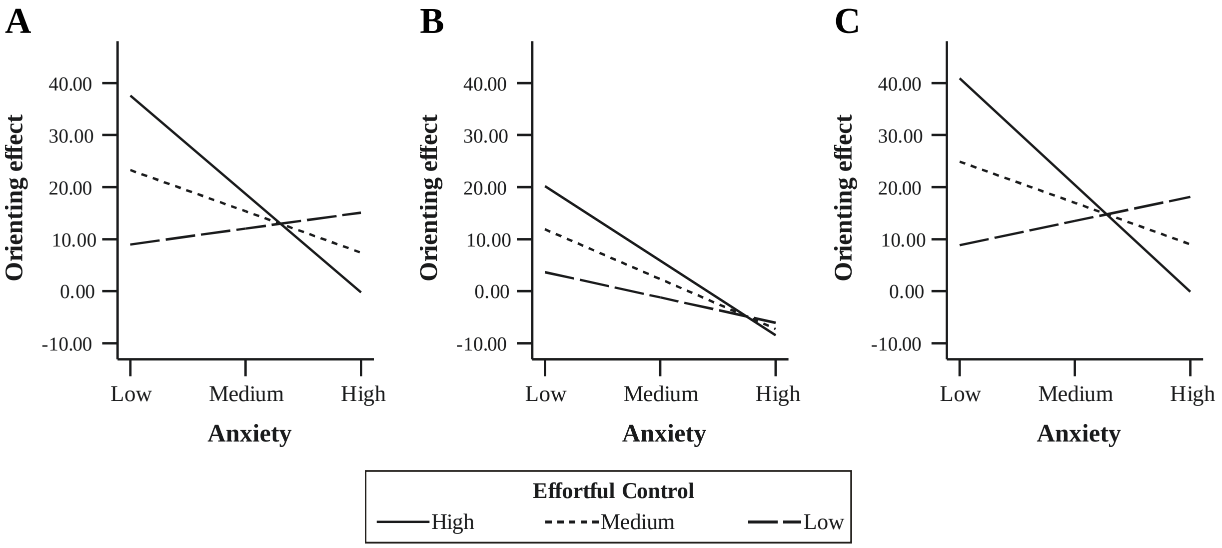

Figure 5.10. Interaction between anxiety and EC in predicting the orienting score in middle childhood for the entire sample (A), for boys (B) and for girls (C).

In other words, it seems that the direct negative relationship between Anxiety and Orienting found in the case of boys holds in the case of girls only at high levels of EC. To better understand this relationship, we plotted girls' RTs in the Center Cue and Spatial Cue conditions as functions of high vs low anxiety and EC, respectively. As Figure 5.11 indicates, girls with both low levels of Anxiety and low levels of EC appear to have the smallest Orienting scores. In fact, in their case the Center Cue–Spatial Cue manipulation appears to have no effect: Wilcoxon's test for two related samples: z = -0.98, *ns*, *M Orienting score* = 8.41 ms. In girls with high Anxiety, the orienting manipulation is effective whether children have high or low EC: z = -2.27, p < .05, *M Orienting score* = 23.57 ms for low EC, and z = -2.31, p < .05, *M Orienting score* = 22.08 ms for high EC. Furthermore, the orienting effect was virtually identical irrespective of EC abilities: Mann-Whitney U = 91.00, $p = .77$. The largest Orienting effect was found in children with low Anxiety and high EC: $z = -3.26$, $p < .01$, *M Orienting score* = 33.16 ms. Thus, the interactive effects of Anxiety and EC in the girls' sub-sample can be summarized as follows: the most well regulated children (with low anxiety and high EC) orient most efficiently. Girls with low Anxiety and low EC profit the least from the spatial, predictive cue. In children with high Anxiety, the level of EC a child possesses does not seem to matter. These children's Orienting scores are intermediate between the other two groups, but they have similar values irrespective of EC level.

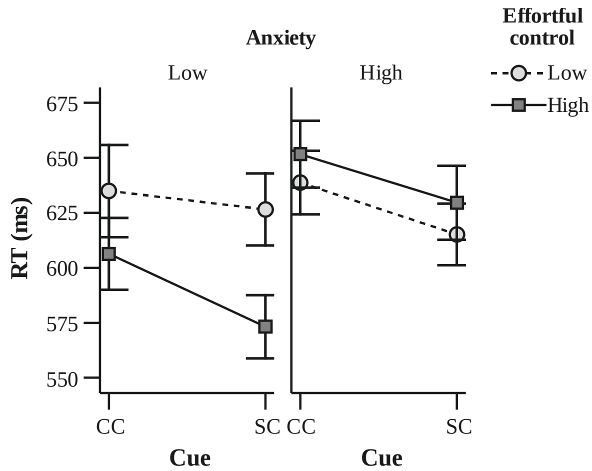

Figure 5.11. Mean RT (± 1 SE) for girls from the middle childhood sample, plotted separately for low anxiety (left panel) and high anxiety (right panel) as a function of cue type and EC. *Note:* CC = Center Cue; SC = Spatial Cue.

5.8.2.4 Child- vs. parent-reported characteristics

While there was no correlation between child- and parent-reported Anxiety ($r = .14$, *ns*), Depression scores were significantly related ($r = .36$, $p < .05$). A 2 (child gender) × 2 (respondent: parent vs. child) MANOVA with anxiety and depression scores as dependent variables indicated that children rated themselves as more anxious than parents rated them [$F(1, 88) = 7.85$, $p < .01$, $\eta_p^2 = .08$] and somewhat more depressed [$F(1, 88) = 3.63$, $p = .06$, $\eta_p^2 = .04$]. Child gender had no impact on either anxiety [$F(1, 88) = 2.11$, $p = .15$, $\eta_p^2 = .02$] or depression [$F < 1$, *ns*] and it did not interact with respondent either in rating anxiety [$F(1, 88) = 2.72$, $p = .10$, $\eta_p^2 = .03$] or depression [$F < 1$, *ns*].

Ratings of ER strategies made by parents and children were not significantly related (*r*s between .00 and .21, all *ns*). Parents rated their children as higher in all ER strategies than children did themselves: $F(1, 79) = 12.47$, $p < .01$, $\eta_p^2 = .14$ for Active coping; $F(1, 79) = 6.38$, $p < .05$, $\eta_p^2 = .08$ for Distraction; $F(1, 79) = 12.75$, $p < .01$, $\eta_p^2 = .14$ for Avoidance; $F(1, 79) = 39.29$, $p < .001$, $\eta_p^2 = .33$ for Support seeking. Child gender and its interaction with respondent had no effect on ratings of ER: all *F*s < 2, *p*s > .10.

Table 5.9
Descriptive statistics for variables assessed through self-report, for the total middle childhood sample, and separated by gender

	Total sample M (SD)	**Boys** M (SD)	**Girls** M (SD)
Anxiety (RCADS)	24.84 (14.31)	20.05 (11.05)	29.22 (15.73)
Depression (RCADS)	6.73 (3.95)	6.43 (3.80)	7.00 (4.15)
Emotion regulation (CCSC-R1)			
Active coping	2.30 (0.57)	2.36 (0.71)	2.23 (0.38)
Distraction	2.66 (0.79)	2.66 (0.86)	2.66 (0.73)
Avoidance	2.30 (0.49)	2.30 (0.59)	2.29 (0.37)
Support seeking	2.23 (0.73)	2.30 (0.88)	2.16 (0.56)
Attention (Child ANT)			
RT (ms)	601.76 (48.87)	602.61 (51.85)	600.91 (46.84)
Accuracy (% errors)	4.40 (3.40)	5.34 (3.63)	3.46 (2.94)
ANT Alerting	71.21 (42.01)	72.20 (48.53)	70.22 (35.39)
ANT Orienting	25.54 (33.94)	35.11 (33.81)	15.98 (31.96)
ANT Conflict	71.59 (34.09)	82.24 (33.58)	60.93 (31.82)

5.8.2.5 Child self-report data: Attention and ER

We found no significant correlations between general ANT performance (overall RT and error rate) and ER strategies. Correlations between attention network scores and ER strategies are presented in Table 5.. As can be seen, high Avoidance was linked to lower Conflict scores at the overall group level (r = -.33, $p < .05$) and in girls (r = -.51, $p < .05$), while Active coping was related to lower Alerting in girls (r = -.47, $p < .05$).

Table 5.10
Correlations between study variables measured through child self-report and attention network scores for the entire middle childhood sample and separated by children's gender

	Total sample			**Boys**			**Girls**		
	A	**O**	**C**	**A**	**O**	**C**	**A**	**O**	**C**
Anxiety (RCADS)	-.03	-.12	-.38*	-.21	.16	-.27	.15	-.18	-.33
Depression (RCADS)	-.04	-.07	-.16	-.23	-.02	-.25	.18	-.08	-.06
Emotion regulation (CCSC-R1)									
Active coping	-.24	.19	-.20	-.17	.26	-.29	-.47*	-.04	-.18
Distraction	-.06	-.17	-.06	-.14	-.11	-.07	.05	-.28	-.05
Avoidance	.03	.08	-.33*	.04	.08	-.26	.00	.07	-.51*
Support seeking	-.17	.18	-.12	-.11	.16	-.16	-.32	.19	-.15

Note: A = Alerting; O = Orienting; C = Conflict.
$*p < .05$; $^{+} p < .10$

A 2 (high vs low Avoidance) × 2 (Congruent vs Incongruent Flanker) mixed ANOVA found a statistically significant Avoidance × flanker type interaction in the case of girls [F (1, 18) = 5.81; $p < .05$; $\eta_p^2 = .24$], but not at the entire sample level [F (1, 39) = 2.69; $p = .11$; $\eta_p^2 = .06$]. Post-hoc *t*-tests revealed no statistically significant RT differences between low and highly avoidant girls in either the Congruent [$t(18) = 0.35$, *ns*] or Incongruent Flanker [$t(18) = 1.61$, *ns*] conditions. However, the sample was small, and as Figure 5.12A indicates, girls with higher avoidant tendencies indeed appeared to have better executive attention performance.

For the active coping – alerting relationship found in girls, the interaction effect was not statistically significant: F (1, 18) = 2.73; $p = .12$; $\eta_p^2 = .13$. As Figure 5.12B indicates, girls with higher Active coping skills tend to have overall slower RTs and lower Alerting scores.

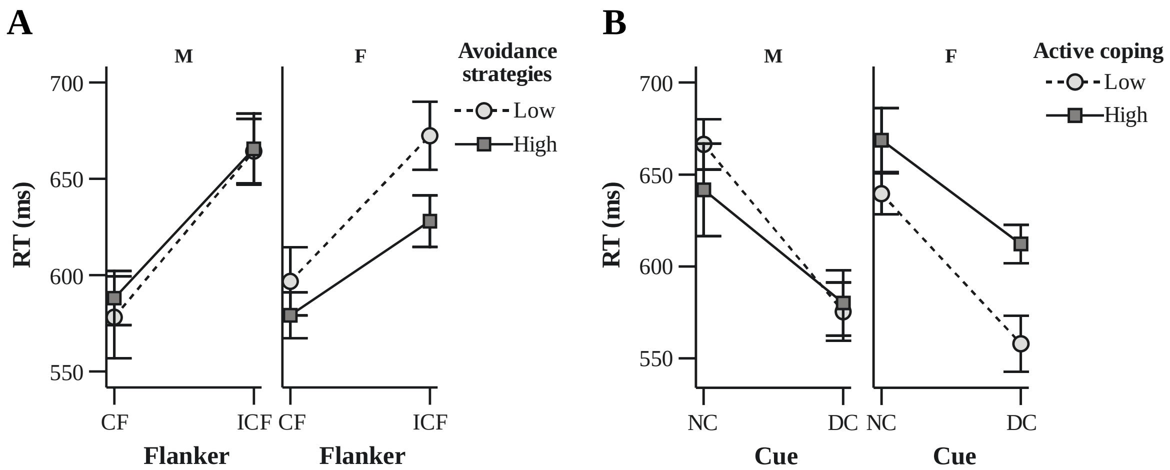

Figure 5.12. Mean RT (± 1 SE) for the middle childhood self-report sample, plotted separately for boys (left panel) and girls (right panel) as a function of (A) flanker type and Avoidace and (B) Cue type and Active coping.
Note: CF = Congruent Flanker; ICF = Incongruent Flanker; NC = No Cue; DC = Double Cue.

5.8.2.6 Child self-report data: Anxiety / Depression and attention

We found no correlations between Anxiety or Depression and indices of general ANT performance. While Depression scores were not related with attention network scores, high Anxiety was significantly related to lower conflict scores at the total sample level ($r = -.38$, $p < .05$). The 2 (high vs. low Anxiety) × 2 (Congruent vs. Incongruent Flanker) interaction effect was statistically significant: $F(1, 42) = 6.58$; $p < .05$; $\eta_p^2 = .14$. Post-hoc *t*-test comparisons showed that children had similar RTs in the Congruent Flanker condition [$t(42) = 0.31$, *ns*] and those with higher Anxiety had somewhat lower Conflict scores [$t(42) = 1.74$, $p = .09$], but this was only a tendency, not a statistically significant result (see also Figure 5.13).

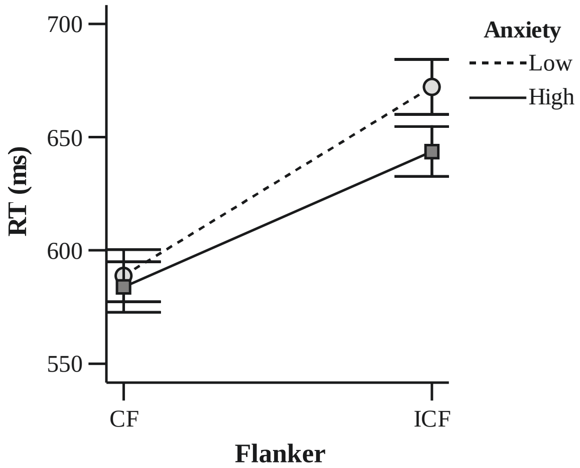

Figure 5.13. Mean RT (± 1 SE) in middle childhood, plotted as a function of flanker type and anxiety. *Note:* CF = Congruent Flanker; ICF = Incongruent Flanker.

Due to the low sample size in the self-report group, no moderation was tested here.

5.8.3 Discussion

The present study took investigated the two main objectives stated at the outset while taking into account the results of the previous study, and using a similar methodology.

Regarding general ANT performance, as in our previous study, performance improved (faster responses, lower error rates) as children got older, with the most important change occurring between 8 and 9 years. However, we found no improvement in any of the three attentional networks. These results are in line with those of Rueda, Fan et al. (2004), who found little evidence for change in the three attentional networks in a similar age sample. However, contrary to Rueda's results, we did find an interaction between the alerting and conflict networks. This interaction was similar to the one found by Fan et al. (2009) and Callejas et al. (2004; 2005) in adults. Namely, all cueing conditions had a detrimental effect on executive attention, but this effect was strongest (and statistically significant) in the case of the Double Cue condition.

In line with results obtained in preschoolers, children with higher EC abilities also had better overall performance (faster responses and lower error rates). Additionally, high inhibitory control was related to lower conflict scores. While this relationship was partially mediated by children's age, it is in line with previous research (Simonds et al., 2007) and theorizing (Berger, Henik, & Rafal, 2005; Rueda, Posner, & Rothbart, 2005) indicating links between executive attention and temperamental self-regulation. This indicates that in this older sample better inhibitory control is undoubtedly associated with lower conflict scores, and therefore better executive attention. In light of these results and those obtained in the previous study, it is likely that the relationship between inhibitory control as assessed through parent-report and executive attention measured by the ANT is more complex than previously thought and is influenced by the developmental level of the child. The link between high orienting scores and high inhibitory control is more difficult to explain and further studies are necessary to clarify its nature.

With respect to ER strategies, high alerting scores were linked to reduced use of avoidant strategies in girls. In other words, better regulated girls had lower RTs than less well regulated girls (including in the No Cue condition, although here the difference did not reach statistical significance), and at the same time were more responsive to the alerting cue. To put it another way, girls with reduced avoidant tendencies had improved phasic alertness, while intrinsic alertness performance was similar across the whole group. It is possible that different combinations of intrinsic and phasic alertness performance reflect different patterns of task engagement. Low performance in both might reflect a state of low arousal and reduced task engagement. In fact, Coull et al. (2001) have shown that RTs increase in both alerting conditions after the administration of clonidine (but phasic alertness is impaired more). Impaired performance in the absence of a warning cue and fast responses when such a warning is given might reflect an imbalance between the voluntary versus reflexive aspects of attention, like the pattern found in our previous study. Lastly, good (or moderate) intrinsic alertness performance combined with good phasic alertness might reflect well-regulated attention. Thus it is likely that children with good ER skills also have well-modulated attentional mechanisms. Whether there is a causal link between them or not is difficult to tell. Further research is necessary to determine how reliable these relationships are, and to better understand their nature.

Regarding attentional networks and anxiety, there are several aspects that need to be discussed. First, when investigating the interactions (correlations) between the three attentional networks separately for high- and low-anxiety children, we found that the interaction between alerting and executive attention previously found in the entire group was in fact present only in the high-anxiety group. This possibly indicates that the alerting system is more disruptive of executive attention, in high anxiety, which, again, would be in line with the predictions of the ACT. This might be due to an overactive phasic alertness mechanism like the one found in preschoolers, but it might be more subtle as we did not find a direct (or moderated) relationship between anxiety and alerting in this sample. However, due to the fact that the cue by flanker by anxiety interaction effect was not statistically significant, this result must be interpreted with caution.

Beyond these effects, the most important finding related to anxiety was the replication of Moryia and Tanno's (2009b) anxiety–orienting relationship in a much younger sample. Although in our data this relationship was a direct one only in the boys sub-sample, our findings indicate, like those of Moryia and Tanno, that in boys high trait anxiety is associated with a diminished orienting effect. This result points to a potential deficit in moving and engaging attention to an exogenously cued location (and probably also in disengaging attention from fixation) in boys with higher anxiety, i.e., in taking advantage of the spatial cues for the purpose of more efficient performance. These results are reminiscent of data showing deficits in disengagement from threat in anxious participants (Fox, Russo, Bowles, & Dutton, 2001; Georgiou et al., 2005), but they are all the more interesting considering that the ANT is a neutral, non-emotional task. Our data indicates that at least in the case of boys, higher levels of anxiety are associated with what appear to be difficulties in efficient orienting of attention to exogenous, task-relevant cues. Lastly, our results showed that although there was no direct relationship between anxiety and orienting in the case of girls, the relationship between the two was moderated by EC. More precisely, the negative link between anxiety and orienting was only significant at high levels of EC. While this might constitute an apparent paradox (we would expect this effect to occur at *low* levels of EC), further analyses indicated that in fact at high levels of anxiety, girls had similarly small orienting scores (the same pattern as the one seen in boys). However, in girls this effect appears to be less specific, as it is also present in those with low anxiety and low EC.

Results from the child self-report sample showed that high anxiety and high avoidance were associated with low conflict scores, while high active coping was associated with low alerting. It is interesting that while so far we have found little evidence for links between anxiety and conflict, this link appears to be present here. While we would have expected to find evidence for impaired executive attention in children with high anxiety, our finding is somewhat similar to previous findings in studies using emotional faces as inter-trial stimuli (Dennis et al., 2008; Finucane & Power, 2010), where high state and trait anxiety were associated with better executive attention following the presentation of fearful faces in adults. Since here we used no emotional stimuli, future studies should clarify whether this finding can be replicated. As far as avoidance is concerned, it is possible that a certain degree of executive control might be necessary to develop efficient avoidance (even though this mechanism is not very adaptive in the long run). The high active coping-low alerting relationship is apparently in the direction we would have expected, and most authors would probably interpret this as high active coping-good alerting performance. However, our exploration of the results appears to indicate possibly a certain level of disengagement with the task in children with higher active coping skills. Future studies should determine how reliable these correlations are (by using larger samples) and how children (and their parents) perceive ER strategies like avoidance and active coping.

In conclusion, our results indicate that in middle childhood executive attention is related to temperamental inhibitory control, that high alerting is linked to the use of adaptive ER strategies, that children with higher anxiety tend to orient more slowly in response to exogenous cues, and tend to manifest higher interference between alerting and executive attention.

5.9 Study 2C: Attentional networks and anxiety in adulthood

5.9.1 Method

5.9.1.1 Participants

The initial sample was composed of 90 undergraduate students enrolled in the Psychology program at the Babeş-Bolyai University (BBU) in Cluj-Napoca, Romania. These participants represent a sub-sample of the group included in Study 1C. Participants were recruited through an announcement informing them about the study, and received course credit for participation. A number of 5 participants (4 females, 1 male) were eliminated due to having more than 10% errors. This error rate was considered too high for adult participants in this task as it indicates poor engagement with the task. Thus, the final sample consisted of 85 participants (73 females), aged 19-44 years (M = 23.09, SD = 5.83). However, it should be noted that due to the source of our participant pool and the nature of the selection process, the majority of our participants (i.e., N = 67) were below 25 years of age.

5.9.1.2 Measures

Anxiety and depression

Trait anxiety was assessed using the Romanian version of the *State Trait Anxiety Inventory* (STAI; Spielberger, 1983; see Pitariu & Peleasa, 2007 for the Romanian version) and depression was assessed using the *Beck Depression Inventory* (BDI; Beck, Steer, & Carbin, 1988; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

Temperament

Participants completed the Romanian version of the *Adult Temperament Questionnaire* (ATQ; Derryberry & Rothbart, 1988; Evans & Rothbart, 2007). Details regarding this instrument can be found in Chapter 3, Study 1C. For the purposes of the present study, we selected sub-scales for Fear (α = .83), Sadness (α = .86), Attentional control (α = .86), and Inhibitory control (α = .64), as well as the higher-order dimensions of NA (α = .90) and EC (α = .90).

Emotion regulation

Participants completed the Romanian version of the *Cognitive Emotion Regulation Questionnaire* (CERQ; Garnefski, Legerstee, Kraaij, van den Kommer, & Teerds, 2002; Perţa et al., in preparation; see Chapter 3, Study 1C for details). In the current sample internal consistency indices ranged between .66 and .90. In the present study we did not include the higher-order Maladaptive and Adaptive ER dimensions.

Attentional networks

The adult version of the Attention Network Test (Fan et al., 2002) was used to assess the efficiency of the three attentional networks in our adult sample. Each trial starts with a central fixation cross (presented for 400-1600 ms), followed – in 75% of the trials – by a warning cue (an asterisk displayed for 100 ms) and then (after 400 ms) by the target display. The target display consists of the target arrow, pointing right or left and presented centrally above or below fixation, alone or flanked by two other arrows on each side. The participant must respond within 1700 ms by pressing the left or right mouse pad button.

Two variables are manipulated within the task: the type of warning cue given and the type of flankers used. The *cue conditions* are as follows: (1) No Cue; (2) Center Cue (the asterisk is displayed in the center of the screen); (3) Double Cue (two asterisk are displayed – one below, one above fixation) and (4) Spatial Cue (one asterisk, presented either above or below fixation; the cue is 100% valid). The *target display* can be composed of either (1) the target arrow presented alone (Neutral Flanker condition) or the target arrow flanked by two other arrows on each side (2) pointing in the same direction (Congruent Flankers), or (3) in the opposite direction (Incongruent Flankers). The efficiency of the three attentional networks was determined exactly as in the two previous studies involving children.

5.9.1.3 Missing data

In a number of 7 participants, data was missing from the CERQ strategies of Catastrophizing and Other-blame.

5.9.1.4 Procedure

The experiment took place at the Developmental Psychology Lab in the Psychology Department of the BBU. Each participant completed the four questionnaires described above and was tested using the ANT. As in the case of children, the task was administered using a laptop computer with a 15-inch display, with the screen resolution set to 1024 × 768. The left and right buttons of the mouse pad were used to collect responses. The task started with a practice block consisting of 24 trials, during which participants received written feedback after each trial. The practice block was followed by three blocks consisting of 96 trials each. No feedback was given during the three experimental blocks. The entire task lasted approximately 20 minutes (including instructions and breaks).

5.9.2 Results

Except for the results of preliminary analyses, all further results are presented for the entire sample only, as gender-separate analyses did not reveal different results in males and females.

5.9.2.1 Preliminary analyses

As before, Depression scores showed a significant departure from normality (Kolmogorov-Smirnov statistic = .13, $p < .01$), due to a positive skew in the data (i.e., very few participants had high scores on the BDI). We used a square-root transformation on Depression scores, which was effective in normalizing the distribution (Kolmogorov-Smirnov statistic = .07, $p > .20$). We therefore include both the original and the normalized data in the analyses.

Table 5.11
Descriptive statistics for study variables for the total adult sample, and separated by gender

	Total sample M (SD)	**Males** M (SD)	**Females** M (SD)	**df**	**t-test**
Anxiety (STAI-Trait)	40.54 (8.89)	34.33 (5.60)	41.56 (8.94)	83	-2.71**
Depression (BDI)	7.29 (5.99)	4.58 (4.74)	7.74 (6.09)	83	-1.71
Depression norm. (BDI)	2.43 (1.20)	1.81 (1.20)	2.53 (1.17)	83	-1.97
Temperament (ATQ)					
Negative Affect (NA)	4.00 (0.58)	3.27 (0.34)	4.12 (0.52)	83	-5.46***
Fear	4.03 (0.97)	2.86 (0.46)	4.22 (0.89)	83	-5.18***
Sadness	4.07 (0.87)	3.26 (0.71)	4.21 (0.83)	83	-3.76***
Effortful Control (EC)	4.29 (0.72)	4.72 (0.54)	4.21 (0.72)	83	2.33*
Attentional control	4.07 (0.91)	4.92 (0.57)	3.93 (0.88)	83	3.78***
Inhibitory control	4.28 (0.74)	4.61 (0.80)	4.23 (0.72)	83	1.65
Activation control	4.50 (0.96)	4.62 (0.67)	4.48 (1.00)	83	0.44
Emotion regulation (CERQ)					
Self-blame	10.55 (2.15)	9.42 (2.11)	10.74 (2.11)	83	-2.01*
Acceptance	11.93 (2.89)	11.42 (3.06)	12.01 (2.87)	83	-0.66
Rumination	12.95 (3.40)	10.92 (3.15)	13.29 (3.35)	83	-2.29*
Positive Refocusing	9.46 (3.37)	10.58 (3.18)	9.27 (3.39)	83	1.25
Refocus on Planning	15.09 (3.37)	15.25 (3.70)	15.07 (3.33)	83	0.17
Positive Reappraisal	14.51 (3.59)	13.83 (4.32)	14.62 (3.48)	83	-0.70
Putting into Perspective	12.94 (3.68)	12.25 (3.55)	13.05 (3.71)	83	-0.70
Catastrophizing	7.06 (2.88)	6.82 (2.71)	7.10 (2.92)	83	-0.30
Other-blame	8.09 (2.18)	9.00 (2.32)	7.94 (2.14)	83	1.51
Attention (ANT)					
RT	513.81 (48.35)	503.58 (44.18)	515.49 (49.08)	83	-0.79
Accuracy (% errors)	2.05 (1.78)	1.68 (1.04)	2.11 (1.87)	83	-0.78
ANT Alerting	38.33 (20.88)	25.67 (18.35)	40.41 (20.65)	83	-2.32*
ANT Orienting	39.90 (20.32)	38.58 (21.27)	40.12 (20.31)	83	-0.24
ANT Conflict	95.95 (32.46)	97.08 (21.80)	95.77 (34.01)	83	0.13

$*p < .05$; $**p < .01$; $***p < .001$

Descriptive statistics for all measures of interest, for the entire sample and separated by gender, are presented in Table 5.11. As in our studies focusing on children, we first investigated the presence of correlations with age, and gender differences. However, due to the disproportionate number of participants below 25 years and females in our sample, these results should be interpreted with caution[13].

Gender and age

Levene's test revealed unequal variances only for Fear (F = 7.07, p < .01); for all other variables variance was equal in males and females. Women had higher scores than men for Anxiety [t(83) = 2.71, p < .01], Fear [t(26.82) = 8.05, p < .001], Sadness [t(83) = 3.76, p < .001], overall NA [t(159) = 5.47, p < .001] and the ER strategies of Self-blame [t(83) = 2.01, p < .05] and Rumination [t(83) = 2.29, p < .05] (see Table 5.11 for details). Men had higher scores for Attentional control [t(83) = 3.79, p < .001] and EC [t(159) = 2.33, p < .05]. Within this sample there were no gender-related differences in Depression.

Due to the non-normal distribution of participants' age in our sample, we carried out nonparametric correlations (Spearman's ρ) between age and all variables of interest. As age increased, so did Inhibitory control and EC skills (ρ = .35, p < .01 and ρ = .25, p < .05, respectively), while the tendency to use ER strategies of Acceptance and Rumination decreased (ρ = -.22, p < .05 and ρ = -.34, p < .01, respectively). Anxiety and Depression did not vary with age (ρs < .19, *ns*).

Adult ANT

Descriptive statistics by cue and flanker condition are presented in Table 5.12. We found no RT or accuracy differences between males and females: t(83) < .80, *ns*. However, females had higher Alerting scores than males: t(83) = 2.33, p < .05. Error rates dropped with age (ρ = -.23, p < .05), as did Alerting scores (ρ = -.22, p < .05).

Table 5.12
Mean ANT RTs (in ms) and SDs as a function of cue and flanker conditions for the adult sample

Flanker type	**Cue type**			
	No cue	*Center cue*	*Double cue*	*Spatial cue*
Neutral	519.50 (45.14)	485.82 (47.33)	482.61 (47.55)	455.94 (45.31)
Congruent	521.72 (49.83)	491.48 (54.68)	483.49 (49.94)	457.60 (47.65)
Incongruent	612.14 (71.84)	602.05 (66.23)	585.56 (69.12)	535.12 (67.38)

We conducted a 4 (cue) × 3 (flanker) repeated measures ANOVA with RT as the dependent variable. Main effects were found for Cue [F(3, 252) = 325.48, p < .001, η_p^2 = .80], Flanker type [F(2, 168) = 614.07, p < .001, η_p^2 = .88], and the interaction of Cue and Flanker conditions: F(6, 504) = 19.36, p < .001, η_p^2 = .19.

[13] Despite this unequal age distribution, the main analyses were not fundamentally affected by the over-representation of young adults. While these analyses are presented only for the entire sample, each one of them was carried out twice – once with all, second without the older participants and the results were essentially identical.

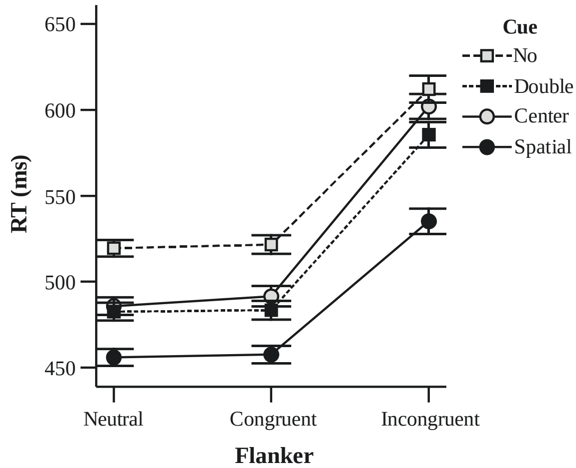

Figure 5.14. Mean RT (± 1 SE) in the adult sample, plotted as a function of flanker and cue conditions.

Post-hoc pairwise comparisons with Bonferroni correction found statistically significant RT differences between all Cue conditions: the longest RTs were found in the No Cue condition, followed by the Center Cue, Double Cue, and Spatial Cue conditions. In the case of flanker conditions, RTs were significantly longer in the Incongruent Flanker condition compared to both the Neutral and Congruent Flanker conditions. See Table 5.12 and Figure 5.13 for descriptive statistics. The cue × flanker interaction found here is in line with data obtained by Fan et al. (2002) in adults. As Figure 5.14 indicates, Conflict scores were larger in the case of double and center cues. In order to further determine the nature of this interaction, we carried out correlations between overall RT and all three attention network scores. Overall RT correlated with the Conflict score (r = .37, p < .001), but except for a marginally significant correlation between Alerting and Orienting (r = .19, p = .08) there were no other correlations between the three attention network scores.

5.9.2.2 Attentional networks, EC and ER

As in our previous two studies we first investigated the relationships between self-regulation measures and overall ANT performance indicators (overall RT and error rates), and then focused on the more specific relationships with attention network scores. We found no statistically significant relationships between general performance indicators and EC or any of its sub-dimensions (all |*r*s| < .18, *ns*), indicating that in adults self-regulatory abilities are not related to overall performance in this task. Similarly, no relationships were found between EC and its sub-dimensions and attention network scores (all |*r*s| < .14, *ns*). ER strategies were not related to overall ANT performance (all |*r*s| < .18, *ns*). However, participants with higher Conflict scores reported more frequent use of Self-blame (r = .24, p < .05) and less frequent use of Acceptance (r = -.22, p < .05).

Table 5.13
Correlations between study variables and attention network scores for the entire sample and for female participants.

	Total sample			Females		
	A	**O**	**C**	**A**	**O**	**C**
Anxiety (STAI-Trait)	.05	-.12	-.05	-.06	-.17	-.05
Depression (BDI)	.00	-.27*	-.13	-.10	-.32*	-.18
Depression norm. (BDI)	.01	-.20	-.10	-.11	-.28*	-.13
Temperament (ATQ)						
Negative Affect (NA)	.05	.00	-.12	-.10	-.03	-.12
Fearfulness	.02	.01	-.07	-.15	-.01	-.07
Sadness	.12	.08	-.14	.01	.04	-.15
Effortful Control (EC)	.01	.06	.13	.07	.06	.15
Attentional control	.01	.05	.13	.11	.07	.18
Inhibitory control	.01	.06	.14	.05	.05	.10
Activation control	.00	.04	.07	.01	.02	.09
Emotion regulation (CERQ)						
Self-blame	.05	.08	.24*	.00	.09	$.21^{+}$
Acceptance	-.05	-.13	-.22*	-.07	-.17	-.28*
Rumination	.17	-.09	.00	.14	-.15	-.05
Positive Refocusing	-.12	.10	-.03	-.13	.08	-.06
Refocus on Planning	.14	.14	$.19^{+}$	.21	.18	.14
Positive Reappraisal	.03	.08	.09	.01	.04	.03
Putting into Perspective	-.03	.03	.01	-.10	.02	-.03
Catastrophizing	.08	-.12	.04	.07	-.14	.00
Other-blame	.03	-.09	-.02	.07	-.09	-.09

Note: A = Alerting; O = Orienting; C = Conflict.
*$p < .05$; $^{+}p < .10$

A 2 (high vs. low Self-blame) × 2 (Congruent vs. Incongruent Flanker) ANOVA with RT as the dependent variable found a significant interaction effect: $F(1, 83) = 6.65$, $p < .05$, $\eta_p^2 = .07$. Post-hoc comparisons were not statistically significant. A similar analysis found no Acceptance × flanker interaction effect: $F(1, 83) = 1.79$, $p = .18$, $\eta_p^2 = .02$. However, as Figures 5.15A and 5.15B indicate, in both cases the tendency was for participants high in Self-blame and those low in Acceptance to have higher RTs in the Incongruent Flanker condition, and relatively similar RTs in the Congruent Flanker condition.

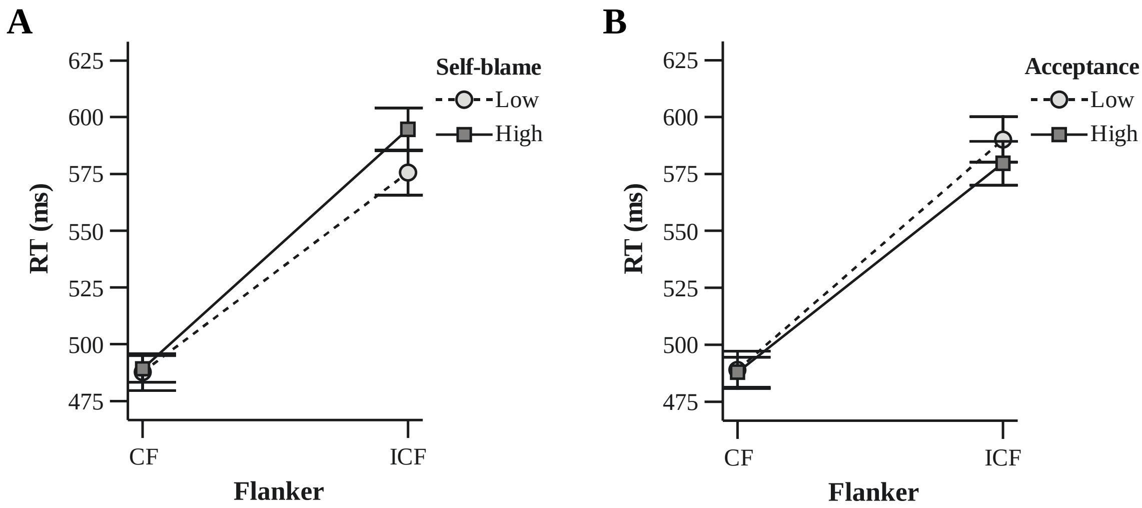

Figure 5.15. Mean RT (± 1 SE) for the adult sample, plotted as a function of (A) flanker type and self-blame and (B) flanker type and acceptance.
Note: CF = Congruent Flanker; ICF = Incongruent Flanker.

5.9.2.3 Anxiety / Depression, attention and EC

Neither Anxiety nor Depression scores were related to general ANT performance (RT and error rates). As Table 5.13 indicates, anxiety was not related to any of the three attention network scores. However, high Depression scores were related to low Orienting scores (the correlation was significant only in the female sample when we used the normalized version of Depression scores).

We further explored the Depression-orienting correlation through a 2 (high vs. low Depression) × 2 (Center Cue vs. Spatial Cue) mixed ANOVA with RT as a dependent variable. The Depression × cue type interaction was statistically significant: $F(1, 83) = 5.05$, $p < .05$; $\eta_p^2 = .06$. Post-hoc comparisons were not statistically significant (see Figure 5.16).

We investigated whether anxiety influenced the interaction between attentional networks through a 4 (cue) × 3 (flanker) ANCOVA with anxiety as a covariate and RT as the dependent variable. No interaction effect was found: $F < 1$, *ns*. A similar result was found when Depression was used as a covariate ($F < 1$, *ns*.). However, high Alerting was related to high Orienting in participants with high Anxiety ($r = .31$, $p < .05$), but not those with low anxiety ($r = .11$, *ns*), and with both high Orienting and high Conflict scores in high Depression ($r = .39$, $p < .05$ with Orienting, $r = .35$, $p < .05$ with Conflict), but not low Depression ($r = .08$, *ns* with Orienting, $r = -.13$, *ns* with Conflict).

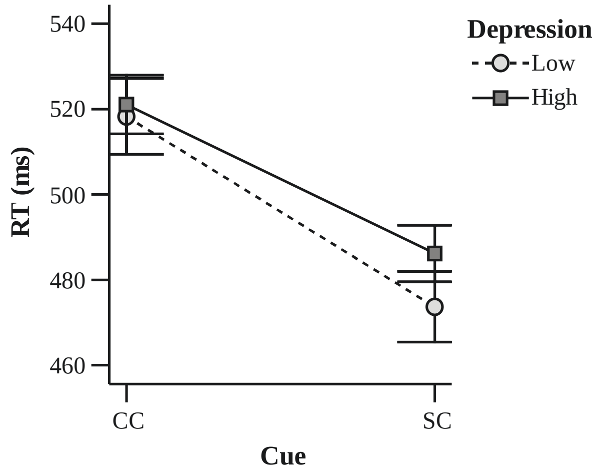

Figure 5.16. Mean RT (± 1 SE) for the adult sample, plotted as a function of cue type and depression. Description. *Note:* CC = Center Cue; SC = Spatial Cue.

Moderation analyses were conducted with a methodology identical to the one described in the two previous studies included in this chapter. However, in adults EC did not moderate the relationships between either Anxiety or Depression and attentional networks.

5.9.3 Discussion

As in our middle childhood sample, we found interactions between cue and flanker conditions. These interactions were explained, on the one hand, by the fact that, as in our previous study, there was a tendency for alerting cues (Double Cue and Center Cue) to disrupt the participants' ability to resolve interference. On the other hand, there was a small correlation between the alerting and orienting networks. This latter correlation, although small, is in line with previous research in the literature, indicating the fact that the alerting network influences orienting (Callejas et al., 2004; 2005; Fan et al., 2009).

In contrast with the previous two studies, neither EC nor any of its sub-dimensions were related to general ANT performance, or any attentional network. However, there was a tendency for participants with higher conflict scores to use self-blame more frequently and acceptance more rarely as ER strategies. In other words, as we would expect, participants with impaired executive attention were somewhat more likely to have poorer ER abilities, although these effects were smaller than the ones found in younger participants. There were no relationships between attention and refocusing or positive reappraisal, although we would have expected these two ER strategies to be more related to attention.

Anxiety was not related to the three attentional networks, neither directly or through the moderation of EC. However, depression was related here to low orienting scores. This finding was similar to the one present in Moria and Tanno's (2009b) study and in our middle childhood sample (in the case of anxiety). Namely, adults with higher depression scores oriented more slowly after the presentation of the exogenous spatial cue. In our previous study, we linked the high anxiety–slow orienting with previous research regarding the threat-related slow attentional disengagement found in high anxiety (E. Fox et al., 2002). Since this is an adult sample, one more interpretation is possible. Research shows that, apart from the type of cueing and cue validity, orienting performance is also affected by timing manipulations. More precisely, the interval between cue and target (i.e., the SOA) influences the effect of cueing on performance. While short SOAs (< 200 ms) facilitate performance (resuting in faster RTs), SOAs higher than 300 ms tend to be associated with longer RTs (sometimes even reversing the validity effect).

This phenomenon is know as *inhibition of return* (IOR; Posner & Cohen, 1984) and evidence suggests that it is caused by oculomotor programming, which tends to favor exploration of novel spatial locations at the expense of the ones already "visited" (see Klein, 2000; Lupiáñez, Klein & Bartolomeo, 2006 for reviews). Thus, it is possible that the slower orienting associated with higher depression found here might be a side-effect of differences in IOR associated with different levels of depression. This is a possibility that remains to be investigated in future research.

As in our middle childhood sample, the interaction between cues and flankers was not modified as a function of anxiety (or of depression). However, high alerting was related to high orienting in participants with high anxiety and those with high depression, and to high conflict scores in participants with high depression. Thus, it seems that as we move from preschoolers to adults alerting stops being related to anxiety directly, but it increasingly affects the other two attentional networks in persons with high anxiety.

5.10 General discussion

The research presented in this chapter aimed to determine primarily whether high anxiety is related to alterations in the three essential attentional functions postulated by Posner and Petersen's (1990) model (alerting, orienting and executive attention). We considered this model relevant since it allowed us to look at anxiety-related attentional functioning in a non-emotional context, and through the lens of a set of mechanisms with clearly specified behavioral and neurofunctional correlates. As a second objective, we were interested in whether we could find any links between attention and self-regulatory abilities (namely EC and ER strategies). This objective was considered relevant especially in the case of ER, since very little previous research has investigated the role of attentional mechanisms (assessed with objective attention tasks) in its development. Both of these objectives were followed from a developmental, cross-sectional perspective, as we focused on three age samples: preschool, middle childhood and young adulthood.

Taken together, our results indicate that the alerting and orienting systems play a more important role in anxiety than executive attention does, at least as far as neutral contexts are concerned. In preschoolers (in girls) higher alerting was linked to fearfulness, and to anxiety when inhibitory control was low. In both cases the higher alerting scores reflected impaired intrinsic alertness (i.e., reduced ability to maintain attentional focus on the task endogenously) and overactive phasic alertness. In other words, as predicted by ACT, in girls who were prone to anxiety and had reduced inhibitory control abilities attention was more stimulus-driven and less goal-driven. In middle childhood, high anxiety was associated with slow orienting to the spatial stimulus. The relationship was relatively specific in that in was not related to depression. However, the same pattern was present in girls with low anxiety and low EC. In adults, anxiety was no longer associated with any attentional alterations, but we found links between slow orienting and depression. In other words, the orienting pattern that had been linked to anxiety in middle childhood was now linked to depression. Research indicate that developmentally depression tends to follow anxiety (Muris, Merckelbach, Schmidt, Gadet, & Bogie, 2001), which might explain the developmental pattern we found. As already mentioned, executive attention (measured as flanker interference) played little role in relation to anxiety. Except for a link between executive attention and self-reported anxiety in middle childhood (where high anxiety was actually related with *better* executive attention), none of our findings indicated that high anxiety might be associated with impairments in the ability to inhibit a prepotent response and activate the appropriate one. This is not necessarily surprising, as Eysenck et al. (2007) have already suggested that inhibitory mechanisms might be affected especially when emotional processing is involved (which was not the case here). However, inhibitory and EC abilities were involved in a different manner, as they moderated the anxiety-attention links.

One interesting result was represented by the interactions/correlations between attentional networks. Even more interesting is the fact that these relationships are stronger in high anxiety and their links tend to strengthen as anxious people get older. In young children alerting is more directly linked to anxiety (especially in girls), while the three neural networks do not interact. The fact that an imbalance in bottom-up versus top-down regulation of alertness is associated with anxiety at such a young age is extremely relevant from a developmental point of view, as alerting is considered a basic attentional mechanism, one that contributes to the development of later, more complex attentional functioning (Sturm & Willmes, 2001). And as our results indicate, this appears to be true especially in the case of high anxiety. Based on our data it is possible to hypothesize an early anxiety-related imbalance in alertness mechanisms, which then cascades to affect the development of (at least) orienting and executive attention. In other words, after the preschool years, we do not see any more links between anxiety and alerting on the surface, but these mechanisms continue to affect attentional functioning in high anxiety in more subtle ways.

With respect to our second objective, we found that – put in a developmental context – the relationship between questionnaire-measured effortful/inhibitory control, and executive attention assessed as flanker interference is not as straightforward as previous theorizing and research indicates. As our data shows, the postulated link between high EC abilities and low flanker interference appears to be present only in middle childhood. It is difficult to explain why this link is not present in adults, but it is possible that the task is not demanding enough at this age and does not put enough pressure on executive mechanisms from a behavioral point of view.

The relationships between ER strategies and attentional networks were rather complex, especially when regarded developmentally. Namely, high alerting was associated with low cognitive restructuring in preschoolers, and low parent-reported avoidance in girls in middle childhood. However, in all these cases high alerting reflected faster intrinsic *and* phasic alertness. A similar pattern was present in orienting in preschoolers: high orienting was associated with high cognitive restructuring. High conflict scores were linked to full-sample high constructive coping and high distraction in boys in the case of preschoolers, but were associated with high self-blame and low acceptance in adults. however, preschoolers with high conflict scores and adaptive ER abilities had a tendency to be faster in both congruent and incongruent trials, while in adults higher conflict scores reflected genuine executive attention problems (although the effects were much smaller than in adults). Results were more puzzling in the case of self-reported ER in middle childhood (especially the association between high avoidance and apparently poor executive attention in girls), but here the sample was small, which raises the question of the reliability of these relationships. It is difficult to extract a coherent picture from this segment of our data. However, it shows, on the one hand, that unilateral interpretations of “high” and “low” attention networks scores can be misleading, and that these scores need to be put into context. On the other hand, our results point to the need for more research regarding attention-anxiety links. While the role of attentional mechanisms as developmental regulators of cognitive performance, behavior, and emotional arousal is well recognized (e.g., Posner &

Rothbart, 1998; Rothbart, Sheese, & Posner, 2007), the functioning of these mechanisms in relation to ER strategies in children and adults is extremely under-researched.

Another interesting aspect of our data, and worthy of further research, regards gender differences (especially in children) in the way attentional networks were related to self-regulation and to anxiety. There is little research regarding gender-related differences in attentional functioning. One recent study (Neuhaus et al., 2009) found almost no behavioral differences, but found larger ERP amplitudes at Cz for double cues, and for all target conditions (neutral, congruent, incongruent) in females. In our own studies, the only difference we found was in middle childhood, where girls had smaller conflict scores when compared to boys. However, the patterning of relationships between attention and anxiety/self-regulation was more complex, which indicates the need to investigate these differences even when scores across individual variables are relatively similar.

Our results and their interpretation must be regarded keeping in mind certain constraints and limitations. First, it should be noted that most effects that were related to our main objectives were small or moderate. However, this is not necessarily a limit in itself, as this magnitude is to be expected in this type of research focusing on individual differences. Second, the gender distribution in our adult sample was very uneven. Results did not change when we eliminated male participants, but it is still possible that in a larger male sample we would have found different links between anxiety/depression and attentional networks than we found in this sample. Third, the order in which we took the relevant measures (questionnaires followed by ANT testing) limited the directionality of the relationships we could test. For example, although it is likely that attentional mechanisms play an important role in the development of ER strategies, we could not test an attention → ER relationship. On the other hand, the opposite ordering would have been difficult to justify theoretically (it would have been feasible had we manipulated emotional state, so as to reasonably expect significant ER efforts during the task). Therefore, we limited our analyses to running simple correlations. Lastly, like all studies included in this thesis, this research has the limits inherent in cross-sectional research (as opposed to longitudinal research). Since we did not follow participants for an extended period of time, we do not know whether some of our interpretations (e.g., the one regarding the influence of alerting on the development of orienting and executive attention) would stand the test of a longitudinal approach.

These limitations notwithstanding, our results have important implications for the development of attentional networks from preschool on, and especially for building a better theory of how attentional mechanisms are altered in anxiety, even when no (measurable) emotional processing is involved. Understanding these mechanisms is extremely important as these are the attentional "tools" children and adults use in everyday activities such as learning, working or studying, and they further influence the way information is processed and memorized. In fact, a few studies suggest that children with higher anxiety tend to have lower school performance (e.g., Ialongo et al., 1995) and that this link is mediated at least by working memory processes (see Visu-Petra, Ciairano, & Miclea, 2006 for a review). Our results raise the possibility of preventive interventions through attentional training. Recent attempts to train attentional mechanisms through the use of specially designed video games in preschoolers (Rueda et al., 2005) or through the use of meditation in adults (Tang et al., 2007) have met with notable success, i.e., improved executive attention in both children and adults, and a reduction of anxiety and depression scores in adults.

Chapter 6.
Anxiety and distractibility: Attentional filtering and perceptual load

As already discussed in Chapter 4, there is evidence to suggest that anxiety is associated with increased distractibility, especially when distractors are threat-related (A. Byrne & Michael W. Eysenck, 1995; Calvo et al., 2006; Michael W. Eysenck & Graydon, 1989; Gerdes et al., 2008; Edmund Keogh, F. W. Bond, Christopher C. French, A. Richards, & R. E. Davis, 2004; Edmund Keogh & Christopher C. French, 2001; Andrew Mathews et al., 1990; Rinck et al., 2003; Rinck et al., 2005). This is in line with predictions made by the ACT, based on the hypothesized imbalance between bottom-up and top-down mechanisms, as well as the predicted deficits in executive inhibitory mechanisms (Derakshan & Michael W. Eysenck, 2009; Michael W Eysenck et al., 2007). The topic is a relevant one since studies show that higher distractibility is generally associated with poorer academic performance in children (Merrell & Tymms, 2005; Rabiner, D. W. Murray, L. Schmid, & Malone, 2004), as well as reduced work efficiency and increased risk for accidents in adults (Jones & Martin, 2003; Simpson, Wadsworth, Moss, & Smith, 2005; Wallace & Vodanovich, 2003).

In the present chapter, we investigate distractibility associated with emotionally-valenced stimuli in the context of anxiety. We chose to approach the issue from the perspective of a theoretical model that explains attentional filtering by taking into account the processing resources engaged by the task. As already mentioned, the more general term “selective attention” is often used by researchers in the field (see e.g., Desimone & Duncan, 1995; Lavie, 2005). Therefore, in this chapter we will use the two terms – “filtering” and “selective attention” – interchangeably.

6.1 Selective attention / Filtering

As discussed already, filtering is one of the most important functions of attention; it involves selecting out stimuli (external or internal) that are irrelevant for one’s goals. This means that good filtering abilities should be associated with less interference from such stimuli and therefore less distraction. In the context of the already discussed evidence for increased distractibility in anxiety, it is therefore relevant to investigate the filtering function of selective attention, and potential individual and task-related factors that might influence it. In what follows, we discuss what is probably the most widely accepted current model of selective attention – a model proposed by Nilli Lavie (Lavie & Tsal, 1994; Lavie, 2005b, 2010). Despite its potential for generating testable predictions and advancing knowledge about attentional functioning in anxiety, the model has been rarely used in this context, and, as usually, no research using this model has focused on anxiety in children.

6.1.1 Perceptual load theory

As discussed Chapter 4, one of the earliest controversies in attention research was the "early" versus "late" selection debate, in other words the debate regarding the locus where selection takes place in the processing stream. This controversy gradually moved from the field of auditory processing (employing variations of the dichotic listening paradigm) to visual attention. However, for a long time the debate remained unresolved, with data able to support (and refute) both the early and the late selection view (see Driver, 2001; Johnston & Dark, 1986; Pashler, 1998; Styles, 2006 for reviews; see Chapter 3 for a summary).

A resolution that largely settled the controversy was proposed by Lavie in a simple and elegant model (Lavie & Tsal, 1994; see Lavie, 2005; 2010 for reviews). The author started from a suggestion made by Kahneman and Treisman (1984), who noticed that data favoring early selection was generally obtained in experiments in which participants were overloaded with both relevant and irrelevant stimuli and required to give relatively complex responses, while late selection research used less crowded displays to which simple detection responses were required. These were potentially important methodological confounds, and, indeed, Lavie and Tsal (1994) demonstrated – in a systematic review – that processing load *was* the main difference between the two approaches.

As a consequence, Lavie and Tsal (1994) proposed that the locus of selection was a function of the *perceptual load* involved in the relevant task. Tasks with higher perceptual loads typically require more attentional resources than tasks with lower loads (see Norman & Bobrow, 1975). Lavie proposed that early selection is possible only when load is so high as to approach or exceed the upper limit of available resources. Any stimuli (such as irrelevant distractors) that go beyond this capacity will be ignored. In situations of low perceptual load, since not all processing resources are engaged in the target task, some are automatically allocated to the processing of distractors. In other words, when the relevant, target stimuli are not engaging enough to exhaust all attentional capacity, additional resources tend to "spill" to the processing of irrelevant, distractor stimuli. In short, selection can occur either early or late in the processing stream depending on the perceptual load involved in the central task.

To date, research largely supports Lavie's theory (but, as in many other cases, almost all of it focuses on young adults, with two notable exceptions discussed below). Perceptual load has been manipulated either by varying the number of relevant items (e.g., words, letters, images, etc.) displayed for processing (Lavie, 1995, 2005b; Lavie & S. Cox, 1997; Lavie & Tsal, 1994) or by changing the amount of processing required for the exact same type of display (Cartwright-Finch & Lavie, 2007; Lavie, 1995, 2005b; S. Schwartz et al., 2005). One of the prototypical experimental paradigms associated with load theory was initially used by Lavie and Cox (1997), who combined elements from a visual search task with elements of a flanker task. They manipulated perceptual load by varying the number of relevant stimuli displayed (the conditions of the task are illustrated in Figure 6.1). Participants were presented with a set of stimuli (letters) in the center of the display and asked to detect as quickly and accurately as possible the presence of one of two potential targets ("X" or "N"). Load was manipulated by varying the number of relevant letters (i.e., the set size: between 1 and 6). Participants were also instructed to ignore distractors displayed peripherally. Distractors were either *incompatible* with the target present in the display (e.g., the target was an "X" and the distractor an "N"), *compatible* (e.g., the target and the distractor were both "X") or *neutral* (e.g., the target was an "X" and the distractor an "S"), thus manipulating response conflict. The hypothesis was that if perceptual load affects the degree to which distractors are processed, then interference from incompatible distractors should be significantly reduced at higher loads (where all attentional resources are occupied by the central task). Results showed that the compatibility effect (i.e., $RT_{incompatible} - RT_{neutral}$) decreased with load and became non-significant once the maximum perceptual processing capacity was reached, i.e., at six elements. More recent research shows that perceptual load also affects attentional capture, which is more likely under conditions of low load (B. S. Gibson & Bryant, 2008). Additionally, there is evidence that high perceptual load can also effectively suppress *internal* distractors (i.e., it decreases the number of mind wandering episodes; Forster & Lavie, 2009). The effect of perceptual load holds even when the number of elements in the display is kept constant while the processing requirements of the task are varied (Lavie, 1995; see also Schwartz et al., 2005). However, perceptual load does not equal general task difficulty. As shown by Lavie and de Fockert (2003), a difficult task that does not fully engage attentional resources is ineffective in filtering out distractors. The authors varied task difficulty by presenting normal target stimuli or sensory degraded ones (through reduction of size, intensity, presentation duration, or masking). While both high perceptual load and stimulus degradation resulted in higher RTs and lower accuracy, only high load successfully cancelled the effect of incompatible distractors while sensory degrading the stimuli had the opposite effect (it increased distractor interference).

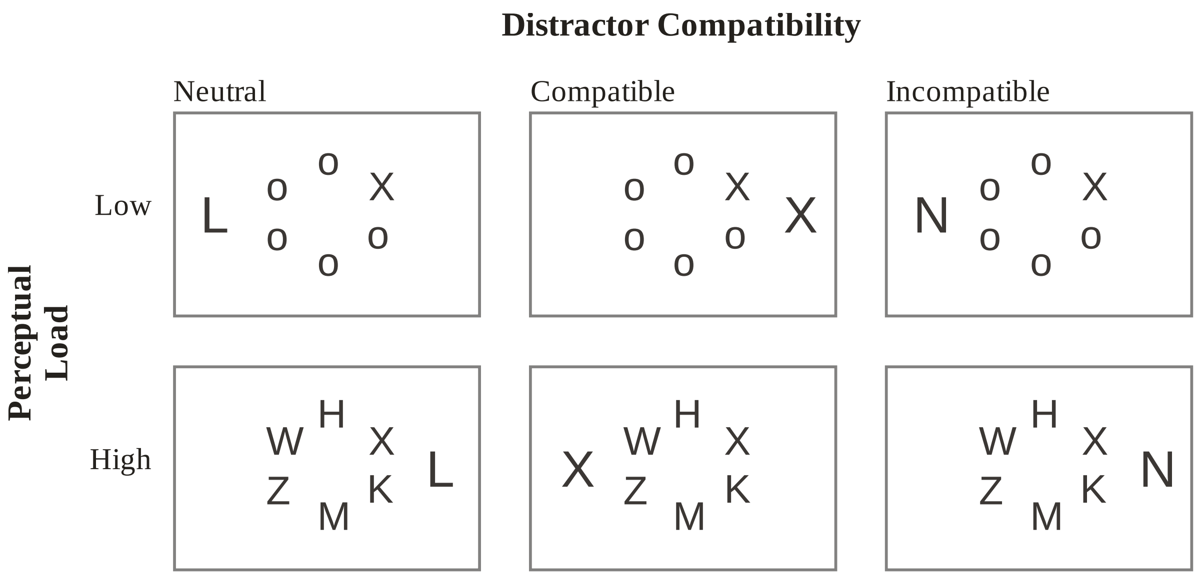

Figure 6.1. Examples of displays illustrating the conditions involved in Lavie's selective attention task. (Figure reconstructed based on Lavie & Cox, 1997).

An important question for load theory refers to the involvement of stimulus- and goal-driven mechanisms in selection, and their interaction with perceptual load. Lavie (2000) proposed that attentional resources are allocated in a passive, automatic manner until they are exhausted, which is why a high perceptual load is necessary in order to achieve effective selection. The fact that selection is not an active phenomenon in this scenario (i.e., distractors are not actively inhibited) is supported by evidence showing that negative priming[14] is virtually abolished at high perceptual loads (where distractor suppression is maximal), while still present at low loads (Lavie & E. Fox, 2000). Additional support comes from research indicating that passive engagement (rather than active focusing) is enough to keep attention from "straying" (Folk, Ester, & Troemel, 2009). More precisely, Folk et al. (2009) asked participants to find a letter of a particular color in a stream of letters presented rapidly at fixation. A central and a peripheral distractor appeared at different points during the stream (each in 66% of the trials). Results showed that when the occurrence of a peripheral distractor was preceded by a central distractor, attentional capture was "locked out" (i.e., the peripheral distractors had no impact on processing). This does not imply that active control (i.e., goal-driven) mechanisms play no role in selection. In fact, their involvement is essential in low load situations: When perceptual load is low, both relevant and irrelevant stimuli are perceived and therefore compete for processing resources. In these situations, active control mechanisms can suppress distractor processing by assigning priorities for resource orientation (Lavie, 2000; see also the biased competition models of Desimone & Duncan, 1995 and Miller & Cohen, 2001 discussed in Chapter 4). In other words, while stimulus-driven mechanisms are sufficient for successful distractor rejection in high perceptual load situations, in situations of low load, effective selection will depend on the efficiency of implementing goal-driven control mechanisms. Recent studies have shown that when these latter mechanisms are disrupted (by increasing *cognitive* – as opposed to perceptual – load), distractor interference increases (De Fockert, Rees, Frith, & Lavie, 2001; Lavie & de Fockert, 2005, 2006; Lavie, Hirst, de Fockert, & Viding, 2004). The prototypical methodology for manipulating cognitive load involves a WM task combined with a selective attention task. For example, Lavie et al. (2004) used the attentional task proposed by Lavie and Cox (1997), and interleaved the trials with WM trials. A WM set composed of one (low load) up to six (high load) digits was presented before each attention trial, and a probe digit was presented after. Results indicated that the effects of cognitive load were opposite to those of perceptual load: higher WM loads were systematically associated with higher distractor interference in the attentional task (irrespective of perceptual load). In other words, when the top-down mechanisms that are responsible for actively maintaining task goals and priorities are burdened with supplementary material, distractor suppression is less successful. These results are corroborated by data showing that attentional capture by irrelevant distractors is also more likely under conditions of high WM load (Lavie & De Fockert, 2005, 2006; but see Burnham, 2010 for a different result).

Perceptual load theory does not state that only bottom-up mechanisms are involved in high load situations and only top-down mechanisms in low load situations. It is likely that both types of mechanisms are involved at all times, but stimulus-driven ones are sufficient for selection in high perceptual load situations, while goal-driven processing *must* intervene in low perceptual load situations. In addition, it is possible that top-down mechanisms intervene at later stages of processing, while early stages are dominated by salience-driven mechanisms (Lavie, 2000; see also Van der Stigchel et al., 2009 for a recent review supporting this position).

[14] Negative priming (i.e., slowing of the response to a previously ignored stimulus) is considered a reflection of active inhibitory mechanisms influencing attentional processing (see Fox, 1995; Tipper, 2001 for details and discussion of other explanations of the phenomenon).

6.1.1.1 Perceptual load theory and development of selective attention

To date, we are aware of only two studies that have investigated the modulation of selective attention by perceptual load in typical development: one has compared the effect in young versus older adults (> 65 years; Maylor & Lavie, 1998), while the other has investigated the same effect in young adults versus children aged 7-12 years (Huang-Pollock, Carr, & Nigg, 2002). Both studies used Lavie's classic experimental paradigm (see again Figure 6.1). Maylor and Lavie (1998) found that while older adults were more distractible even at the lowest load level (one element), the compatibility effect dropped significantly in their case when set size included four elements (compared to six in the case of younger participants). A similar effect was present in the case of children (Huang-Pollock et al., 2002): they showed more distractibility at low loads, and the decrease in interference occurred earlier compared to young adults (between set sizes 1 and 2 in the case of 7-8-year-olds; between set sizes 2 and 6 in the case of 9-10-year-olds; 11-12-year-olds showed a more gradual decrease). This indicates that, when compared to young adults, children have limited attentional processing resources, or that they use more resources than adults do to process the same display. In either case, children's attentional resources are exhausted faster, and thus a lower perceptual load is needed to suppress distractor processing.

6.1.1.2 Perceptual load and distractor processing in the brain

Additional support for Lavie's theory comes from neuroimaging research. In agreement with the main hypotheses of the theory, several studies have shown that attention and perceptual load modulates distractor processing in the brain (Fu, Fedota, Greenwood, & Parasuraman, 2010; Fu et al., 2009; O'Connor, Fukui, Pinsk, & Kastner, 2002; Rees, Frith, & Lavie, 1997; Rees, Russell, Frith, & Driver, 1999; Rorden, Guerrini, Swainson, Lazzeri, & Baylis, 2008; Schwartz et al., 2005; Yi, Woodman, Widders, Marois, & Chun, 2004; see Lavie, 2005, 2010; for reviews).

Research that manipulated attentional focus without varying perceptual load indicates that BOLD activity associated with unattended stimuli is typically reduced compared to conditions when those stimuli are attended. For example, Rees et al (1999) showed that when participants were presented with streams of superimposed letter strings and drawings of objects, activity in areas associated with letter and word processing (left occipital, posterior basal temporal, parietal cortex, prefrontal cortex) was significantly reduced when the task was to monitor for repetitions of objects. Similarly, ignoring pictures of places while monitoring for superimposed face repetitions results in a significantly reduced parahippocampal activity related to the place backgrounds (Yi et al., 2004).

However, more direct evidence comes from studies that have also included load manipulations in their designs. The first study to investigate brain activity in relation to perceptual load theory used an experimental paradigm in which the participants' task was to determine whether centrally presented words were in uppercase versus lowercase letters (low load condition), or whether they were bisyllabic versus mono- or trisyllabic (high load condition). Distractors were represented by a field of dots in the periphery of the visual field; the dots were either stationary or moving radially outward. Results showed that activity in area V5/MT (a part of the visual system involved in the perception of motion) was significantly reduced in the high load condition compared to the low load condition (Rees et al., 1997). Similarly, Schwartz et al. (2005) asked participants to monitor a stream of colored T shapes with different orientations either for a red T (low load) or a conjunction of features – upright yellow T or upside down green T (high load). The peripheral (distractor) stimuli were represented by checkerboards. Under high load, activity in visual cortex was significantly suppressed.

Additionally, in line with predictions made by perceptual load theory, high perceptual load appears to "gate" neural processing relatively early, as indicated both by fMRI as well as ERP studies. For example, Schwartz et al. (2005) found that high load-associated suppression already occurred in V1 but extended up to V4 (both are "early" areas in the visual stream; see O'Connor et al., 2002 for similar results). Recent ERP research (e.g., Fu et al., 2009, 2010; Rorden et al., 2008; see Handy & Mangun, 2000 for earlier research) supports these results, as early potentials (P1, N1) are also modulated by perceptual load.

6.1.1.3 Emotional faces as distractors

Most of the research discussed up to this point used a conflict manipulation to vary the relationship between target stimuli and distractors. In this type of task, distractors' interfering effect is partly due to their association with the activated response set. However, as pointed out by Forster and Lavie (2008a, 2008b), most distracting stimuli in real life are completely irrelevant from the point of view of the tasks people are trying to focus on, and yet they still manage to capture attention (e.g., billboards by the sides of the road while driving, the sound of the TV in the other room while a child tries to focus on her homework). Completely irrelevant distractors – such as moving dots or peripheral checkerboards – have been used in fMRI studies (as discussed above; see Rees et al., 1997 and Schwartz et al., 2005). However, while these studies found reliable BOLD modulation as a function of perceptual load, this modulation was not present at the behavioral level, and neither was there a significant disruptive effect of distractor presence. It is possible that these null results were due to the small sample sizes typically used in fMRI research, since there is evidence that completely irrelevant stimuli *do* capture attention and disrupt processing in visual search tasks (see e.g., Beck & Kastner, 2005; Lamy & Zoaris, 2009; Theeuwes, 2005). However, Forster and Lavie (2008a, 2008b) recently provided evidence with more direct implications for perceptual load theory. They used a central task similar to the one used by Lavie and Cox (1997) but displayed completely irrelevant stimuli as distractors (meaningful: cartoon characters or meaningless: random shapes). Results showed that both meaningful and meaningless distractors interfered with processing in the target task (although meaningful stimuli had a stronger impact) (Forster & Lavie, 2008a), and that interference from irrelevant distractors was eliminated under high perceptual load conditions (Forster & Lavie, 2008b).

Thus, there is evidence to indicate that completely irrelevant distractors can disrupt focused attention, and their effects can be cancelled by increasing perceptual load in the target task. One special type of powerful distractors is represented by human emotional faces. There is considerable evidence that facial emotional expressions are processed rapidly and tend to elicit automatic, stimulus-driven attention (Batty & M. J. Taylor, 2003; Blau, U. Maurer, Tottenham, & McCandliss, 2007; Calvo et al., 2006; J. Liu, A. Harris, & Kanwisher, 2002; Milders, Sahraie, & Logan, 2008; Palermo & Rhodes, 2007; Roesch, Sander, Mumenthaler, Kerzel, & Scherer, 2010; Vuilleumier & Pourtois, 2007), although it is debatable whether this can take place in the absence of awareness and attentional resources (see Öhman & Mineka, 2001 and Pessoa & Ungerleider, 2005 for two opposing views on the matter). In terms of speed, research shows that emotional faces are detected and recognized faster and more accurately when compared to neutral faces, even at very short exposure durations (estimates range from 20 to 200 ms; Calvo et al., 2006; Calvo & Esteves, 2005; Liu et al., 2002; Milders et al., 2008; Roesch et al., 2010).

In fMRI research, one traditional correlate of (negative) emotional expressions has been amygdala activation (LeDoux, 2000b; Öhman & Mineka, 2001b; Phelps, 2006; Whalen, 1998). In ERP studies, emotion recognition has been investigated in relation with the N170, the earliest face-specific potential. It occurs – as the name implies – on average around 170 ms after stimulus onset, and its amplitude is enhanced in response to faces (especially those signaling threat) versus other stimuli (C. Jacques & Rossion, 2004). Behavioral and neurophysiological methodology has the potential to indicate which emotional expression has priority in capturing attentional resources (i.e., which one is detected faster and most accurately, which one is associated with the most intense BOLD signal or the highest N170 amplitude). Unfortunately, in the case of adults such research has generated extremely mixed results: different studies tend to favor fearful (Öhman & Mineka, 2001b; Vuilleumier et al., 2001; Whalen et al., 2001), angry (E. Fox et al., 2000; Horstmann & Bauland, 2006; Horstmann, Scharlau, & Ansorge, 2006; Pinkham, Griffin, Robert Baron, Sasson, & Gur, 2010), happy (Calvo & Marrero, 2009; Calvo, Nummenmaa, & Avero, 2010; Milders et al., 2008) or even all emotional facial expressions compared to neutral faces (Derntl et al., 2009; Eimer, A. Holmes, & McGlone, 2003; A. Holmes, Vuilleumier, & Eimer, 2003; Roesch et al., 2010).

In children, research indicates that adult ERP patterns associated with the recognition of emotional face expressions appears only in middle childhood (M. J. Taylor, Batty, & Itier, 2004) or even adolescence (Batty & M. J. Taylor, 2006). In terms of priorities, facial expressions of happiness tend to be favored. Happiness is the emotion that is developmentally recognized first, typically before the age of five (Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; see Herba & Phillips, 2004 for a review), it is recognized more accurately than anger by preschoolers (Gao & Maurer, 2009, 2010; Walden & Field, 1982), and faster than all negative emotions (which tend to be processed at the same speed), in children aged 7-10 years (De Sonneville et al., 2002). Happy faces also tend to activate the amygdala to a larger degree than angry faces in children aged 3-8 years (Todd, Evans, Morris, Lewis, & Taylor, 2010). In older children (11-year-olds) neutral faces have a stronger impact (compared to fearful faces; Thomas et al., 2001). On the other hand, other recent studies (e.g., LoBue, 2009; Waters & Lipp, 2008) show that both children (aged 5 and 8-11 years, respectively) and adults detect angry and fearful faces more rapidly than happy and sad faces.

Thus, faces tend to be processed quickly in both adults and children (although it is less clear which emotion has priority). However, the question is whether the effects of emotional facial expressions can be suppressed when they are unattended. FMRI research has focused on activation in the amygdala (using mostly fearful versus neutral faces), and there is currently a controversy surrounding the fate of unattended threat-related faces in the amygdala. Some previous studies (Öhman, 2002; Vuilleumier et al., 2001; Whalen et al., 1998; see also Vuilleumier & Pourtois, 2007) indicated that while the BOLD signal was modulated in areas like the fusiform gyrus, it remained just as strong in the amygdala whether fearful faces were attended or not. For example, Vuilleumier et al. (2001) presented a display that contained a pair of houses and a pair of faces with different identities, but displaying the same emotion (neutral or fearful). Each pair was presented either horizontally or vertically, and the task was to determine if the vertical or horizontal pair contained the same picture or not. Results showed that while activity in the fusiform gyrus was modulated by attention, activity in the amygdala (in response to fearful faces) was not. However, further research suggests that the amygdala might not be “immune” to attention manipulations (see Palermo & Rhodes, 2007; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Pessoa & Ungerleider, 2005 for reviews). One of the criticisms against procedures like the one used by Vuilleumier and collaborators is the fact that the processing requirements of the central task are too limited to exhaust all attentional resources. Experiments that used more demanding tasks found that attention modulates processing even in the amygdala (Hsu & Pessoa, 2007; Pessoa et al., 2002; Pessoa, Padmala, & Morland, 2005). When participants had to indicate whether two bars presented peripherally were of the same orientation (unattended condition) versus whether centrally presented faces (fearful, happy, neutral) were male or female (attended condition), activity was attenuated in all brain regions that normally respond differently to emotional faces (including the amygdala!) (Pessoa et al., 2002). Similar results were obtained in a task where bar judgment difficulty was varied continuously (Pessoa et al., 2005), so as to obtain graded levels of processing load. In another study, Hsu and Pessoa (2007) (using a letter search task similar to the one used by Lavie & Cox, 1997, but with faces as distractors) found that amygdala activity associated with fearful faces was suppressed under high load but not under sensory degradation conditions (thus replicating – at the level of amygdala activity – results obtained by Lavie & de Fockert, 2003).

Compared to the controversy that surrounds amygdala activation, research using ERP methodology almost unanimously reports that yes, the N170 is attenuated when emotional faces are unattended (e.g., Eimer et al., 2003; Holmes, Kiss, & Eimer, 2006; Holmes et al., 2003; see Eimer & Holmes, 2007 for a review). This effect has been reported in the case of fearful faces, in the task previously used by Vuilleumier et al. (2001) (Holmes et al., 2003), when faces are presented centrally (as opposed to peripherally; Holmes et al., 2006), and it seems to be present for all emotional facial expressions (Eimer et al., 2003).

Thus, there is neurophysiological evidence to support the idea that attention and perceptual load modulate the interfering effect of emotional face distractors in adults. However, we were unable to identify purely behavioral research investigating the same issue, and most studies cited above report null results on the behavioral level (possibly due to small sample sizes) or do not report the perceptual load by distractor interactions at all. Additionally, at this point we are not aware of any research investigating this issue in the case of children.

6.2 Perceptual load theory and anxiety

Starting from the biased competition model of Desimone and Duncan (1995), Bishop (2008) suggested that emotional valence represents one dimension of stimulus salience (along with color contrast, movement, abrupt onset, novelty, etc.). When signaling threat, this dimension might have an important competitive advantage in the case of anxious persons (resulting in failure to filter out threatening stimuli when they are used as distractors). One way in which this competitive advantage might be overridden is through adequate top-down control, that would allocate attentional resources preferentially to the target task, resulting in inhibition of distractors. However, another strategy to override the influence of threat-related distractors might be to increase the perceptual load of the target task.

There is a limited amount of published research investigating this latter possibility, or at least the degree to which attended versus unattended threat-related stimuli are processed differently by anxious persons. All studies we were able to identify have used emotional faces as distractor stimuli. Most of this data indicates that there is a modulating effect of attention (attended versus unattended) or perceptual load. For example, Ewbank et al. (2009), using the task of Vuilleumier et al. (2001) found that while there was increased amygdala activity in response to attended angry faces in anxious participants, this activation was suppressed when angry faces were unattended. The only research we are aware of that has manipulated perceptual load has been conducted by Sonia Bishop and collaborators (Bishop et al., 2004; Bishop, 2009; Bishop, Jenkins, & Lawrence, 2007). Bishop et al. (2007) showed that while high state anxiety was associated with increased amygdala activity in response to fearful face distractors, high perceptual load suppressed this response in all participants (the task used in this study was a letter search task with letters displayed in a horizontal line superimposed on one distractor face).

In addition to the enhanced amygdala activity in high state anxiety, there is evidence to suggest that trait anxiety is associated with poor prefrontal recruitment under conditions of low perceptual load (i.e., when top-down control would be essential) (Bishop, 2004, 2009; Bishop et al., 2007). Using a modification of the task previously employed by Vuilleumier et al. (2001), Bishop (2004) found that when fearful faces were used as infrequent distractors, there was significant rostral ACC and lateral PFC activation in the low anxiety group. However, this activity was absent in the high anxiety group, indicating that anxious persons tend to recruit top-down control mechanisms to a lesser degree. This result was later replicated in a study with no emotional distractors (i.e., a letter search task with compatible, incompatible or neutral distractor letters) (Bishop, 2009). There is evidence that this PFC activation in low perceptual load situations can be modulated by temperamental attentional control; in other words, higher attentional control abilities are associated with increased PFC activity (Bishop et al., 2007). A more recent study found increased interference from face distractors (especially emotional ones) in participants with low attentional control, but failed to find such an effect in participants with high anxiety (Peers & Lawrence, 2009).

To conclude, there is some (limited) evidence to suggest that tasks that fully occupy attentional resources can successfully diminish distractibility and can suppress distractor-related amygdala activity in participants with high anxiety. Additionally, research suggests that when perceptual resources are not exhausted by the central task, participants with high trait anxiety (and low attentional control) are impaired in recruiting top-down control over attentional resources, while those with good temperamental attentional control skills are more successful in activating these mechanisms.

6.3 The present study

Our main aim was to investigate distractibility in anxiety and to determine whether high perceptual load might decrease this distractibility. We were additionally interested to determine whether EC might also regulate distractibility in low perceptual load situations. We investigated these aspects in middle childhood and young adulthood. Because the task we used (see below) was unfeasible for testing with preschoolers (and was difficult to adapt for this developmental group), no preschool sample was included in the present research.

As it will be shown in more detail below, in order to investigate these aspects we used a task similar to the one initially proposed by Lavie and Cox (1997), but we replaced the letter distractors with faces expressing neutral, happy or angry emotional states. We chose to use faces and not letter distractors, because we reasoned that if we will find any evidence for higher distractibility, chances are higher that this will happen in the presence of emotional distractors. Because previous studies (e.g., Bishop et al., 2007; Eimer et al., 2003; Ewbank et al., 2009; Pessoa & Ungerleider, 2005; Vuilleumier et al., 2001) have used neutral faces as a baseline comparison condition, we adopted the same approach here.

Our expectations were relatively straightforward. First, based on research discussed previously, we expected that higher anxiety would predict higher distractibility for angry faces (versus neutral faces), especially at low perceptual loads (one or two elements; the exact set size might vary for children and adults). Second, we set out to test the potential regulatory influences of high perceptual load (a passive – stimulus-driven – mechanism) and good EC skills (active – goal-driven control). We expected that a high perceptual load would be successful in suppressing distractor interference for all participants, irrespective of anxiety and/or EC status (again, "high" perceptual load might differ for children versus adults). We also predicted that EC might moderate the relationship between anxiety and distractor interference: participants with good EC skills should be less distractible at low perceptual loads irrespective of their anxiety status.

6.4 Study 3: Anxiety and perceptual load in middle childhood and adulthood

6.4.1 Method

6.4.1.1 Participants

Children. Children from a school in Cluj-Napoca who attended first to fourth grade were selected based on informed consents given by parents, child verbal assent, and teacher informal agreement. A total number of 162 parents were contacted initially with the aid of the teachers and school counselor. Out of the total number of parents contacted, 91 consented to take part in the study and filled in the questionnaires (described below). Out of these, a number of 82 children were assessed using the selective attention task, but four children were eliminated from the final analysis due to having more than 33% errors (see Huang-Pollock et al., 2002, Study 2, for a similar cutoff). This process resulted in a final sample of 78 children (42 girls) aged 7-11 years (M = 113.46 months; SD = 14.41; range = 84-133 months). These children represent a sub-sample of the group involved in study 1B; they do not overlap at all with the sample involved in study 2B.

Adults. The initial sample was composed of 118 undergraduate students enrolled in the Psychology program at the Babeş-Bolyai University (BBU) in Cluj-Napoca, Romania. They were recruited through an announcement informing them about the study, and received course credit for participation. A number of 6 participants were eliminated from the final analysis due to having an error percentage higher than 2.5 standard deviations from the mean. This error rate cutoff was previously used by Lavie and collaborators (e.g., Maylor & Lavie, 1998). In addition, our analyses indicated that participants whose error rates were above this cutoff represented clear outliers in our sample. Thus, the final sample consisted of 112 participants (100 females), aged 19-39 years (M = 21.39, SD = 3.40). These participants constitute a sub-sample of the group involved in study 1C.

6.4.1.2 Measures

Anxiety

Children. The Romanian parent-report version of the *Revised Child Anxiety and Depression Scales* (i.e., RCADS-P; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000) was used to assess anxiety symptoms in the middle childhood sample (see Chapter 3 for a description of this instrument). In the present sample, internal consistency indices for the anxiety sub-scales of the RCADS-P ranged between α = .68 and α = .78, while the full anxiety scale had a Cronbach's α of .88.

Adults. Trait anxiety was assessed using the Romanian version of the *State Trait Anxiety Inventory* (STAI; Pitariu & Peleasa, 2007; Spielberger, 1983; α = .93).

Effortful control

Children. Parents were administered the *Temperament in Middle Childhood Questionnaire* (TMCQ; Simonds, 2006, Simonds & Rothbart, 2006); this instrument has been described in detail in Chapter 3. In the current sample, internal consistency for the EC dimension was α = .85.

Adults. Participants completed the *Adult Temperament Questionnaire* (ATQ; Derryberry & Rothbart, 1988; Evans & Rothbart, 2007). A detailed description of this questionnaire can be found in Chapter 3. We selected the sub-scales composing the EC dimension (i.e., attentional control and inhibitory control), for which Cronbach's α = .90.

Selective attention task

The task used here was programmed by the author of this thesis and run using E-Prime version 1.2. It was based on the selective attention experimental paradigm created by Nilli Lavie (see Lavie, 1995; Lavie & Cox, 1997; Maylor & Lavie, 1998) and the version subsequently used to compare performance in young adults versus children by Huang-Pollock et al. (2002). The main difference between the original task and our version was the replacement of the letter distractors with face distractors displaying neutral, happy or angry emotional expressions.

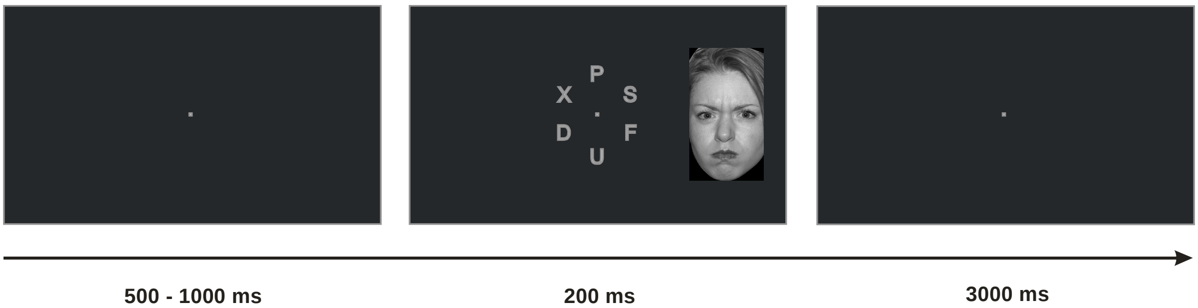

Figure 6.2. Sequence for one trial of the selective attention task. The example illustrates a trial with a set size of 6 and an angry face distractor.

The target display consisted of a central fixation point and a number of 1, 2, 4, or 6 letters (each subtending approximately 0.40° × 0.60° horizontal by vertical visual angle), placed around an imaginary circle (with a radius of 1.6°) around this fixation point (see Figure 6.2). In trials containing less than six letters, empty locations were marked by placeholders ("o" letters). In each trial, one of the letters was the target letter (i.e., an "X" or an "N"). The participant's task was to determine which target letter was present in the display, by pressing the left or right button of the mouse pad, respectively. Each target letter appeared randomly in 50% of the trials, and was placed randomly and with equal probability in one of the six locations around the circle. The rest of the letters (i.e., non-target letters) were selected randomly from a set of five letters (U, F, S, P, D) and displayed in the remaining positions around the circle. Similar letters were used previously by Cartwright-Finch and Lavie (2007). Most studies have used only angular letters as non-targets (see e.g., Lavie & Cox, 1997; Maylor & Lavie, 1998; Huang-Pollock et al., 2002). However, because their features are more similar to the target letters, they would likely increase the difficulty of the task, while the more rounded letters would make target detection easier. Since we were interested to keep the error rate relatively low (especially in the case of children), use of the rounded letters was considered a better alternative.

In addition to the letter stimuli, in each trial a neutral, happy or angry distractor face (3.20° × 4.00°) appeared with equal probability on the left or right side of the letter circle (at an angular distance of 4.60° from fixation). The face stimuli were irrelevant for the participant's task, and participants were instructed to ignore them. The distractor faces were selected from the NimStim battery developed by the Research Network on Early Experience and Brain Development (Tottenham et al., 2009)[15]. We selected the eight Caucasian-looking faces (4 male, 4 female) with the highest inter-rater agreement for the emotions we were interested in: 01, 05, 07, 08, 20, 22, 26, 34. All face images were converted to grayscale, cropped to eliminate as many individual and irrelevant details as possible, and resized to fit the same frame dimensions. All stimuli were displayed on a black, uniform background.

Each trial started with a central fixation point presented for a random variable duration of 500-1000 ms (to prevent participants from locking their responses with the expected time of presentation). The fixation point was followed by the target display, presented for 200 ms, and another fixation point displayed for 3000 ms or until the participant's response (see Figure 6.2). The 200 ms duration has been previously used for the target display in several studies involving only adults (Bishop, 2009; Bishop et al., 2007; Pessoa et al., 2005) or adults and children (Huang-Pollock et al., 2002). Lavie's studies use even shorter display durations (≤ 100 ms; e.g., Cartwright-Finch & Lavie, 2007; Lavie, 1995; Lavie & Cox, 1997). Such short exposures are generally used to prevent peripheral saccades. We considered the 200 ms duration to be more appropriate in the case of children: it is short enough to prevent unwanted saccades (see below), while at the same time allowing a long enough display period to diminish the risk of very high error rates in this group. Previous research shows that upon instruction, children of 8-10 years of age can maintain central gaze fixation for approximately 400 ms after the sudden onset of a peripheral stimulus (Paus, Babenko, & Radil, 1990). Additionally, in the absence of an abrupt peripheral change, already at the age of 4-6 years children can maintain fixation for 3.7 seconds (Aring, Grönlund, Hellström, & Ygge, 2007). In the case of visually guided saccade tasks (i.e., when participants are *required* to make saccades), several studies indicate that children aged 5-11 years need between 250 and 300 ms to initiate a saccade to a peripheral target situated at 10° – 20° (Fukushima, Hatta, & Fukushima, 2000; Munoz, Broughton, Goldring, & Armstrong, 1998; Salman et al., 2006; Yang, Bucci, & Kapoula, 2002). This interval tends to be smaller for smaller angular distances (i.e., 225-250 ms for 5° or less), but it is still relatively high compared to the duration of our target display. In young adults, latency to initiate a guided saccade ranges on average between 180 and 220 ms (Gagnon, O'Driscoll, Petrides, & Pike, 2002; Irving, Steinbach, Lillakas, Babu, & Hutchings, 2006; Walker, Walker, Husain, & Kennard, 2000). While this latency would allow adults to initiate a saccade during stimulus presentation, it is highly likely that doing so would result in an erroneous response during that trial. This would

[15] The emotional distractor stimuli used here were part of the MacBrain Face Stimulus Set, developed by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at nimtottenham@ucla.edu for more information concerning the stimulus set.

have no effect on our RT data, since only RTs from correct trials are analyzed. Lastly, as discussed in paragraph 5.1.1.3, 200 ms should also be sufficient to detect the emotional expressions of distractor faces.

For all participants (both children and adults), an incorrect response or failure to respond was followed by an auditory negative feedback (a tone lasting 1000 ms). Children also received auditory feedback for a correct response. While all versions of the original task used only negative feedback with all participants, we chose to add the positive feedback for children because our pilot studies indicated that it had a beneficial effect on their engagement in the task.

To summarize, the selective attention task used here manipulated the perceptual load (by varying the letter set size: 1, 2, 4 or 6 letters) and the valence of the emotional distractor (angry, happy, neutral). The target display was exposed for a brief duration to prevent peripheral saccades, and feedback was offered upon response.

6.4.1.3 Procedure

Children. Permission for conducting the study inside the school was obtained from the school principal. Parents were contacted with the help of the school counselor and teachers. Each parent received an informed consent letter and three questionnaires assessing child characteristics (RCADS-P and TMCQ). Children whose parents agreed to take part in the study and returned the questionnaires were further selected for testing with the selective attention task.

The task was administered individually by a female experimenter, in a quiet room inside the school. Children sat at an approximate distance of 60 cm from the display. The task was created and run using E-Prime on a laptop computer with a 15-inch display, with the screen resolution set to 1024 × 768. The left and right buttons of the mouse pad were used to collect responses. Stickers with an “X” or “N” printed on them were placed on each button to diminish any potential memory load. The experimenter asked children to place the index finger of each hand on the corresponding button, but children were allowed to use more than one finger on each button if it was more comfortable for them. Before starting the task, the experimenter presented the instructions verbally, using cards with examples of possible stimulus displays. The task started with three practice blocks consisting of 6 trials each. In the first practice block, the target display was kept on screen until the child responded, while in the second and third blocks stimuli were displayed for 500 and 200 ms, respectively. Each child was given verbal feedback and encouragement during the practice blocks. The distractor faces were not presented during the instructions and the practice blocks (to prevent familiarity effects), but the child was told that they would appear during the experimental blocks. The main task consisted of three experimental blocks composed of 96 trials each. The entire task lasted approximately 20 minutes (including instructions and breaks). Upon task completion, each child received a colored badge.

Adults. The experiment took place at the Developmental Psychology Lab in the Psychology Department of the BBU. Upon arriving at the laboratory, each participant was asked to fill in a set of questionnaires (see above). The task was administered subsequently using a laptop computer with a 15-inch display, with the screen resolution set to 1024 × 768. As in the case of children, participants sat at a distance of 60 cm from the screen, and the left and right buttons of the mouse pad were used to collect responses. The task was identical to the one used in the case of children, with the exception that adults only received auditory feedback for incorrect responses.

6.4.1.4 Missing data

In children, data was missing only for RCADS-P ($N = 4$); there was no missing data for EC. There was also no missing data in the adult sample.

6.4.2 Results

Our data analysis plan followed three main aspects. First, as in previous chapters, we carried out preliminary analyses, where we mainly investigated age and gender differences in anxiety, EC and general selective attention task performance. Second, we investigated the relationship between EC and distractor interference at different perceptual load levels in the selective attention task. Lastly, we tested the role of anxiety in distractor interference, as well as the degree to which EC acts as a moderator, at different perceptual load levels. This latter analysis is presented separately for children and adults. It should also be mentioned that in this study results were not significantly different in males versus females. We therefore present them only on a whole-group level.

In order to determine the degree to which emotional faces interfered with processing, we used the neutral face distractors as a baseline condition and computed – for each participant – an angry-neutral (AN-NE) and a happy-neutral (HA-NE) interference score using the following formulas:

$$\text{AN-NE score} = RT_{Angry} - RT_{Neutral}$$

$$\text{HA-NE score} = RT_{Happy} - RT_{Neutral}$$

6.4.2.1 Preliminary analyses

Descriptive statistics for all main variables of interest in the case of children and adults are presented in Table 6.1. Before addressing the main research questions, we verified the presence of gender differences and correlations with age for anxiety and EC. In addition, we conducted a separate analysis on the selective attention task data. In children, in order to include age as a factor in this latter analysis, we grouped the sample into four age groups: 7-years-olds ($N = 12$; $M = 88.75$, $SD = 3.02$), 8-year-olds ($N = 12$; $M = 101.54$, $SD = 3.64$), 9-year-olds ($N = 20$; $M = 113.00$, $SD = 3.26$), 10-11-year-olds ($N = 34$; $M = 127.00$, $SD = 3.18$).

In adults, since the number of males in our sample was too small to conduct any meaningful gender-based comparisons, we only investigated the relationships with age at a correlational level. All analyses presented below remained the same even when carried out only including females.

Gender and age

No gender differences were found in children, for any of the variables of interest. There was a tendency for older children to have higher EC scores ($r = .20$, $p = .08$), indicating that children's EC abilities tend to improve with age. However, no other statistically significant correlations with age were found.

In adults, since the age distribution of our participants was positively skewed, we computed Spearman's nonparametric rho coefficient to investigate the relationships between age and participant characteristics. We found statistically significant negative correlations between age and STAI anxiety (ρ = -.23, $p < .05$). Thus, as in our previous samples, it appears that older participants tend to be less anxious than younger ones.

Table 6.1
Descriptive statistics for children and adults, presented for the full samples, and separated by gender.

	Total sample M (SD)	**Males** M (SD)	**Females** M (SD)
Child sample			
Anxiety (RCADS-P)	19.93 (11.29)	19.45 (9.61)	20.32 (12.58)
Effortful Control (TMCQ)	3.28 (0.41)	3.22 (0.46)	3.34 (0.36)
Selective attention			
RT (ms)	833.94 (177.44)	843.68 (174.85)	825.58 (181.32)
Accuracy (% errors)	9.30 (5.59)	8.71 (5.08)	9.81 (6.01)
Adult sample			
Anxiety (STAI-Trait)	40.85 (10.49)	35.75 (8.29)	41.46 (10.59)
Effortful Control (ATQ)	4.18 (0.71)	4.64 (0.70)	4.13 (0.69)
Selective attention			
RT (ms)	607.28 (73.91)	599.25 (80.37)	608.25 (73.47)
Accuracy (% errors)	3.99 (3.11)	3.07 (1.94)	4.10 (3.21)

Selective attention task

Correct trials with RTs lower than 100 ms or higher than 3000 ms were eliminated from the analysis in both samples. We included both correct median RTs and error percentages as the dependent variables in this preliminary analysis. In the case of errors, all scores (for both children and adults) were positively skewed (Kolmogorov-Smirnov test $p < .001$). Therefore, all error scores were log-transformed to normalize their distributions. The preliminary analysis was conducted on these normalized scores. However, because error rates were generally very low, all subsequent analyses (regarding links with self-regulation and anxiety) were carried out only on RT data.

We first investigated differences in task performance in children versus adults, and then took a closer look at task performance in each group. In all three cases, we investigated the effects of perceptual load (set size) in combination with the distractor valence manipulation (neutral, happy, angry). In children, we also included gender and age as factors in the analysis.

Children vs. Adults. We conducted two separate 2 (age group: children vs. adults) × 4 (set size) × 3 (distractor valence) mixed ANOVAs with RT and errors, respectively, as dependent variables. These analyses indicated that children were significantly slower [$F(1, 188) = 150.46$; $p < .001$; $\eta_p^2 = .45$] and less accurate [$F(1, 188) = 166.23$; $p < .001$; $\eta_p^2 = .47$] than adults. Polynomial contrasts indicated that both RT and errors increased linearly with set size in the entire sample: $F(1, 188) = 516.79$; $p < .001$; $\eta_p^2 = .73$ for RT; $F(1, 188) = 796.09$; $p < .001$; $\eta_p^2 = .81$ for errors. An additional finding was an age group × set size interaction effect [$F(3, 564) = 49.14$; $p < .001$; $\eta_p^2 = .21$ for RT; $F(3, 567) = 22.54$; $p < .001$; $\eta_p^2 = .11$ for errors], reflecting the fact that the increase in set size was associated with a steeper increase in RT and errors in children compared to adults (see Table 6.2). There were no effects of distractor valence and no valence × set size effects, indicating that overall the three types of facial expressions were similarly distracting at all load levels.

Children. We conducted two separate 2 (gender) × 4 (age group) × 4 (set size) × 3 (distractor valence) mixed ANOVAs with RT and errors, respectively, as the dependent variables. Age had a significant effect on both RT [$F(3, 70) = 8.71$; $p < .001$; $\eta_p^2 = .27$] and errors [$F(3, 70) = 7.50$; $p < .001$; $\eta_p^2 = .24$]. Post-hoc pairwise comparisons with Bonferroni correction indicated that 7-year-olds were slower and less accurate than 9- and 10-11-year-olds, while 8-year-olds were slower and less accurate than 10-11-year-olds (see Table 6.2 for descriptive statistics). As expected, polynomial contrasts indicated that both RT and errors increased linearly with set size: $F(1, 70) = 206.98$; $p < .001$; $\eta_p^2 = .75$ for RT; $F(1, 70) = 264.24$; $p < .001$; $\eta_p^2 = .79$ for errors. Mean RT increase was 55.50 ms from one set size to the next. Set size interacted with age in the case of RT [$F(9, 210) = 2.73$; $p < .01$; $\eta_p^2 = .11$] but not errors [$F(9, 210) = 1.14$; $p = .33$; $\eta_p^2 = .05$]. Post-hoc pairwise comparisons with Bonferroni correction indicated that while RTs increased steadily in the case of 7- and 8-year-old children, in the two older groups there was a plateau between set sizes 4 and 6. We found no main effects of distractor valence, on either RT [$F(2, 140) = 1.22$; $p = .30$; $\eta_p^2 = .02$] or errors [$F(2, 140) = 1.10$; $p = .34$; $\eta_p^2 = .02$], and only a marginally significant set size × valence interaction effect at the level of RT [$F(6, 420) = 1.94$; $p = .07$; $\eta_p^2 = .03$]. These results indicate that overall children were similarly distracted by all three facial expressions.

Adults. We conducted two separate 4 (set size) × 3 (valence) mixed ANOVAs with RT and percentage of errors, respectively, as the dependent variables. Polynomial contrasts indicated that both RT and errors increased linearly with set size: $F(1, 111) = 375.13$; $p < .001$; $\eta_p^2 = .77$ and $F(1, 111) = 508.19$; $p < .001$; $\eta_p^2 = .82$, respectively. The mean RT increase was 24.02 ms from one set size to the next. Distractor valence had no main significant effect either in the case of RT [$F(2, 222) = 1.06$; $p = .35$; $\eta_p^2 = .01$] or errors ($F < 1$, *ns*). Lastly, we found no set size × valence interaction in the case of RT [$F(6, 666) = 1.77$; $p = .10$; $\eta_p^2 = .02$] or errors [$F(6, 666) = 1.68$; $p = .12$; $\eta_p^2 = .02$]. Descriptive statistics for RT and errors are presented in Table 6.2.

Table 6.2
Mean RT (± 1 SD) and % errors (± 1 SD) as a functio n of load and distractor valence, for children and adults.

Set size	Distractor valence	7 years		8 years		9 years		10-11 years		Adults	
		RT	% errors	RT	% errors	RT	% errors	RT	% errors	RT	% errors
1	Angry	882.46 (197.98)	5.56 (3.70)	819.23 (102.27)	7.69 (7.95)	764.80 (141.50)	9.79 (9.68)	705.01 (105.89)	6.37 (5.91)	575.88 (69.86)	3.57 (4.61)
	Happy	909.96 (238.39)	5.56 (4.81)	839.38 (110.30)	9.30 (8.86)	753.58 (133.10)	8.33 (9.07)	699.44 (119.52)	6.50 (6.58)	578.27 (72.53)	3.50 (5.02)
	Neutral	947.96 (236.13)	10.07 (4.85)	849.73 (109.30)	8.33 (10.49)	756.43 (132.03	7.50 (7.10)	704.00 (114.59)	6.99 (6.86)	575.82 (73.44)	3.09 (4.06)
2	Angry	971.83 (214.63)	8.33 (6.41)	876.88 (120.20)	7.05 (8.74)	793.20 (134.05)	8.96 (10.67)	736.19 (121.13)	7.60 (6.68)	597.71 (71.04)	3.72 (4.56)
	Happy	1016.58 (255.17)	8.33 (7.33)	892.73 (136.55)	7.05 (5.21)	799.95 (144.60)	7.50 (7.10)	739.84 (137.34)	5.52 (4.89)	595.50 (74.05)	4.06 (5.14)
	Neutral	989.46 (216.91)	7.99 (6.52)	901.69 (160.26)	6.73 (6.49)	799.35 (120.70)	6.88 (6.09)	739.63 (124.87)	4.90 (5.66)	596.62 (74.88)	3.39 (4.80)
4	Angry	1098.08 (302.85)	9.72 (6.73)	1017.73 (152.46)	12.50 (11.41)	850.05 (168.41)	11.04 (10.75)	791.88 (143.21)	8.33 (5.80)	625.25 (83.03)	4.24 (5.03)
	Happy	1060.58 (261.47)	11.11 (8.40)	1018.15 (182.07)	11.86 (10.04)	856.25 (171.74)	11.25 (12.10)	793.28 (145.85)	9.44 (7.63)	620.46 (82.28)	3.68 (5.39)
	Neutral	1112.83 (282.25)	12.15 (5.46)	964.65 (127.54)	7.69 (5.86)	844.93 (135.11)	9.79 (10.41)	798.71 (150.66)	8.95 (6.42)	625.68 (87.84)	3.76 (4.78)
6	Angry	1141.63 (297.07)	14.24 (7.84)	1062.73 (203.53)	15.38 (11.71)	903.30 (191.13)	10.83 (11.10)	819.41 (166.04)	8.95 (6.66)	641.84 (93.14)	4.99 (5.39)
	Happy	1117.04 (274.67)	9.03 (8.30)	1018.31 (201.77)	9.30 (5.42)	873.80 (172.30)	9.38 (7.87)	829.91 (183.10)	8.95 (6.74)	650.83 (98.04)	3.50 (4.32)
	Neutral	1147.21 (309.57)	14.93 (7.84)	1036.65 (198.52)	14.10 (9.40)	913.70 (218.85)	11.25 (11.48)	828.57 (161.42)	9.31 (7.18)	653.48 (100.18)	4.06 (5.72)

6.4.2.2 Filtering and EC

Children. EC was marginally correlated with overall RT (r = -.20, p = .07), indicating a tendency for higher EC to be associated with faster responses. When looking at correlations with RTs for each distractor valence, we found that lower EC scores were related to slower RTs at a set size of 1, when angry (r = -.29, p < .05) and neutral (r = -.25, p < .05) faces were used as distractors. When controlling for age, the correlation became marginally significant in the case of anger distractors (r = -.22, p = .05), and non-significant in the case of neutral distractors (r = -.17, *ns*). This indicates that the distracting effect of neutral faces is mediated by children's age to a larger degree than the effect of angry faces. Table 6.3 presents correlations with valence effects; as can be seen, there was no significant relationship between EC and the valence effect at any set size.

Adults. EC was unrelated to overall RT (r = .13, *ns*) and only marginally related to error percentages (r = -.17, p = .07). We found no other significant correlations in this group (see Table 6.3 for further details).

Table 6.3
Correlations between study variables and interference scores for each set size condition, in children and adults.

		AN-NE score				HA-NE score			
		1	**2**	**4**	**6**	**1**	**2**	**4**	**6**
Children	Anxiety	-.10	.00	.06	.28*	.06	-.10	.02	.25*
	Effortful Control	-.00	.05	-.04	-.02	.12	-.05	.05	-.10
Adults	Anxiety	-.01	.20*	$.18^{+}$	-.02	-.03	.06	-.13	.01
	Effortful Control	.02	.00	-.04	.06	-.08	.06	$.18^{+}$	.03

*$p < .05$; $^{+}p < .10$

6.4.2.3 Filtering and anxiety: child sample

We found no statistically significant correlations between anxiety and overall RT or error percentages: both |*rs*| < .15, *ns*. However, as can be seen in Table 6.3, there was a statistically significant correlation between anxiety and the AN-NE score (r = .28, p < .05) and HA-NE score (r = .25, p < .05), respectively, at a set size of 6.

In order to investigate the effects of anxiety, EC and their interaction upon selective attention, we carried out the equivalent of a moderation analysis using GLM. This type of analysis has the advantage that it allows us to test interactions between both categorical (load, valence effect) and continuous variables.

Anxiety and EC were first centered to reduce multicollinearity, and the interaction term was computed as the multiplicative product of the two centered variables. We then conducted a 4 (load) × 2 (emotional valence effect) repeated measures ANCOVA with gender, age (in months), anxiety, EC and the interaction term as covariates, and the interference score as the dependent variable. The analysis was run in four steps, entering gender and age in the first step, anxiety in the second step, EC in the third, and the interaction term in the final step. This type of analysis is the more economical equivalent of running eight different hierarchical regression analyses (for the eight valence effect scores) to test for moderation (Grace-Martin, personal communication, November 20, 2009). The results of the two types of analyses are identical.

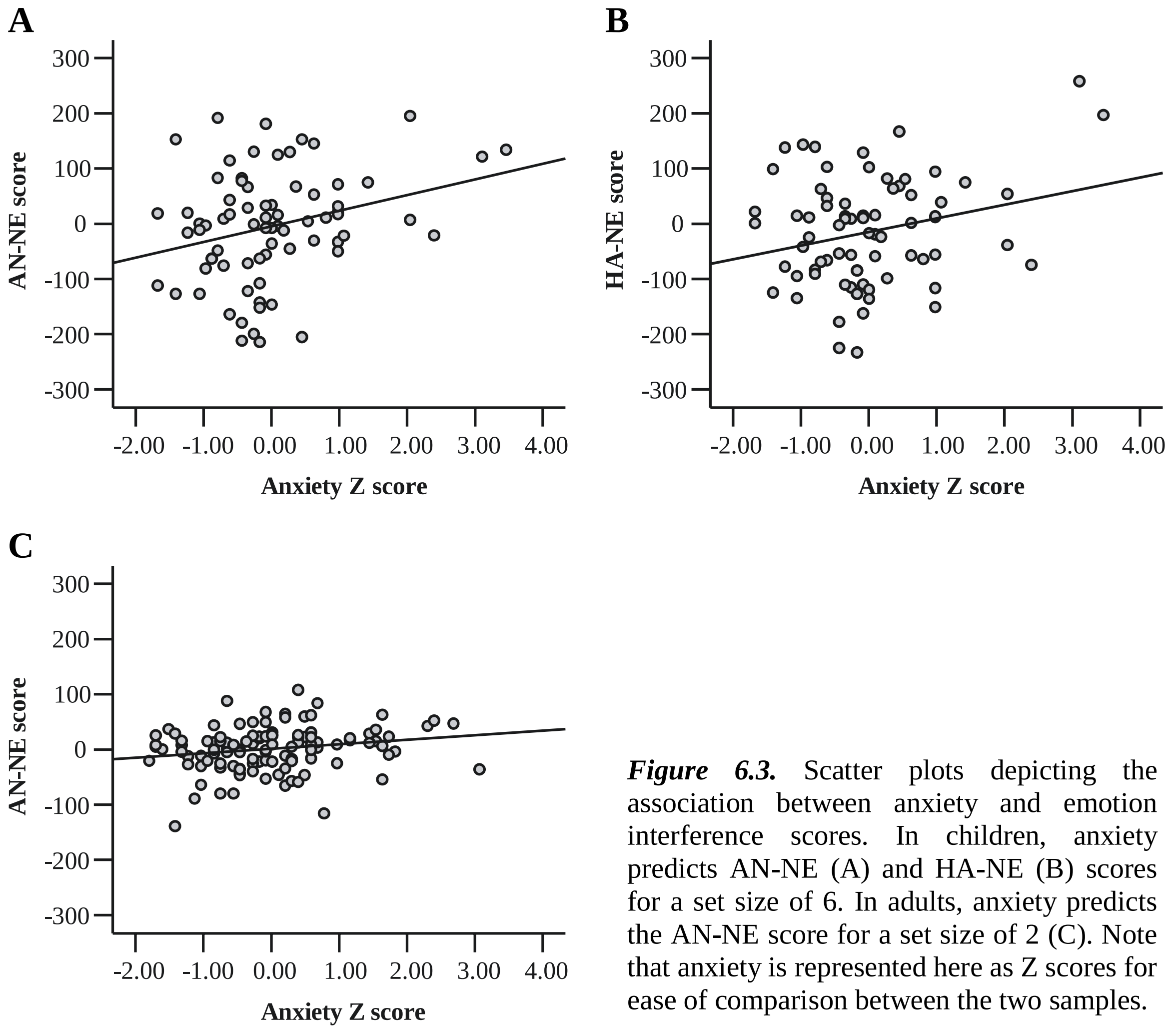

Figure 6.3. Scatter plots depicting the association between anxiety and emotion interference scores. In children, anxiety predicts AN-NE (A) and HA-NE (B) scores for a set size of 6. In adults, anxiety predicts the AN-NE score for a set size of 2 (C). Note that anxiety is represented here as Z scores for ease of comparison between the two samples.

Overall, we found a statistically significant set size × anxiety × EC interaction: $F(3, 204) = 3.22$; $p < .05$; $\eta_p^2 = .05$. However, there was no set size × valence × anxiety × EC interaction effect ($F < 1$, *ns*). This indicates that the effect of set size was modulated by the interaction between anxiety symptoms and EC, but not by the emotion interference condition. It indicates that the interaction of anxiety and EC has a different impact depending on set size.

In the first step of the analysis, age was a significant predictor of the AN-NE score at a set size of 1 ($B = 1.60$, $p < .01$, $\eta_p^2 = .14$), indicating that this score was larger in older children. As Table 6.2 indicates, younger children were more distracted by *neutral* (versus angry) face stimuli, and this tendency decreased with age. In the second step of our analysis – in line with the previously found correlations – high anxiety predicted higher AN-NE and HA-NE interference scores at a set size of 6: $B = 2.53$, $p < .05$, $\eta_p^2 = .08$ and $B = 2.21$, $p < .05$, η_p^2

= .07, respectively. This indicates that children with higher anxiety levels were more prone to be distracted both by angry and happy faces (compared to neutral faces) at a set size of 6, but not at other set sizes; see Figure 6.3A and 6.3B. EC did not represent a statistically significant independent predictor in the third step of the analysis for any of the set size × valence effect combinations, indicating that children's reactions to the varying load and valence effect manipulations was not a function of EC. Results of the final (fourth) step of this analysis are presented in Table 6.5 for all load × valence effect combinations. As can be seen, the interactive effect of anxiety and EC was statistically significant only for a set size of 1, both for the AN-NE score (B = 4.60, p < .01, η_p^2 = .11) and HA-NE score (B = 3.30, p < .05, η_p^2 = .07).

Table 6.4
Hierarchical multiple regression in the child sample, predicting the AN-NE and HA-NE interference scores, respectively, for a set size of 1, with anxiety as a main predictor and EC as a moderator.

	AN-NE score			**HA-NE score**		
	B	SE B	β	B	SE B	β
Step 1	R^2 = .14**			R^2 = .02		
(Constant)	-184.88	55.90		-40.84	53.16	
Gender	-14.03	14.07	-.11	-12.48	13.38	-.11
Age	1.59	0.49	.36**	0.36	0.46	.09
Step 2	ΔR^2 = .01			ΔR^2 = .00		
(Constant)	-184.15	56.03		-41.31	53.43	
Gender	-13.56	14.11	-.11	-12.77	13.45	-.11
Age	1.58	0.49	.36**	0.36	0.47	.09
Anxiety	-0.52	0.62	-.09	0.34	0.60	.07
Step 3	ΔR^2 = .00			ΔR^2 = .02		
(Constant)	-190.35	57.59		-29.28	54.58	
Gender	-12.42	14.36	-.10	-15.00	13.61	-.13
Age	1.63	0.50	.37**	0.27	0.47	.07
Anxiety	-0.50	0.63	-.09	0.29	0.60	.06
EC	-8.99	17.41	-.06	17.45	16.51	.13
Step 4	ΔR^2 = .10**			ΔR^2 = .06*		
(Constant)	-192.03	54.61		-30.49	53.16	
Gender	-7.19	13.73	-.06	-11.24	13.36	-.10
Age	1.60	0.47	.36**	0.25	0.46	.06
Anxiety	0.22	0.64	.04	0.80	0.63	.16
EC	-5.47	16.56	-.04	19.97	16.11	.15
Anxiety × EC	4.60	1.56	.34**	3.30	1.51	.27*

**p < .05; **p < .01*

To further clarify this interaction, the detailed steps of two hierarchical regression analyses having the two set size 1 valence scores as criterion variables are presented in Table 6.4. The full model explained 25% (R^2 = .25, f^2 = 0.33; adjusted R^2 = .19; f^2 = 0.23) of the variability in the AN-NE score, and 10% (R^2 = .10, f^2 = 0.11; adjusted R^2 = .04, f^2 = 0.04) of the HA-NE score variability. As can be seen, the entire model has a medium-large effect upon

AN-NE interference at a set size of 1, but a small one on HA-NE interference. However, as the differences between the coefficients of determination and their adjusted values indicate, it should be noted that in both models there is a certain degree of shrinkage (6% in both cases), indicating that they might generalize less well to a different sample.

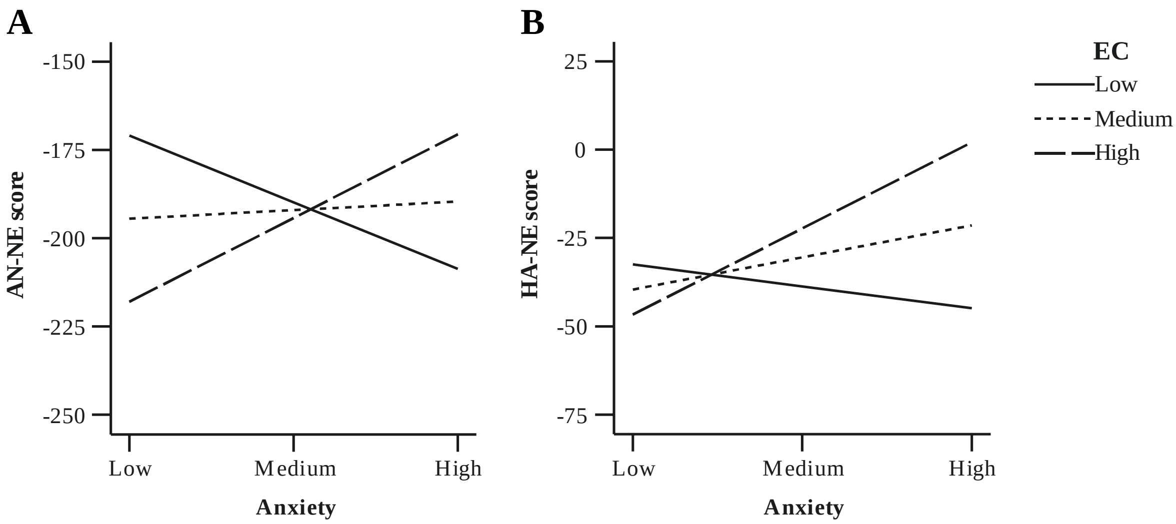

Figure 6.4. Interaction between anxiety and EC in predicting the AN-NE (A) and HA-NE (B) scores for a set size of 1 in the child sample. (Note that the scale is not identical on the y axis.)

As can be seen, in both models, the interaction term added a significant amount of variance to the model (i.e., 10% in the case of the AN-NE score, $f^2 = 0.13$; and 6% in the case of the HA-NE score, $f^2 = 0.07$). While neither anxiety nor EC constituted independent direct predictors of either interference score, in each case the interaction term was a significant predictor: $\beta = .34$, $p < .01$ and $\beta = .27$, $p < .05$, respectively. We probed both interactions using ModGraph (Jose, 2008). For AN-NE interference, the slope was statistically significant only at low EC values [$t(70) = -2.33$, $p < .05$], marginally significant at high values and non-significant at medium values: $t(70) = 1.98$, $p = .05$ and $t(70) = 0.09$, $p = .93$, respectively. As can be seen in Figure 6.4A, the model predicts that a combination of high anxiety and low EC is associated with a higher interfering effect of *neutral* faces compared to angry faces at the lowest perceptual load level. In the case of the HA-NE interference, the slope was only significant at high EC levels [$t(71) = 2.21$, $p < .05$], but not medium or low levels: $t(71) = 1.15$, $p = .26$ and $t(71) = -0.72$, $p = .48$ respectively. In other words, anxiety is positively correlated with the HA-NE score at high EC levels (see Figure 6.4B), indicating that children with high anxiety and high EC tend to be more distracted by happy faces when compared to neutral faces.

6.4.2.4 Filtering and anxiety: adult sample

As in the case of the children sample, we conducted a 4 (set size) × 2 (valence effect) repeated measures ANCOVA, with the centered predictors (anxiety, EC) and their interaction term as covariates and RT as the dependent variable.

We found a statistically significant overall interaction effect of valence and anxiety [$F(1, 108) = 6.71$, $p < .05$, $\eta_p^2 = .06$], indicating that the effect of anxiety manifested differently in the two valence conditions. More precisely, there was a tendency for neutral versus angry faces to be more disruptive in participants with lower anxiety ($M = -4.77$, $SD = 44.37$ for the AN-NE score) compared to those with higher anxiety ($M = -0.90$, $SD = 44.84$ for the AN-NE score).

In the first step of the analysis, anxiety significantly predicted the AN-NE score at a set size of 2, $B = 0.78$, $SE = 0.36$, $p < .05$, $\eta_p^2 = .04$. In the second step, EC did not constitute a significant predictor for any of the valence effect scores. In the last (third) step, parameter estimates indicated that the anxiety × EC term was a significant predictor of the HA-NE effect for a set size of 1: $B = -0.85$, $SE = 0.38$, $p < .05$, $\eta_p^2 = .04$ (see Table 6.5 for details).

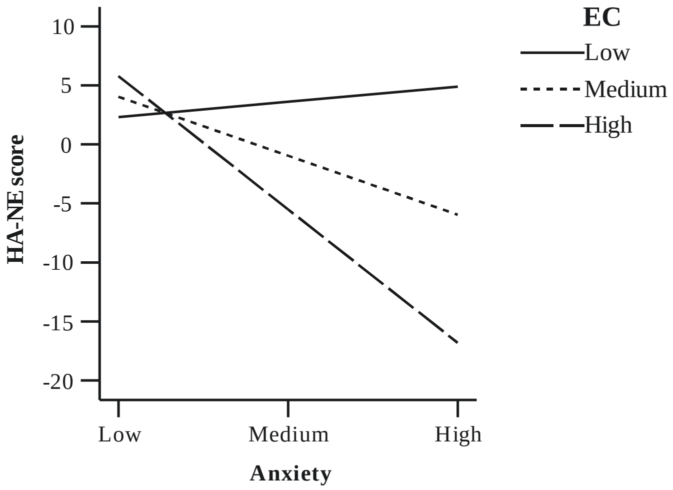

Figure 6.5. Interaction between anxiety and EC in predicting the HA-NE score for a set size of 1 in the adult sample.

When we conducted a hierarchical regression analysis predicting the HA-NE score at a set size of 1, the full model explained 6 % ($R^2 = .06$, $f^2 = 0.06$; adjusted $R^2 = .03$, $f^2 = 0.03$) of the entire variance at the level of HA-NE interference. Thus, the combined effect of the predictors was rather small. Neither anxiety nor EC were significant direct predictors of the anger score. The interaction term was a significant negative predictor of the HA-NE score ($\beta = -.21$, $p < .05$), but it predicted only an additional 4% ($f^2 = 0.04$) of the total variation in the HA-NE score at a set size of 1. Probing the interaction indicated that the slope was statistically significant only for high EC values [$t(108) = -2.23$, $p < .05$], but not for medium or low values: $t(108) = -1.27$, $p = .21$ and $t(108) = 0.30$, $p = .77$, respectively. As can be seen in Figure 6.5, anxiety was negatively related to HA-NE interference in participants with high EC. In other words, neutral faces had a more distracting effect (compared to happy faces) in adults with high anxiety and high EC.

Table 6.5
Parameter estimates of the predictive effects of anxiety, EC and their interaction upon the AN-NE and HA-NE interference scores, in the four load (set size) conditions, in the child and adult samples, respectively.

Set size	Predictor	AN-NE interference score								HA-NE interference score							
		Children				Adults				Children				Adults			
		B	SE B	t	η_p^2	B	SE B	t	η_p^2	B	SE B	t	η_p^2	B	SE B	t	η_p^2
1	(Constant)	-192.07	54.61	-3.52	.15	0.02	3.62	0.00	.00	-30.64	53.16	-0.58	.00	-0.96	3.51	-0.27	.00
	Gender	-7.19	13.73	-0.52	.00	-	-	-	-	-11.24	13.36	-0.84	.01	-	-	-	-
	Age	1.60	0.47	3.38**	.14	-	-	-	-	0.25	0.46	0.55	.00	-	-	-	-
	Anxiety	0.22	0.64	0.34	.00	0.01	0.38	0.02	.00	0.80	0.63	1.28	.02	-0.48	0.36	-1.31	.02
	EC	-6.31	16.54	-0.38	.00	1.12	5.52	0.20	.00	19.37	16.10	1.20	.02	-6.42	5.34	-1.20	.01
	Anxiety X EC	4.60	1.56	2.96**	.11	-0.01	0.39	-0.02	.00	3.30	1.51	2.18*	.07	-0.85	0.38	-2.24*	.04
2	(Constant)	-51.12	68.95	-0.74	.01	0.98	4.19	0.23	.00	36.42	84.32	0.43	.00	0.12	4.13	0.03	.00
	Gender	12.81	17.33	0.74	.01	-	-	-	-	15.89	21.19	0.75	.01	-	-	-	-
	Age	0.29	0.60	0.49	.00	-	-	-	-	-0.38	0.73	-0.51	.00	-	-	-	-
	Anxiety	-0.18	0.81	-0.22	.00	1.10	0.44	2.53*	.06	-0.75	0.99	-0.75	.01	0.55	0.43	1.27	.01
	EC	1.18	20.88	0.06	.00	8.83	6.37	1.39	.02	-9.15	25.53	-0.36	.00	7.33	6.29	1.17	.01
	Anxiety X EC	-1.07	1.96	-0.55	.00	-0.03	0.45	-0.06	.00	0.37	2.40	0.16	.00	0.31	0.45	0.68	.00
4	(Constant)	27.22	85.37	0.32	.00	-3.01	4.54	-0.66	.00	-8.20	101.19	-0.08	.00	-6.69	4.05	-1.65	.02
	Gender	-16.07	21.46	-0.75	.01	-	-	-	-	-25.65	25.43	-1.01	.01	-	-	-	-
	Age	-0.12	0.74	-0.16	.00	-	-	-	-	0.22	0.88	0.25	.00	-	-	-	-
	Anxiety	0.03	1.01	0.03	.00	0.84	0.47	1.77	.03	0.27	1.19	0.23	.00	-0.22	0.42	-0.53	.00
	EC	-4.46	25.85	-0.17	.00	5.17	6.91	0.75	.01	17.33	30.64	0.57	.00	8.83	6.17	1.43	.02
	Anxiety X EC	-2.91	2.43	-1.20	.02	-0.64	0.49	-1.31	.02	0.58	2.88	0.20	.00	-0.37	0.44	-0.84	.01
6	(Constant)	-6.53	92.98	-0.07	.00	-11.42	5.98	-1.91	.03	-129.42	89.81	-1.44	.03	-4.88	5.33	-0.92	.01
	Gender	-14.20	23.37	-0.61	.01	-	-	-	-	-4.44	22.57	-0.20	.00	-	-	-	-
	Age	0.09	0.81	0.11	.00	-	-	-	-	1.04	0.78	1.33	.03	-	-	-	-
	Anxiety	1.92	1.10	1.75	.04	0.09	0.62	0.15	.00	1.55	1.06	1.47	.03	0.11	0.55	0.20	.00
	EC	-11.41	28.16	-0.41	.00	5.64	9.10	0.62	.00	-40.28	27.20	-1.48	.03	4.17	8.11	0.51	.00
	Anxiety X EC	-4.07	2.65	-1.54	.03	0.06	0.64	0.09	.00	-4.84	2.56	-1.89	.05	-0.55	0.58	-0.96	.01

$*p < .05$; $**p < .01$

6.4.3 Discussion

The present study investigated threat-related distractibility in the context of anxiety, varying perceptual load, and EC abilities. We took perceptual load theory (Lavie, 2005; Lavie & Tsal, 1994) and data regarding attentional biases in anxiety as a basis for our predictions. While we expected anxiety to predict higher distractibility in the presence of angry (versus neutral) face distractors especially at low perceptual loads (in both children and adults), we predicted that this relationship would disappear at higher perceptual loads. In other words, we wanted to determine whether passive (stimulus-driven) engagement of attentional resources might help anxious children and adults focus more effectively on the main task. An additional prediction was that at low perceptual loads (where fewer processing resources were passively engaged), good EC abilities might compensate by activating top-down/goal-driven mechanisms to control resource allocation.

As our preliminary analyses indicate, the perceptual load manipulation was successful in both children and adults; the effect of this manipulation was stronger in children, who presented a steeper increase in RT and errors as a function of perceptual load (this might indicate that children need more additional resources for each additional element to be processed). This result is not surprising as it is in line with previous research indicating that the letter search task is effective in manipulating the amount of attentional resources engaged by adults (Lavie & Cox, 1997; Maylor & Lavie, 1998) or children (Huang-Pollock et al., 2002). On the other hand, with respect to the distractors used, emotional faces were no more distracting than neutral faces in either children or adults, under any perceptual load condition. While this is somewhat surprising, the result is in line with behavioral data reported in research involving adults (e.g., Eimer et al., 2003; Pessoa et al., 2002; Holmes et al., 2006), where the impact of unattended emotional versus neutral faces was virtually equal. Similar research involving children is lacking, but our results indicate that, under these circumstances, children of 7 years or older react like adults do.

It is noteworthy that high EC was associated with faster responses at the lowest perceptual load level in children, especially in the case of angry faces. While this effect was not found in our adult sample, it is somewhat in line with previous research reporting associations between higher attentional control and lower distractibility to emotional faces (Peers & Lawrence, 2009), or attentional control and higher PFC activation in response to fearful versus neutral faces (Bishop et al., 2007) at low perceptual loads in adults. In our child sample, EC was also related to lower distractibility in the presence of neutral face distractors, but this effect was – to a certain degree – explained by the children's age. The absence of any contribution from EC in adults indicates that this trait is probably more relevant in the case of children, whose abilities for top-down attentional control are reduced.

The previously found contribution of age to neutral face interference at the lowest perceptual load was corroborated by the regression (GLM) analysis, where age predicted (with a moderate strength) the AN-NE interference score. More precisely, younger children were more distracted by neutral faces (compared to angry faces); this tendency decreased with age, as indicated by the fact that RTs were virtually equal in the older groups (see Table 6.2). These results are not entirely in line with previous research, which showed that children within this age range recognize and process happy faces faster (De Sonneville et al., 2002; Gao & Maurer, 2009, 2010) or they detect threat-related faces (angry or fearful) faster than neutral faces or faces with other emotional expressions (LoBue, 2009; Waters & Lipp, 2009). However, it is difficult to compare our results with this data, since, as already mentioned, research into the processing of unattended face distractors is lacking in children. On the other hand, more in line with our results, there is some data (Durand et al., 2007) indicating that until around the age of 9 years, neutral faces are more difficult to discriminate (children tend to mistake them for happy or sad faces), and some evidence (Thomas et al., 2001) for increased amygdala activation in response to neutral faces (in 11-year-olds versus adults). Thomas et al. interpreted their data from the perspective of Whalen's (1998) proposal that the amygdala activates in response to uncertainty and ambiguity. Neutral faces might be more ambiguous for children, as they are not yet perceived as signals of neutrality. Instead, in children they might be associated with increased vigilance and "continued attempts to decode or interpret" (Thomas et al., 2001, p. 313). It is therefore possible that neutral faces are more salient for younger children (although other research seems to indicate that they are not, when compared to happy or angry faces: e.g., Gao & Maurer, 2009, 2010, LoBue, 2009) or they simply engage more attentional resources, taking them away from the task than children should be focusing on. It is also noteworthy that this effect disappeared from a set size of 2 and up, which might indicate that higher perceptual loads cancelled age-related distractor biases.

As a direct predictor, anxiety predicted both the AN-NE as well as the HA-NE interference scores at a set size of six in children. In adults, anxiety predicted the anger effect at a set size of two items, but not other set sizes. In other words, higher anxiety was associated with higher interference from angry *and* happy faces in children and only angry faces in adults. However, in the case of children this took place at the highest perceptual load level, contrary to our hypothesis that higher perceptual loads should diminish distractibility. In the case of adults, the result was more in line with our prediction since the effect occurred at a low load level and it was emotion-specific (it only occurred for angry faces).

There are two aspects that need to be discussed here. First, our results show that (provided certain perceptual load levels) higher anxiety is associated with interference from emotional faces (both angry and happy) in children, and interference from only angry faces in adults. This indicates that children with higher anxiety are more distracted by emotional faces in general, while the effect is more specific in adults, who are only distracted by angry faces. In the case of adults, our results are in line with previous research showing threat-related biases in adults with high levels of anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & IJzendoorn, 2007; Cisler & Koster, 2010). As discussed in Chapter 4, data regarding children is more mixed (Ehrenreich & Alan M Gross, 2002; Heim-Dreger et al., 2006; M. Kindt et al., 1997; M W Vasey et al., 1996; Waters et al., 2004b), and there is (to our knowledge) no published research informative to the way children react when emotional faces act as peripheral distractors. However, recent unpublished data from our laboratory supports our findings: in a visual search task, children aged 9-15 years with high anxiety showed increased distraction when they were presented with a neutral face among "crowds" of angry or happy faces and were asked to find the discrepant face (Susa, personal communication, August 2010).

Second, contrary to our prediction, the highest levels of anxiety-related distractibility were present at the maximum load level, when – according to perceptual load theory – all available attentional resources should be occupied by the central task (Lavie, 1995, 2005b; Lavie & Tsal, 1994). In addition, no such effects were found at lower loads. A similar "atypical" result has previously been obtained by Huang-Pollock, Nigg, and Carr (2005) in

ADHD children with sluggish cognitive tempo (SCT)[16]. They used a letter search task with letter distractors (the task used in Huang-Pollock et al., 2002; discussed in paragraph 6.1.1.1), and found a pattern of performance similar to the one we found: children with SCT were more distractible compared to those without SCT only at a set size of six elements. The authors interpreted this pattern of performance as indicating possible early selection deficits, but did not clarify precisely what such a deficit would entail. In a very recent study using Lavie and Cox's (1997) experimental paradigm, Moriya and Tanno (2010)[17] found that while interference from incompatible distractors was similar in participants with high and low social anxiety at the lowest set size, a high perceptual load suppressed distractor interference only in those with low anxiety. Participants with high anxiety were just as distracted at a set size of six. According to the authors, these results were an indication that executive inhibition of distractors might not be deficient in anxiety, but instead people with high (social) anxiety might have larger "pools" of processing resources or they distribute them differently compared to low anxious people. Lastly, Eltiti and collaborators (Eltiti, Wallace, & Fox, 2005; see also Paquet & Craig, 1997) showed that, on the one hand, distractor interference can be suppressed even at low perceptual loads if target stimuli are distinctive enough, and on the other hand, distractor stimuli can interfere with target processing even at high loads if they are salient enough. Taking into account this previous data, our results can be interpreted as indicating either that high anxiety is associated with more perceptual processing resources, or that emotional faces are such salient distractors for anxious children, that they fail to be filtered out by the highest perceptual load of the central task. While the first possibility is an intriguing one, we would need evidence that higher emotion-related distractibility is also present at low perceptual loads. And such evidence is lacking from our data. The second hypothesis has the same problem as the first. However, it is possible that in set sizes 1 to 4 the target letter appeared so salient to children that it suppressed the effect of the distractors (in line with the ideas put forward by Eltiti et al., 2005). However, this is a possibility that needs to be investigated further in future studies, in conjunction with determining why this phenomenon is present only in children.

While anxiety predicted variation in distractibility at different perceptual loads in children and adults, EC moderated the effect of anxiety on distractibility at the same load level (i.e., a set size of 1) in both groups. Anxiety predicted increased distractibility for neutral faces compared to angry faces in children who had low EC abilities and less neutral face distractibility – compared to both angry and happy faces – in children with high EC (but note that the effect for angry faces was on the edge of significance). This latter effect was reversed in adults: higher anxiety was associated with higher neutral face distractibility (compared to happy face distractors) at high EC levels. Thus, it seems that in this case our hypothesis is only partially supported: the perceptual load level where EC acts as a moderator is – as expected – low. However, the pattern of effects is not as predicted, since children with high anxiety and low EC appear to be distracted by neutral faces more than by angry faces, while children with high EC and high anxiety are less distracted by neutral faces overall. Considering the pattern of our data, we can conclude that EC tends to modulate distractibility for neutral faces in the more anxious children (since predicted values tend to approach zero at higher anxiety scores):

[16] "Sluggish cognitive tempo" is an informal descriptive term for a subgroup within the ADHD-Predominantly Inattentive subtype.
[17] We had formulated our hypotheses and had gathered our data before this paper was published. Since it played no role in generating our hypotheses, we chose not to mention it in the theoretical part of this chapter.

higher EC abilities equal less distractibility. However, this leaves open the question of why less anxious children would be less distractible when they have low EC abilities and more distractible when their EC abilities are high. In adults with high EC levels, low anxiety was associated with less distractibility while more anxiety with more distractibility. To conclude, it is clear that although we have found evidence for a moderating role of EC, the pattern of results is rather complex, and does not support our hypothesis. These results clearly need further research, perhaps in the context of a different experimental design, which would allow for a clearer assessment of the effect of neutral face distractors.

Our results must be regarded taking into account certain limitations. First, all effects found in this study are small or moderate at best. This is probably the reason why we found very few interactions between trait measures (anxiety, EC) and within-subject measures (set size, interference scores or distractor valences). Therefore, future studies should probably use larger samples to detect these effects. Second, since neutral faces appear to have a distracting effect especially in children (at least under some circumstances), they might not constitute an adequate baseline condition for this group in this type of task. A more adequate baseline might be a “no distractor” condition, or a condition using non-face stimuli as distractors.

Keeping in mind these limitations, we can conclude that we did find evidence for higher emotion-related distractibility in participants with higher levels of anxiety. However, this tendency was emotion-specific only in adults. Second, increasing perceptual load as a strategy for improving focus on the central task had the expected effect only in adults (but note that even here effects were weak). This manipulation was ineffective in children, as it appeared to increase distractibility. However, this paradox in our results should be an interesting challenge for future research, as it might help us understand how attentional resources are managed across different developmental levels, and how they are influenced by anxiety, processing load and distracting stimuli. Lastly, our data indicates that having better EC skills is relatively ineffective in modulating distractor interference at the lowest perceptual load, as high EC sometimes appeared to favor distractibility (especially in the presence of neutral faces). Future research should clarify the reason for this discrepancy.

Chapter 7.
Anxiety across development: Final conclusions and implications

The present thesis has focused on anxiety, one of the most prevalent forms of emotional problems, affecting children as well as adults, with important long-term consequences at the level of psychopathology, academic achievement, and general quality of life. We chose to investigate anxiety from two perspectives: its potential predictors (here we focused on temperament and ER strategies) and its links to attentional functioning. We also employed a developmental approach, in the form of a cross-sectional design.

7.1 Summary of the thesis and main findings

In *Chapter 1*, we introduced the problem of anxiety, by discussing data on the worldwide prevalence of anxiety disorders in adults, as well as children and adolescents. We discussed the two ways in which anxiety has been conceptualized in the research literature, namely as a *disorder* (the clinical perspective) or as a *trait* (i.e., a characteristic varying continuously in the general population that reflects the predisposition to react with a state of anxiety even in the face of mild threats or novel situations; e.g., Endler & Kocovski, 2001; Spielberger, 1983). We next discussed developmental aspects associated with anxiety symptoms, such as the way they evolve over the lifespan up to adulthood, and the impact they have on general mental health, academic achievement, quality of life and work performance. Finally, we discussed briefly some of the most important correlates of anxiety, such as individual differences in temperament, cognitive correlates (memory, attention, cognitive interpretation of ambiguous situations) and general aspects regarding the brain substrate of anxiety.

The rest of the thesis can be divided into two parts: Chapters 2 and 3 focus on individual differences in temperament and ER, and their role in predicting anxiety symptoms in children and adults, while Chapters 4-6 focus on the links between anxiety and attentional functioning.

Recent years have seen an increasing interest in individual characteristics that might predispose children to current or future emotional and behavioral problems, and this research trend has likewise affected the study of anxiety. Thus, in *Chapter 2* we conducted a theoretical review of the literature focusing on two aspects that are more and more in the focus of anxiety researchers, namely temperament (i.e., biologically based individual differences in reactivity/arousal and self-regulation; Goldsmith et al., 1987; Kagan, 1998; Rothbart, Ahadi, & Evans, 2000) and ER (extrinsic and intrinsic mechanisms that help modulate the characteristics of emotional reactions; Thompson, Lewis, & Calkins, 2008; Thompson, 1994). We discussed two models of temperament that have dominated the developmental literature in the past two decades, namely Kagan's behavioral inhibition (BI) model (Kagan, 1998; Kagan et al., 1989) and Rothbart's multidimensional model (Rothbart, 1981; Rothbart & Bates, 1998, 2006). Both models have been involved in developmental research on anxiety. Kagan's model has generated longitudinal studies showing that children characterized by temperamental inhibition in the face of novel social situations where primarily at risk for social anxiety, but also other types of anxiety disorders in adolescence or adulthood. Rothbart's model has a shorter history in the study of anxiety. However, it has the advantage that it takes into account not only emotional reactivity (through the dimensions of Surgency/Extraversion – SE and Negative Affect – NA), but also an individual's ability to regulate his/her own behavior (Effortful Control – EC). Anxiety research focusing on this model has investigated the independent or interactive roles that NA and EC might play in the development of anxiety, and has emphasized the potentially protective effects of a high EC. Another aspect of self-regulation – ER – has been investigated only recently, in research that has found links between a tendency to use passive or generally maladaptive ER strategies and anxiety.

Based on the research reviewed in Chapter 2, we formulated a set of objectives and hypotheses which were investigated in *Chapter 3*. These objectives and hypotheses are summarized, together with the corresponding results, in Table 7.1. Overall, the studies included in this chapter showed that the pattern of relationships between NA, EC and anxiety changes across the three developmental groups included in our study. NA is a clear predictor of high anxiety symptoms in all age groups (although its effect is reduced in adulthood). However, our results indicate that the role and importance of EC tends to change over development. While high EC/inhibitory control is associated with increased risk in preschoolers (in girls), high EC acts as a protective factor, cancelling out the relationship between NA and anxiety in middle childhood (especially in girls). In adults, our results indicate that the importance of EC might be even stronger, as EC potentially modulates NA itself and thus indirectly influences anxiety. The role of ER in anxiety was generally as expected, at least on a correlational level: passive ER, avoidance and maladaptive ER were related to higher anxiety. However, we found less evidence for a mediating or moderating role of ER. Additionally, our data in the case of schoolchildren indicated the value of obtaining *self*-report (as opposed to parent-report) from children.

Chapter 4 introduced the second part of the thesis, with a focus on attention and its relationship to anxiety. While a large part of research has focused on threat-related attentional biases, we were interested to go beyond this topic, and to focus instead on more general and fundamental attentional mechanisms. Therefore, we discussed Attentional Control Theory (ACT; Eysenck et al., 2007), which has a broader scope than most models focusing on threat-related attentional biases, and which postulates that anxiety-related attentional functioning is characterized by an imbalance between top-down and bottom-up mechanisms, with a dominance of the latter. Additionally, we reviewed some of the fundamental research on attention, the main functions accomplished by it (and their development). Because we considered that the characteristics of top-down and bottom-up attentional mechanisms were insufficiently specified in ACT, we reviewed the most important models for these processes in fundamental attentional research. Finally, we returned to the anxiety–attention relationship; by reviewing the literature, we concluded that most functions of attention have not been adequately investigated in the context of anxiety (especially in the case of children).

In *Chapter 5* we focused on Posner and Petersen's (1990) model of three attentional networks – alerting, orienting and executive attention – and investigated their functioning in anxiety, in children and adults (see Table 7.1 for details on the studies). Interest in this model in the context of anxiety has emerged only within the past three years, and there is at present no published data involving children. Therefore, although we were guided by predictions of the ACT, our approach was largely exploratory, with few clearly formulated hypotheses. Our data indicated that the alerting and orienting networks were more relevant for anxiety than executive attention. We found some indication for a possible anxiety- or fearfulness-related imbalance between bottom-up and top-down mechanisms regulating alertness in preschool girls, while anxiety was associated with slow orienting in middle childhood. In adults, there was no link between attention and anxiety; instead, depression was associated with slow orienting here. Our secondary interest in attentional network functioning and self-regulatory mechanisms (EC and ER) generated a more complex pattern of results, and pointed toward the need for further research in this area (see Table 7.1 for details).

In *Chapter 6*, we approached the problem of distractibility from the perspective of Lavie's (Lavie, 2005b, 2010; Lavie & Tsal, 1994) model for the filtering function. Lavie's model attributes a very important role to perceptual load. We thus investigated whether high perceptual load – by exhausting attentional resources – would reduce distractibility in the presence of threatening faces in participants with high anxiety. Additionally, we were interested whether high EC would have the same effect at low perceptual loads (see Table 7.1 for details). Results of this study showed that high anxiety was associated with general emotion-related distractibility in children, but this took place – contrary to our expectations – at the highest perceptual load level, indicating the possibility that high anxiety was associated with deficits in controlling the width of the attentional "spotlight" in children. In adults, results were more specific and more in line with our expectations, as anxiety-related distractibility was high only in the presence of angry face distractors, presented at a low perceptual load. We failed to find a clear, hypothesis-congruent involvement of EC.

Apart from these main results, two further aspects that we focused on were the degree to which our findings were specific for anxiety (for this reason, in Chapters 3 and 5 we included measures of depression) and the degree to which the patterns of relationships we found were moderated by gender. The first issue was motivated mainly by the fact that many studies focusing on children tend to use general measures of internalizing problems. While we found many similarities between anxiety and depression, there were enough differences to justify an empirical approach that separates the two. In the case of gender, our data shows that different patterns of predictors hold true for anxiety in girls and boys. Taking into account the different prevalence and intensity in adults, this approach is justified.

Table 7.1
Summary of main thesis findings.

Chapter	Objectives / Hypotheses tested	Results		
		Preschool	**Middle childhood**	**Adulthood**
3		*N* = 119; 4-7 years	*N* = 221; 6-11 years	*N* = 175; 19-36 years
	O1. Temperament – Anxiety relationships **H1:** NA and EC predict anxiety independently (High NA predicts high anxiety; high EC predicts low anxiety). **H2:** EC moderates the relationship between NA and anxiety (NA and EC interact); at high EC levels, the NA-Anxiety relationship is annulled or diminished	▪ **H1:** supported for NA ▪ **H1:** not supported for EC; EC and inhibitory control predict *high* anxiety ▪ **H2:** not supported; inhibitory control *amplifies* the NA-Anxiety relationship in girls	▪ **H1:** supported for NA ▪ **H1:** not supported for EC. ▪ **H2:** supported; at high EC, the NA-Anxiety relationship is cancelled (especially in girls).	▪ **H1:** supported for NA ▪ **H1:** not supported for EC ▪ **H2:** not supported ▪ Incidental finding: EC modulates NA and (indirectly) anxiety
	O2. ER – Anxiety relationships **H3:** Anxiety symptoms correlate with use of passive / maladaptive ER strategies in general. **H4:** Some ER strategies mediate the relationship between NA and anxiety. **H5:** Some ER strategies moderate the relationship between NA and anxiety.	▪ **H3:** supported; Passive ER strategies (avoidance, venting, emotional intervention) are related to anxiety in boys ▪ **H4:** not supported ▪ **H5:** supported; Passive ER amplifies the NA-Anxiety relationship	▪ **H3:** supported only when using child self-reports; Avoidance related to anxiety (especially in girls) ▪ **H4:** not supported ▪ **H5:** not supported	▪ **H3:** supported; anxiety related positively to maladaptive ER and negatively to adaptive ER. ▪ **H4:** not supported ▪ **H5:** not supported ▪ Incidental finding: maladaptive ER modulates NA and (indirectly) anxiety
	O3*. EC – ER relationships **H6*:** Good EC skills are positively correlated with adaptive/active ER strategies and negatively related to maladaptive/passive ER strategies.	▪ ***H6:*** Generally supported; EC negatively related to Aggressive ER	▪ ***H6:*** Generally supported; EC positively linked to active coping	▪ ***H6:*** Generally supported; EC positively related to adaptive ER, negatively related to maladaptive ER

Chapter	Objectives / Hypotheses tested	Results		
		Preschool	**Middle childhood**	**Adulthood**
5		*N* = 97; 4-7 years	*N* = 106; 6-11 years	*N* = 85; 19-44 years
	O1. Anxiety – attentional networks Direct anxiety–attention relationships? Moderated anxiety–attention relationship?	▪ No direct relationship ▪ Inhibitory control moderates the anxiety-*alerting* relationship in girls ▪ Incidental finding: fearfulness is related to efficient *phasic alertness* and inefficient *intrinsic alertness* in girls	▪ Anxiety–*orienting* relationship in boys; slow orienting to exogenous valid cues ▪ Anxiety–*orienting* relationship in girls, moderated by EC	▪ No relationship ▪ (Depression linked to slow orienting).
	O2*. Attentional networks and self-regulation (EC and ER)			
	EC – executive attention	▪ Inhibitory control linked to high *conflict* scores	▪ EC linked to low *conflict* scores (i.e., good executive attention performance)	▪ No relationship
	ER – attentional networks	▪ High *conflict* linked to low aggressive ER and high active ER in boys	▪ High *alerting* linked to low avoidance	▪ High *conflict* linked to high self-blame and low acceptance

Chapter	Objectives / Hypotheses tested	Results		
		Preschool	Middle childhood	Adulthood
6		-	*N* = 78; 7-11 years	*N* = 112; 19-39 years
	O1. Anxiety – attentional filtering **H1:** Anxiety associated with slower performance in the presence of angry face distractors (compared to neutral face distractors), at low perceptual loads (set sizes of 1 or 2). **H2:** This higher distractibility should disappear at high perceptual loads; i.e., at high perceptual loads anxiety should not be related to speed of response in the presence of angry face distractors. **H3:** EC moderates anxiety-related performance at low perceptual loads; i.e., in participants with high EC, the relationship between anxiety and distractibility should be diminished or absent.	-	▪ **H1:** not supported; anxiety is associated with higher distractibility by angry *as well as* happy face distractors, *at the highest perceptual load level* (set size 6). ▪ **H2:** not supported; anxiety is related to distractibility *only* at the highest perceptual load. ▪ **H3:** not supported; high EC appears to promote distractibility.	▪ **H1:** supported; anxiety is associated with higher distractibility only in the presence of angry face distractors, *at a low perceptual load* (set size 2). ▪ **H2:** supported ▪ **H3:** not supported

* Secondary objective/hypothesis.

7.2 Original contributions

Regarded in the context of previous studies, our thesis makes a few important contributions to developmental research on anxiety, its predictors and its attentional correlates.

First, while the cross-sectional methodology is by no means new in developmental research (see Robinson, Schmidt, & Teti, 2005 for a review), this is – to our knowledge – the first cross-sectional approach to both topics investigated in this thesis. Previous similar approaches have used a longitudinal methodology to investigate the temperament–anxiety link from the perspective of BI (e.g., Biederman et al., 2001, 1993). However, this is the first cross-sectional approach focusing on the multidimensional model of temperament, ER and attention in relation to anxiety. This approach has proven useful in providing a clearer understanding of some of the potential changes that occur across developmental stages.

Second, research interest in ER strategies and their relationship to anxiety is relatively new. And while there have been a few studies focusing on adults or adolescents (e.g., Garnefski, Kraaij, & Spinhoven, 2001; Garnefski, Kraaij, & van Etten, 2005; Garnefski, Legerstee, Kraaij, van den Kommer, & Teerds, 2002; Tortella-Feliu, Balle, & Sesé, 2010) research in children is much more limited, and nearly absent in preschoolers (we were able to identify only one study involving preschoolers: Blair, Denham, Kochanoff, & Whipple, 2004).

Third, the thesis contains a theoretical analysis on attentional functions and the degree to which they have been investigated in anxiety (see Chapter 4). While most research on attentional performance in anxiety has focused on threat-related biases, our analysis points to the need for expanding the range of attentional mechanisms investigated. At the same time, such an analysis can constitute a foundation for a more systematic research program into general attentional functioning in anxiety.

Fourth, the focus on general attentional mechanisms and their functioning in anxiety is a relatively new topic, for which only a handful of studies have been published thus far, and all of them over the past three years (e.g., Dennis & Chen, 2007; Dennis, Chen, & McCandliss, 2008; Moriya & Tanno, 2009a, 2009b). However, to our knowledge this is the first attempt to investigate this topic in children. While our exploratory studies using the ANT in the three developmental samples have generated more questions than answers, we see the results as promising, and indicating the need for further research on the topic. Our thesis also contains the first attempt to use Lavie's perceptual load model to study anxiety-related attentional filtering in children. Previous studies inspired by this model have focused exclusively on adults (Bishop et al., 2004; Bishop, 2009; Bishop et al., 2007). We have been able to identify only two previous studies that have investigated the impact of perceptual load in children, and neither involved anxiety; one focused on typical development (Huang-Pollock et al., 2002), the other on ADHD (Huang-Pollock et al., 2005).

Fifth, the thesis includes the first attempt to investigate the links between general attentional functioning and ER strategies. While this was probably the most exploratory aspect of our thesis, it is one worthy of further investigation.

Finally, at the level of statistical methodology, we decided to avoid the popular median-split strategy. This strategy is very common in research investigating anxiety and cognitive performance, and despite its documented disadvantages in terms of statistical accuracy (Jacob Cohen, 1983; Irwin & McClelland, 2003; MacCallum et al., 2002), contimnues to dominate the field.

7.3 Implications of thesis findings and future directions

Although it was not our initial intention, the two parts of the thesis have a common theme (apart from anxiety), namely the dichotomy, or balance between automatic / bottom-up processes and controlled / top-down processes. While this dichotomy was discussed explicitly in the case of attention, it is implicit in the first part of the thesis as well, more precisely in the balance between negative emotional reactivity and processes that regulate this reactivity (mainly EC). Our results brought some partial support to the idea that reactive / bottom-up mechanisms dominate in anxious individuals, but that regulatory / top-down mechanisms can modulate this reactivity. Although our research has generated – especially in its second part – more questions than answers, we believe that the idea of an imbalance between the two types of systems is highly relevant from a developmental perspective. More precisely, if bottom-up emotional and attentional systems are indeed overactive in individuals with high anxiety or at risk for an anxiety disorder, it would be very relevant to understand *if* and *how* this affects the development of top-down systems. For example, NA and EC systems might develop independently of each other, or might interact during development. It is possible that high negative emotional reactivity might impair the development of adequate EC skills, or, on the contrary, might promote EC development as a compensatory mechanism. It would be interesting to know under what circumstances these scenarios are possible. The same questions apply to attentional mechanisms; as we have seen in Chapter 5, the three attentional networks interact more and more across development. Therefore, it would be interesting to know whether and how a highly reactive stimulus-driven system might affect the development of attention in general.

It is more difficult to include ER in this bottom-up / top-down dichotomy, as current research tends to see ER strategies as involving both automatic and controlled processes, although probably in different proportions (Compas, 2009; Eisenberg & Spinrad, 2004; Gross & Thompson, 2007; Skinner, Edge, Altman, & Sherwood, 2003). However, in the case of ER, any future cross-sectional or longitudinal study should first solve a limitation our research had at the level of assessed ER strategies. More precisely, we lacked measures that focused on the same types of ER strategies in all developmental groups. Such instruments would be extremely useful in understanding the development of ER strategies, as well as their impact on other areas of development.

Our data does not allow us to infer clear causal relationships. However, our results raise the possibility for interventions at the level of factors that might have a protective role. For example, it would be interesting to determine if trainings aimed at developing better EC abilities might help children with high NA, and decrease their risk for high anxiety. Our data, as well as data from other studies (Kochanska et al., 1996; Kochanska et al., 1998; Thorell et al., 2004) indicates that such an intervention might prove effective only starting in middle childhood, and that such an intervention should probably be tailored taking into account gender differences. Similar interventions might be used to diminish the use of passive/maladaptive ER and to promote effective and adaptive ER strategies. In fact, such suggestions already exist in the literature. One example is *Emotion Regulation Therapy* (ERT) proposed by Mennin (2004) for the treatment of generalized anxiety disorder. In children, the training of adaptive ER strategies might also take the form of preventive intervention.

With respect to attention, our results indicate that alertness and orienting, as well as filtering are worthy of further investigation in anxiety. After determining the extent to which these functions are affected in anxiety, future studies might also investigate whether and how much potentially impaired attentional functioning is involved in academic achievement and work performance. Additionally, anxiety-related impairments in general attentional functioning point towards the potential usefulness of attentional training interventions. Such forms of training already exist for attentional biases (e.g., Harris & Menzies, 1998; Pitica, Susa, & Benga, 2010; Schmidt, Richey, Buckner, & Timpano, 2009; Wells, White, & Carter, 1997), and some studies have also focused on more general forms of attentional training, using either computer programs or games (see Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005 for such training in children; see Tang et al., 2007; Tang & Posner, 2009 for examples in adults).

To conclude, throughout the present thesis we have attempted to investigate anxiety and its development cross-sectionally, and from a double perspective: that of individual differences that might act as predictors of anxiety symptoms, and that of attentional mechanisms that might be negatively affected in anxiety. Our results open interesting possibilities for future research, and indicate potential areas of intervention.

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