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The effects of anxiety on attentional networks in children and adolescents

PhD Thesis Abstract

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Abstract Contents

Key words: childhood anxiety, attentional processing of threat-related information, temperament, attentional control, attentional networks.

Introduction

Anxiety disorders are prevalent through the lifespan and are associated with several negative consequences on individual's development. Given the early occurrence of clinical anxiety and its chronic course researchers within developmental psychopathology are interested in elucidating the factors responsible for continuity and change in anxious behaviors (Weems, 2008).

In the present thesis we adopted a cognitive approach in studying vulnerability mechanisms associated with anxiety in children and adolescents given that it has been proposed that anxiety is a future-oriented mood state involving the cognitive processes for the evaluation of potentially dangerous future events (Barlow, 2002).

Within this cognitive framework, the relation between anxiety and attention is an area that has generated considerable interest in both adults and children. The main question of theoretical models and researchers was related to whether individuals with higher levels of anxiety and anxiety disorders manifest attentional biases in the presence of threatening information. Threat-related attentional biases refer to the tendency of anxious persons to preferentially allocate their attentional resources towards threatening information in the environment. To a certain degree these attentional biases in the favor of threat are considered to be an adaptive response because they may serve to prepare the persons to respond fast to threatening situations. However, it is believed that for anxious persons threat-related attentional biases become less adaptive, because in their case these stimuli continue to capture attention even if further processing indicates that they are irrelevant to the current goals or when they currently pose no realistic threat (Balgrove, Derrick, Watson, 2010).

The main objective of this thesis was to investigate in children and adolescents the effect of anxiety on attentional processes that occur in the presence of threatening stimuli. In pursuing this objective, we first took into consideration the assumptions put forward by the theoretical frameworks of anxiety and attention and secondly, we attempted to design our empirical studies in order to be able to formulate some answers to several important areas of controversies that have emerged after reviewing the empirical evidence reported in the literature regarding the relation between childhood anxiety and threat-related attentional biases.

Chapter 1. Anxiety and attentional processing

1.1 An information-processing framework on childhood anxiety

Information processing frameworks (Daleiden & Vasey, 1997; Pine, 2007) focus on the cognitive distortions (biases) that characterize childhood anxiety. Three types of cognitive distortions are believed to be relevant to pediatric anxiety: attentional biases (increased attentional allocation toward threat information), appraisal biases (the tendency of anxious individuals to classify non-threatening stimuli as threatening), and memory / learning biases (perturbations in recognizing safety signals or inhibiting fear responses when safety cues are present). As it can be seen, all these biases reflect exaggerated threat-related information processing. This increased threat processing can be observed at both neural and behavioral level. Moreover, these biases are hypothesized to interact at various stages of information processing to foster and maintain heightened anxiety. Specifically, it is assumed that attentional biases appear at an early stage of information processing and

they further support the development of other anxiety-related biases (Watts & Weems, 2006).

In sum, information processing models characterize pediatric anxiety, personality and temperamental traits associated with the risk for anxiety (high levels of trait anxiety, or temperamental predispositions such as high reactivity, behavioral inhibition) in terms of perturbations in the processing of threat-related information. All these perturbations have in common the failure to regulate threat-related information processing in contexts that are minimally threatening for most individuals.

As we mentioned earlier, in the present thesis, we will focus on the effects of individual differences in anxiety regarding the attentional processing of threat-related material. This is of particular interest given that attention mechanisms appear early in the flow of information and act as "gate-keepers", influencing which aspects of the environment are selected for processing and thus how the child experiences his or her social world (Perez-Edgar et al., 2011).

1.2 Attentional networks framework – a broader approach in studying anxiety and attention processes

In general, when referring to how anxiety impacts attention processes, cognitive theories of anxiety consider attention as a unitary system. We consider that the relation between anxiety and attention could be better understood if we acknowledge that attention is not a unitary system. Posner & Peterson (1990) have advanced the idea that there are three specific functionally and anatomically distinct attentional networks: alerting, orienting and executive control. These three networks are assumed to subserve different attentional functions (mechanisms).

Therefore, in the present thesis our approach was to use the attentional networks framework for both the analysis process of attentional biases literature and for the design of our empirical investigations. With regard to the attentional biases literature as it can be seen in the next section, we explored the theoretical assumptions of cognitive theories of anxiety regarding attention functioning and the data supporting these assumptions by looking how attentional networks (mechanisms) such as orienting and executive attention might be affected by anxiety when threatening information is present. In designing our empirical studies we employed different attentional paradigms in order to assess the functioning, in the presence of emotional information, of different attentional mechanisms in highly trait anxious children.

1.3 Theoretical models of anxiety and attention

Theoretical frameworks of anxiety and attention assume that hypervigilance to threat-related information is not simply a by-product of the anxious state but a significant contributor to the development and maintenance of anxiety disorders (Williams, Mathews & MacLeod, 1996). Regarding the attentional networks (mechanisms) that may underlie attentional biases towards threat these theoretical accounts can be divided into two subcategories: those postulating that in the presence of threatening stimuli anxiety affects the *orienting mechanism* of attention, specifically high anxious individuals will automatically orient their attention towards threat (Williams et al 1988; Beck & Clark, 1997; Mogg and Bradley, 1998) and; those assuming that attentional biases towards threat are the consequence

of more *voluntary attentional processes* such as impaired executive attentional control (Eysenck et al., 2007).

1.3.1 Theoretical perspectives of anxiety and attention orienting towards threat-related information

Williams et al. (1988) assume the existence of two mechanisms involved in stimulus processing: the affective decision mechanism (ADM) and the resource allocation mechanism (RAM). The main role of the ADM is to assess the threat value of incoming stimuli. If the stimulus is appraised as highly threatening, the RAM at an early stage of visual processing will orient the attentional resources towards that stimulus. According to this model, trait anxiety modulates the RAM; specifically high trait anxious individuals will orient their attention towards threat, whereas low trait anxious individuals will orient their attention away from threatening stimuli.

Another model put forward by Beck and Clark (1997) postulates that the orienting component of attention of anxious persons is highly sensitive to threat. Specifically, anxiety is associated with a greater tendency to orient resources towards threat-related information in the environment.

Mogg and Bradley's cognitive-motivational model (1998) suggests that attentional allocation towards threat is influenced by two systems: the valance evaluation system (VES) and a goal engagement system (GES). The former system is responsible for the initial, preconscious appraisal of stimulus valance and it is believed that anxiety influences the reactivity of this system, with a heightened sensitivity to threat in high trait anxious persons (Cisler & Koster, 2010). If a stimulus is assessed as threatening, the latter system (GES) will interrupt the ongoing activity and attention will be directed towards the threatening input. Another important specification of this model is that we can expect to find differences between anxious and non-anxious persons in relation to attention orienting towards threatening stimuli only in the case of mild threat value.

1.3.2 Theoretical perspectives of anxiety and impaired executive attentional control processes in the presence of threat-related information

The general feature of these models is their assumption that faster attentional processing of threatening stimuli is a consequence of impaired attentional control. Specifically, for high trait anxious persons is harder to activate and implement goal-directed processes or top-down attentional control such as inhibition and flexible attentional shifting in order to override their initial attentional biases towards threat. Referring to Posner's & Peterson (1990) framework of attention we can see these impairments in attentional control processes in anxious persons as reflecting impoverished functioning of executive control network. Therefore, in this section we are going to outline the theories of anxiety and attention that have emphasized the idea that anxiety impairs executive control network.

Attentional control theory (ACT) is a recent theoretical framework developed to understand attention in anxiety. This theory predicts that anxiety has an impact on the ability to inhibit the processing of threatening stimuli in order to perform the task relevant to the individual's current goal. Putting it in different words, anxiety disrupts the balance between

stimulus-driven and goal-directed systems that govern the selection from the environment of the task-relevant input. Also, it is important to mention that Eysenck et al., (2007) pointed out that anxiety affects attentional control processes irrespective of whether a threat-related stimulus was present or absent. However, the impairment of attentional control processes should be more evident when the anxious individual is confronted with threat-related material during contexts that place demands on goal-directed resources, namely tasks that tax executive attentional processes or working memory resources.

A close related hypothesis to the idea of impaired attentional control is the one postulated by Fox and her collaborators regarding the difficulty of anxious persons to disengage attentional resources form threat (Fox et al., 2001, 2002). Specifically, these researchers proposed that threat stimuli do not influence the initial orienting in anxious individuals. Instead, anxious individuals will present delayed disengagement from threatening stimuli. Delayed disengagement can be regarded as a consequence of failing to inhibit the processing of threat-related information. Accordingly, attentional control might be seen as a higher-order regulatory mechanism controlling the lower-order mechanisms of attention such as orienting and disengagement.

Another model of attentional biases that focuses on controlled, voluntary attention is Matthews & Mackintosh's (1999) model that is based on an automatic threat evaluation system (TES) but also acknowledges the role of controlled processing. TES is involved in the evaluation of stimulus input and the output of this system feeds into a distracter / threat representation. The interference caused by threat distracter representation might be overcome in attentionally demanding tasks by voluntary, controlled attentional processing aimed at attending task-relevant information and strengthening their representations (Cisler & Koster, 2010). Therefore, it is assumed that voluntary effort elicited by the main task demands can override interference from threatening irrelevant information.

Lonigan et al al.'s (2004) model suggests that there are individual differences in attentional control within an anxious population. According to this view, attentional control is seen as a self-regulative temperamental trait that can be used to override the tendency of anxious persons to orient their attention towards threat. Therefore, the prediction of this model is that only a subset of the anxious persons will manifest impaired attentional control processes in the presence of threatening information. Furthermore, this model emphasizes that there is an important interaction between self-regulative temperamental traits such as attentional control and reactive temperamental traits such as negative affectivity that further shape a person predisposition to orient attention towards threat information and to develop anxiety disorders. Thus, this model has been advanced within developmental psychopathology perspective and is seen as a general framework that tries to explain the acquisition of threat-related attentional biases and anxiety.

Chapter 2. Temperamental factors associated with the development of attentional processing biases and anxiety

There are many different theoretical approaches to the study of temperament (e.g. Kagan, 1999; Rothbart, 2000; Thomas & Chess, 1977) but in general this construct has been viewed as a reflection of innate individual differences in the manner in which one reacts to environmental stimuli and how one regulates this reactivity (White, Helfinstein & Fox, 2010).

High levels of reactive temperamental traits (e.g. behavioral inhibition, negative affectivity) are thought to make children to be prone to threat-related information and heightened rates of anxiety disorders.

Kagan's (1999) temperamental construct of *behavioral inhibition* (BI) refers to inborn tendencies of some children to respond with restraint, caution and withdrawal in the face of novel events or situations including unfamiliar contexts, toys, peers, and adults (Edgar, & Fox, 2005; Muris, Meesters, & Blijlevens 2007). BI was associated specifically with social anxiety (Biderman et al. 2001; Schwartz, Snidman, & Kagan, 1999). Despite the strong link between BI and the development of anxiety disorders, only a subset of inhibited children go on to develop anxiety disorders (Perez-Edgar et al., 2011). One factor that is thought to be involved in the transition from the vulnerability to clinical levels of anxiety is attentional processing of threat-related information.

Another reactive temperamental trait that has been related to acquisition of attentional processing biases and anxiety is negative affectivity. This temperamental trait is conceptualized as a general propensity to experience negative emotions such as fear, sadness, hostility, frustration in response to negative stimuli (Clark & Watson, 1991). According to Rothbart's theory (1991) of temperament that postulates two major dimensions of temperament, namely reactivity and self-regulation, negative affectivity is a subordinate factor of the reactive dimension of temperament. It is important to stress that negative affectivity consists of various lower-order traits, such as fear, frustration, sadness, and discomfort (Rothbart, 2007).

Studies that have analyzed negative affect in relation to childhood anxiety demonstrated that various lower-order traits predict the type of psychological symptoms (internalizing problems versus externalizing problems) children eventually come to experience. Also of central importance are the interactions between negative affect and other temperamental factors (effortful control, extraversion) for developing a predisposition to experience anxiety disorders (Anthony, Lonigan, Hooe, & Philips, 2002; Eisenberg, Cumberland, & Spinard, 2001).

We consider that in order to gain a better understanding of the relation between negative affect and the development of anxiety, researchers should focus on lower-order traits of negative affect, such as fear. Temperamental fearfulness refers to the tendency to experience unpleasant affect related to anticipation of distress (Ellis & Rothbart, 2001).

Regarding the relation between NA and attention bias towards threat it is predicted that children with high levels of NA such as fearfulness are vulnerable to show increased attentional orienting towards threatening information (Lonigan & Vasey, 2009).

In sum, all these aspects discussed above underline that one defining characteristic of reactive temperamental traits is hyper-vigilance towards threatening stimuli in the environment and this perturbation in attentional processing of these stimuli may increase further the vulnerability to develop and maintain anxiety.

However, it appears that certain self-regulatory processes can help children with high levels of reactivity to regulate their tendency to orient attention toward threatening information. Self-regulation is a broad construct consisting of cognitive and behavioural

processes that allow individuals to maintain optimal levels of emotional, motivational, and cognitive arousal for social adaptation and / or accomplishing goals (Blair & Diamond, 2008; Eisenberg & Spinard, 2004). Researchers have studied self-regulation form a temperament-based or a cognitive / neural systems approach (Liew, in press). Therefore, research in the area of self regulation identifies two types of control: cognitive, termed executive function, and socioaffective, termed effortful control (MacDonald, 2008). Executive functions involve the ability to engage in deliberate, goal-directed thought and action via inhibitory control, attention shifting or cognitive flexibility, and working memory processes (Liew, in press; Diamond, Barnett, Thomas, & Munro, 2007). Effortful control (EC) involves the ‘’efficiency of executive attention, including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and to detect errors” (Rothbart & Bates, 2006). This temperamental-based trait consists of several subcomponents such as: attentional shifting (the ability to flexibly reallocate attention toward task-relevant stimuli) attentional focusing (the ability to maintain the focus of attention on task-relevant information), inhibitory control (the ability to inhibit and override dominant behaviours in favour of more appropriate subdominant behaviours) and activation control (the capacity to perform an action when there is a strong tendency to avoid it). Together attentional shifting and attentional focusing form the attentional control subcomponent of EC. From the definition of effortful control we can observe that Rothbart’s construct of effortful control is situated at the intersection of the temperament and executive functions, particularly executive attention (the ability to maintain continuity of behaviour in accordance with goals when conflicting responses are in competition), literatures. The emergence of effortful control is believed to be linked to anterior attention system and executive attention (Posner & Rothbart, 2007). Therefore, in Rothbart’s view attentional mechanisms and networks are central components of self-regulative temperamental trait of effortful control. Furthermore, both effortful control and executive attention involve a common brain network consisting of frontal structures such as anterior cingulate and lateral prefrontal cortex. Neuroimagining studies showed that the dorsal side of the anterior cingulate was found to be activated in cognitive conflict tasks such as Stroop task and the ventral side of the anterior cingulate was found to be activated by emotional tasks and emotional states (Bush, Luu, & Posner, 2000).

Developmentally, even though effortful control begins to emerge towards the end of the first year of life, studies using fMRI indicate that executive attention reaches adult level of precision only in the end of adolescence (Luna, Padmanabhan, O’Hearn, 2010).

The importance of EC comes from multiple child outcomes that seem to be influenced by this self-regulative temperamental trait. The focus of the present analysis will be on the role EC plays in the manifestation of threat-related attentional biases and anxiety like symptoms.

Higher levels of EC have been linked to fewer internalizing emotional problems such as anxiety and depression (Muris, Mayer, & Hofman, 2008). However, despite this negative association that was found between the broad temperamental dimension of EC and psychopathology, recent data pointed that components underlying effortful control such as attentional control (attentional shifting and attentional focusing) and inhibitory control when examined separately, likely contribute to the regulation of negative emotional states (e.g. anxiety) in distinct ways (White, McDermott, Degnan, Henderson, & Fox, 2011). For example, while high levels of attentional shifting may serve as a resilience factor against anxiety symptoms for children high in behavioural inhibition, high levels of inhibitory control may serve as a risk factor for these children (White et al. 2011).

Additionally, the importance of studying subcomponents of EC in relation to risk for psychopathology comes from a number of studies with children and adolescent samples that have investigated the relation between attentional control and anxiety disorder symptoms. All

these studies were correlational and relied on samples with non- clinical levels of anxiety and there are at least two conclusions relevant for the present analysis that can be drawn from this line of research: 1) low levels of attentional control are associated with high levels of anxiety symptoms; 2) attentional control makes independent contributions to children's level of anxiety symptoms

With regard to the relation between EC and attentional biases toward threat-related information, previous research has shown that children with fearful temperament that exhibit high levels of EC did not show the bias to allocate their attention toward threat stimuli (Lonigan & Vasey, 2009). However, there are few studies that have investigated the impact of subcomponents of EC on attentional biases toward threat (see Helzer, Smith, & Reed, 2009).

In summary, all these aspects mentioned in this section regarding the temperamental factors associated with the acquisition of threat-related attentional biases and anxiety emphasize on the one hand, the importance to consider both the reactive and self-regulative aspects of temperament and on the other hand to go beyond the broad dimension of NA or EC and to focus on their subcomponents when examining the relation between temperament, attention to threat and anxiety.

Chapter 3. Empirical evidence for attentional processing of threat-related information in childhood anxiety

In this chapter, we review the empirical evidence for attentional biases towards threat in anxious children, and the challenges raised by this evidence.

3.1 Empirical evidence for attention orienting toward threat information in anxious children

The evidence for fast attention orienting towards threat in anxious children tends to be considerably less consistent than in adults. In anxious children, indices of initial orienting to threat in preference to neutral stimuli have been typically investigated using the dot-probe paradigm. This task involves the simultaneous presentation of two stimuli on a computer screen, one emotional (positive or threatening) and the other one neutral. Following a brief stimulus presentation (e.g. 500 ms) the stimuli disappear and a probe appears in a location previously occupied by one of the stimuli. Participants are required to indicate the location of the probe (e.g. left or right). The rationale underling this task is that anxious persons compared with nonanxious ones will be significantly faster to respond to probes that replace the threatening stimulus from the pair in comparison with probes that replace the neutral stimulus. It is important to note that in the dot-probe literature the effect mentioned above (shorter reaction times for the dot replacing the threatening stimulus compared to the dot replacing the neutral stimulus) has been considered to reflect vigilance towards threat and it has been used interchangeably with selective attention or attention orienting. In contrast, slower reaction times when the probe replaces the threatening stimulus compared with when the probe replaces the neutral stimulus has been argued to reflect threat avoidance or a tendency to orient attention away from threat (MacLeod, Mathews, & Tata, 1986).

Studies showing that either subclinical levels of anxiety (Vasey, Elhag, &, Daleiden, 1996) or anxiety disorders (Vasey et al., 1995; Taghavi et al., 1999; Dalgleish et al., 2001) are

associated with attention orienting to threat have mostly sampled older children (9-19 years) and used in the dot-probe word stimuli.

In contrast, evidence of attention orienting to emotional faces and evidence coming from studies that have included children from a younger age range are currently mixed. For example, some studies reported that clinically anxious children oriented their attention away from angry faces (Pine et al., 2005; Monk et al., 2008). Yet, other data indicate that children with anxiety disorders show the same vigilance towards all emotional stimuli (e.g. positive stimuli), not just towards the negative, threatening ones (Boyer et al., 2006; Waters et al., 2008).

Moreover, studies investigating non-clinical anxiety in samples of children of different ages reveal several other challenging results. Attentional biases seem to be present at all levels of trait anxiety, both in the presence and absence of non-clinical symptoms of anxiety at young ages (Kindt, Bogels, & Morren, 2003; Morren, Kindt, van den Hout, & van Kasteren, 2003; Waters, Lipp, & Spence, 2004). Kindt et al. (2003) hypothesize that at an early age (under 9 or 10 years of age) all children are biased to selectively attend to threat, but as they develop their inhibitory control only the high anxious ones preserve these biases at older ages, into adolescence and probably adulthood (Kindt et al., 2003; Kindt & Van Den Hout, 2001; Kindt, van den Hout, de Jong, & Hoekzema, 2000). Also, studies on children with non-clinical anxiety report a rather weak association between anxiety level and attentional biases (Telzer et al., 2008).

Taken together, these diverging findings on attention orienting to threat in anxious children raise the need on the one hand, to investigate, besides anxiety, other potential factors that might influence initial orienting to threat and on the other hand, to explore possible variables that might moderate the relation between attention orienting to threat and childhood anxiety.

3.2 Empirical evidence for the impact of childhood anxiety on attentional control processes

With respect to the effect of childhood anxiety on attentional control processes in the presence of threatening material the very few studies that have been reported in the literature varied enormously in the way they defined and measured attentional control.

The most commonly employed paradigm for assessing attentional control processes in the context of emotional information in anxious children is the emotional Stroop task. Performance on this task is thought to reflect the attempts to inhibit the processing of distracting word or picture information, while maintaining attention on the colour of the word or on the colour of a picture, such a face, displaying either a neutral or an angry expression.

Although findings from the emotional Stroop paradigm have been interpreted by some researchers as evidence for impaired attentional control in anxious children, it is unclear which attentional mechanisms are being taped by this paradigm. Also, in children this paradigm has shown a mixed set of results (Hadwin & Field, 2010). Specifically, some studies reported greater interference from threatening stimuli in clinically anxious children (Taghavi, Dalgleish, Moradi, Neshat-Doost, & Yule, 2003), in children with specific fears such as spider phobia (Martin & Jones, 1995) and in adolescents with elevated levels of trait anxiety (Richards, 2000). Other findings suggest that Stroop interference from threatening stimuli occurs in both anxious and nonanxious children (Eschenbeck et al., 2004). Also, there are studies that failed to find Stroop interference for both anxious and nonanxious children (Kindt, Bogles & Morren, 2003).

Moreover, other studies have used behavioural inhibition tasks such as emotional Go/No Go task (Waters & Valvoi, 2009; Landouceur et al., 2006) or tasks that loaded

working memory capacity (Ladouceur et al., 2009) for the assessment of attentional control processes. Although we agree with the idea that a task is never a pure measure of any underlying construct (Astle & Scerif, 2009) we believe that, these tasks employed by the past researches in order to investigate the ability to control attention in the presence of threat stimuli, were unable to distinguish whether anxiety in the presence of threat is associated with impaired ability to inhibit, filter out these stimuli or / and with an impaired ability to flexible shift attention in accordance to task requirements.

In summary, although there is evidence to indicate that both subclinical anxiety and clinical anxiety are associated in the presence of threat information with faster attention orienting towards threat and with impaired attentional control, it is clear that there are inconsistencies in the available data. Therefore, there is a clear need on the one hand, to search for other factors (predictors) that might influence threat-related attentional processing and on the other hand, to use more sensitive methodological tools for the assessment of threat-related attentional processing in order to be able to differentiate between varied attentional mechanisms.

3.3 Developmental sequence of the attention-anxiety relation

Longitudinal work reported in the literature has focused exclusively on the relation between attention orienting toward threat and anxiety. The objectives of these studies were as follow: first, to analyze whether attention shapes the trajectory of anxious behaviour and second to investigate whether anxious behaviour in early development might show different relation with attention, measured concurrently, as opposed to later in development (Shechner et al., 2011).

Regarding the first objectives there is empirical evidence proving that behaviourally inhibited preschoolers who oriented their attention toward threat on the dot-probe task showed more stable forms of social withdrawal than behaviourally inhibited preschoolers who did not orient toward threat (Perez-Edgar et al., 2011).

With respect to whether anxious behaviour (e.g. behavioural inhibition) shows different relation with attention during development it was found that the relation between behavioural inhibition and orienting changed as children mature (Perez-Edgar et al. 2010; Perez-Edgar et al., 2011). Specifically, although attention orienting toward threat modulated association between behaviour inhibition and anxiety, before school age, there was no direct relation between behavioural inhibition and threat-related attention orienting. However, early inhibition predicted threat orienting in adolescence. Thus, this pattern of results proves that age influences anxiety-attention associations.

3.4 Neural correlates of biased attentional processing of threat in anxiety

Imagining studies regarding attentional biases in anxiety seek the neural mechanisms underlying biased attentional processing of threat-related information. The majority of these studies because they analyzed the neural concomitants of attention orienting were conducted on dot-probe performance (Britton et al., in press).

In the next section we will provide a brief review of the studies that have examined, particularly in children, the neural correlates of attention orienting toward threatening information.

3.4.1 Neural correlates of attention orienting toward threatening information in anxious children

Imagining studies analyzing in children the relation between anxiety and attention orienting toward threat-related material have only recently begun to emerge. As we already mentioned above, the dot-probe paradigm was commonly used by these studies in order to measure biased attention orienting toward threatening stimuli and the ERP or fMRI were used to index brain activity.

In general, findings suggest that short presentation of threat may be processed by the rapid thalamo-amygdala pathway. Thus, in the context of a short exposure to threatening information it was showed that adolescents with clinically levels of anxiety exhibited greater amygdala activation compared to non-anxious adolescents (Monk et al., 2008). In contrast, longer exposure to threat may allow the cortical structures such as ventrolateral prefrontal cortex (PFC) to facilitate emotional regulation. In this context, studies revealed that adolescents with generalized anxiety disorder (GAD) had greater ventrolateral PFC activation (VLPFC) than non-anxious adolescents. No between groups differences emerged in amygdala activation (Monk et al. 2006; Britton et al. in press). Moreover, anxiety severity and VLPFC activation were negatively correlated.

Although, the results summarized above need further replication, we can speculate that the extent to which cortical structures are effectively engaged may track the ability to down-regulate hyper-responsivity of the amygdala and the severity of anxiety (Perez-Edgar & Bar-Haim, 2010).

3.4.2 The neural correlates of attentional control processes in anxiety

On the neuronal level, the link between anxiety and the recruitment of attentional control processes in the presence of threat was under - investigated and the available studies were conducted mostly with adults and revealed a mixed picture.

Specifically, while some studies reported an increased recruitment of neural control mechanisms (e.g. Ansari & Derakshan, 2011) others reported reduced activation in prefrontal areas associated with attentional control processes (e.g. Bishop, 2009; Klumpp et al, 2011). For example, Ansari & Derakshan (2011) investigated the neural correlates of cognitive effort during pre-target preparation in trait anxiety using mixed antisaccade task, with emotionally neutral stimuli, that manipulated the interval between offset of instructional cue and onset of the target (CTI interval). Neural correlates of cognitive effort were assessed using ERP, namely by examining slow-wave cortical potentials. The results demonstrated that high trait anxious individuals presented greater cognitive effort compared to low-anxious individuals as indexed by frontal EEG activity during medium and long CTI interval. Moreover, at the behavioural level, when there was time to prepare the correct response (medium and long interval between cue and target onset) there were no group differences in either RTs or accuracy. Thus, these results indicate that during a neutral attentional task when cognitive resources are available for effortful processing, high-anxious individuals can achieve, by using greater cognitive resources than non-anxious persons, performance that is comparable to the low-anxious individuals. However, Klumpp et al. (2011) investigated in adults the relation between trait anxiety and anterior cingulated cortex (ACC) activation in response to interference from threat-related distracters. This finding showed that a high level of trait

anxiety was associated with reduced ACC activation which was discussed in terms of diminished top-down attentional control capacity in relation to threatening distracters. Moreover, a similar pattern of results were revealed by Bishop (2009) that found reduced activation of dorsolateral prefrontal (DLPFC) in highly anxious individuals during an emotionally neutral attentional task.

Overall, in the light of all these empirical studies we can conclude that there is a clear need to conduct future studies, especially using emotional information, in order to have a clearer picture about the nature of neural mechanisms associated with the deficit of attentional control processes in anxiety. Furthermore, it would be important to investigate in anxiety the time course of attentional control recruitment since there are recent data (Osinsky, Alexander, Gebhardt, & Hennig, 2010) showing that trait anxiety influence the dynamic adjustments of attentional control processes (e.g. how anxiety influence the adjustment of attentional control from trial to trial during an attentional task).

Chapter 4. General overview and main objectives of the present thesis

Within the three chapters summarized above we have presented on the one hand, the theoretical frameworks of anxiety and attention and on the other hand, the temperamental traits associated with acquisition of biased attentional processing of threatening information and anxiety. Moreover, we have reviewed empirical evidence for attentional processing of threat-related information in childhood anxiety. In the following chapters (5, 6, 7) we conducted three empirical studies in order to attempt to provide some answers to the highlighted issues and controversies that were reviewed above regarding both the automatic orienting mechanism and the effortful attentional control mechanisms that underline attentional biases phenomenon.

There are several characteristics of the present thesis that should be highlighted. First, we chose to investigate our research objectives with children aged 9-14. We decided upon this age group based on previous studies with children that have demonstrated a more robust effect of anxiety-specific biases in older children (9 to 14 years of age) compared to younger children (under 9 or 10 years of age) who might manifest attentional biases towards threat regardless of the anxiety level (Kindt, Bogels, & Morren, 2003; Kindt & Van Den Hout, 2001). Secondly, we studied non-clinical anxiety by selecting children from the general population based on self-report measure of trait anxiety. We chose to investigate attentional processes in the context of non-clinical samples because we were interested in vulnerability and protective mechanisms implicated in anxiety. We consider that when researching these mechanisms in clinical samples it is more difficult to establish whether they acted prior to the development of the anxiety disorder or are part of the symptoms. Thirdly, we attempted to go beyond the broad concept of attentional biases and to guide our theoretical and empirical approach by distinguishing different attentional mechanisms that might underlie the preferential processing of threat in anxiety.

In relation to attention orienting mechanism, it is argued in this thesis that temperamental factors might predispose children to manifest hypervigilance to threat-related information (Study 1). Specifically, higher levels of temperamental traits involving sensitivity towards threat (e.g., negative affectivity, behavioural inhibition) in conjunction with lower levels of regulative temperamental traits such as effortful control are considered to be one of the factors that can make children probe to allocate their attention towards threatening information (Lonigan, Vasey, Phillips, & Hazen, 2004). Moreover, according to this view,

regulative temperamental traits (effortful control) can be regarded as variables that moderate the relation between attention orienting to threat and anxiety.

Therefore, in *study 1 (Chapter 5)* we investigated on the one hand, the impact of reactive and regulative temperamental traits on attention orienting towards threat-related information (attentional biases) and on the other hand, we analyzed whether self-regulative temperamental trait of attentional control might moderate the relation between attentional biases and anxiety symptoms. We chose Rothbart's model for the assessment of temperamental traits and for the generation of our empirical hypothesis regarding the relation between temperament, attentional biases and anxiety.

With respect to the relation between anxiety and attentional control it is important to mention that in this thesis our intention was to study the concept of attentional control from a temperamental based approach and from a cognitive approach. From a temperamental based approach we were interested in assessing individual differences in attentional control via temperament questionnaire and to analyze whether these differences may modulate any observed effects of anxiety on attentional processing in the presence of threatening information. From a cognitive approach we were interested in assessing, using cognitive tasks, (see Study 2 – Chapter 6 and Study 3 – Chapter 7) the impact of anxiety on the efficiency of executive attentional control processes / mechanisms (inhibition and attentional shifting), in the presence of threatening stimuli. Therefore, we argued that presenting task-irrelevant threatening stimuli in attentional tasks that distinguish between different attentional control processes would allow us to investigate whether anxiety impairs, in the context of threatening distracters, inhibition and attentional shifting.

Thus, as far as attentional control is concerned, in *Study 2* we used an emotional version of the visual search task in order to investigate in middle childhood the effects of high levels of trait anxiety on ability to inhibit the processing of threatening distracters. In other words, our aim was to analyze whether children with higher levels of trait anxiety manifest greater attentional distractibility from angry faces.

Study 3 aimed to further establish the effects of anxiety on attentional control processes in the context of threatening distracters. In order to pursue this goal we developed an attentional task that engaged and imposed a load on the attentional control processes (attentional shifting and inhibition). While performing this main task, simultaneously we displayed emotional faces that were completely irrelevant for the main task. In conducting this study we assumed that in the contexts that place demands on goal-directed attentional resources, namely a task that taxes inhibition and attentional shifting, anxious children are predicted to show greater performance deficits for the main task in the presence of threatening distracters. This effect might be possible because both the ability to filter out threatening distracters and the ability to perform an attentional demanding task engage common-pool resources (e.g. prefrontal neural structures from the anterior attentional system).

Chapter 5. Study 1: Temperament, attention orienting to threat and anxiety symptoms in children

In the present chapter we investigated the effects of individual differences in fearful temperament and attentional control on attention allocation toward threat. Furthermore, we were also interested in determining whether attention orienting to threatening information have a unique contributory influence on childhood anxiety, and whether individual differences in attentional control might modulate this relation.

5.1 Introduction

Most of the research in this domain has been conducted in adults. Among adults, evidence seems to indicate that the tendency to orient attention towards threatening information may play an important role in anxiety disorders as well as in subclinical levels of anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

Research on childhood anxiety has also begun to examine the association between attentional biases toward threat and anxiety. Although there is evidence for threat-related attentional biases in anxious children, several studies reported challenging results. For example, some studies found evidence for attentional biases towards threat (e.g. Roy, et al., 2008), while others found a pattern of attentional avoidance in relation with threatening stimuli (e.g. Monk, et al., 2006). Furthermore, some studies revealed that attentional biases are present in both anxious and nonanxious children (e.g. Eschenbeck, Kohlmann, Heim-Dreger, Koller, & Leser, 2004), whereas in other studies, attentional biases toward threat were limited to children who were clinically diagnosed with anxiety disorders (Roy et al., 2008). Also, there is some evidence that anxious children manifest attentional biases for both positive (happy faces) and threatening stimuli (angry faces).

These diverging findings on threat-related attentional biases in children and the question related to the role of these biases in the onset and maintenance of clinical anxiety have recently encouraged developmental perspectives to look at the potential routes through which these biases toward threat emerge in children. One theoretical position suggests that temperamental factors might predispose children to manifest attentional biases toward threat (Pine, Helfinstein, Bar-Haim, Nelson, & Fox, 2009).

5.1.1 Temperament and attentional biases

Lonigan, Vasey, Phillips, Hazen (2004) advanced a model which assumes that temperamental factors are associated with the acquisition of attentional biases. Specifically, temperamental traits involving sensitivity towards threat (e.g., negative affectivity, behavioral inhibition) are considered to be one of the factors that can make children prone to allocate their attention towards threatening information (Helzer, Connor- Smith, & Reed, 2009). Therefore, according to this position, attentional biases are expected to emerge early in life in children born with an underlying anxiety predisposition such as high levels of negative affectivity, and to play a mediating role in the relation between temperament and the development of anxiety disorders.

To date, there are few studies that have specifically examined the link between temperament and attentional biases towards threat, but these initial results suggest that

children with fearful temperament - an important aspect of negative affectivity - tend to preferentially allocate their attention toward threat (White, Helfinstein & Fox, 2010). Moreover, in a recent study, Lonigan and Vasey (2009) used a dot probe task with neutral and threatening words and found that children with high levels of negative affectivity, a temperamental reactive factor associated with risk factors for anxiety disorders, and high levels of attentional control, did not show attention biases towards threatening words, while children with high levels of negative affectivity coupled with low attentional control presented vigilance towards these stimuli. These results highlight the importance of analyzing the role of regulative temperamental factors such as attentional control processes, given that attentional biases might be shaped by interactions between regulative and reactive temperamental traits.

However, children may vary in the extent to which they are able to use voluntary attention to control their tendency to prioritize threat information. Specifically, efficient attentional control processes may help fearful temperament children inhibit the processing of task-irrelevant information and focus on the task-relevant information in the environment (Pine et al., 2009). The temperamental trait of attentional control reflects individual differences in the ability to focus and shift attention and is related to children's capacity for self-regulation (Simonds, Kieras, Rueda, & Rothbart, 2007). A critical function of attentional control reflects the ability to disengage attention from threatening irrelevant information and keep attention focused on task relevant stimuli. Therefore, regulative temperamental traits such as attentional control, might moderate the relation between reactive temperamental traits (e.g. fearful temperament) and attentional biases toward threat. High attentional control can enable children to override initial reactive attentional biases, and further to serve as a protective factor against the development of anxiety disorders (Vervoort et al., 2011).

We believe that investigating the relation between temperamental variables and the attention towards threat will provide important information about the mechanisms underlying the emergence of attentional biases. Moreover, such an approach can help to inform prevention strategies regarding children that are prone to develop anxiety disorders.

5.1.2 Impact of attentional biases on anxiety symptoms

Researchers have also looked into the assumption that attentional biases are an etiological factor for anxiety problems (for example: Schmidt, Richey, Buckener, & Timpano, 2009). Such studies show modifications in state anxiety and in emotional vulnerability to stress for participants who went through an attentional bias induction procedure (Clark, MacLeod, & Shirazee, 2008; See, MacLeod, & Bidle, 2009). More recently, studies have used the attentional training procedure to reduce attentional biases and negative emotions of participants. Results suggest the possibility of reducing anxious symptoms through such an attentional training procedure (Amir, Beard, Burns, & Bomyea, 2009; Schmidt et al., 2009).

This research is encouraging because it provides experimental evidence of a possible causal role of attentional biases to threat in the development of anxiety. However, there are few studies in both children and adult samples investigating the impact of attentional allocation on anxiety (Helzer, Connor-Smith & Reed, 2009; Watts & Weems, 2006). Determining if selective attention to threat information is linearly related to anxious symptoms in non-clinical samples is one of the first important steps in testing the hypothesis of attentional biases preceding anxiety disorders (Watts & Weems, 2006).

5.1.3 Attentional biases, individual differences in attentional control and anxiety in children

Lonigan, Vasey, Phillips, and Hazen (2004) proposed that the understanding of the connection between attentional biases and childhood anxiety can be enhanced by considering factors that might moderate this connection. Their model takes into consideration the temperamental trait of effortful control, discussed in developmental literature by Rothbart, Ahadi, and Evans (2000), and it suggests that attentional biases for threat can be seen in anxious children who have low effortful control. Effortful control is a self-regulatory trait including processes that can help children modulate their attentional and emotional reactivity (Rothbart & Ahadi, 1994). An important aspect of effortful control is attentional control, which pertains to the ability to flexibly focus and shift attention (Muris, Mayer, van Lint, & Hofman, 2008).

Prior studies investigating the moderating role of attentional control have typically framed the question as whether the interaction between anxiety and attentional control predicts attentional biases (for an exception see Helzer, Connor- Smith, & Reed, 2009).

Given on the one hand the prediction derived from the theoretical cognitive models of anxiety regarding the possible etiological role of attentional biases to threat for developing anxiety disorders, and on the other hand the potential clinical importance for prevention and intervention strategies, we consider important to frame the question of the moderating role of attentional control in terms of the interaction between attentional biases and attentional control in predicting anxiety symptoms.

Also, it might be useful to look for the possible moderator effect of attention control, as reflected by the interaction term between attentional biases and attentional control, owing to the fact that particularly with non-clinical samples some studies revealed weak or inconsistent results regarding the association between attention towards threat and anxiety. For example, some studies revealed that attentional biases are present in both anxious and nonanxious children (e.g. Eschenbeck, Kohlmann, Heim-Dreger, Koller, & Lesser, 2004). Also, studies on children with non-clinical anxiety report a rather weak association between anxiety level and attentional biases (Telzer et al., 2008), while others found a pattern of attentional avoidance in relation with threatening stimuli (e.g. Monk, et al., 2006). Therefore, understanding the connection between attentional biases and childhood anxiety can be enhanced by considering factors that might moderate this connection. For example, it might be shown that attention to threat has a negative impact (higher levels of anxiety symptoms) on some children (ex. those who have also low attentional control) and does not have on the others (those with high levels of attentional control).

5.1.4 The present study

Our main aim was to examine in children aged 9 to 14 the effects of individual differences in fearful temperament and attentional control processes on attention orienting towards threat. Of greatest interest was the interaction effect between fearful temperament and attentional control on attention orienting toward threatening information.

We were also interested to determine whether attention orienting to threatening information has a unique contributory influence on childhood anxiety, and whether individual differences in attentional control might modulate this relation.

Our hypotheses were the following: first, regarding the influence of fearful temperament we expected that children with higher levels of fearful temperament would show

enhanced attentional allocation toward angry faces, compared with low fearful children; second, based on research discussed previously regarding the role of individual differences in attentional control in modulating reactive attentional biases toward threat, we expected that attentional control might moderate the relation between fearful temperament and threat-related attentional biases. Specifically, our prediction was that we would find a significant association between fearful temperament and attentional biases toward angry faces in the case of children with low levels of attentional control. Third, previous results regarding attention allocation toward happy faces are mixed, some studies conducted in children and also in adults found a bias toward happy faces (Waters, et al., 2008), whereas others did not (Telzer et al., 2008). Therefore, the inclusion of happy-neutral trails was exploratory and we did not have any specific predictions regarding the direction of attentional processes for happy faces in children with different levels of fear and attentional control.

With respect to the impact of attention orienting to threatening information on anxiety symptoms we postulated that we will find a significant association between attention orienting toward threat and anxiety in children with low levels of temperamental attentional control.

5.2 Method

5.2.1 Participants

An initial sample of 185 school-aged children participated in this research. However data from only 163 children out of which 76 were girls were included in the final analysis as only these children had responded to all questionnaires and completed the computerized dot-probe task. The age range of the participants was between 9 years and one month and 13 years and 10 months (mean age = 137 months, *SD* = 15). We obtained written parental informed consent and verbal consent from each child before the testing. All children had normal or corrected vision and did not have a psychiatric diagnosis.

5.2.2 Measures

The questionnaires employed in this study were the fear subscale from the Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Ellis & Rothbart, 2001), the child version of the Attention Control Scale (ACS-C; Derryberry & Reed, 2002) and the Spence Child Anxiety Scale (SCAS; Spence, 1998).

The EATQ-R is a measure of temperament, self-regulation and behavioral problems designed to be used with 9- to- 15- year –old children and adolescents. We selected the fear subscale of this questionnaire to assess self-reported temperamental fear in children. The fear subscale reflects the tendency toward unpleasant anticipation of distress (Helzer, et al., 2009). Children are asked to rate each item on a 5 point Likert scale and assess with what frequency the item is true or false in their case. Some examples of items from the fear subscale of the EATQ-R are: “I worry about getting into trouble” or “I worry about my parent(s) dying or leaving me”. The EATQ-R has been adapted for use with Romanian children following these steps: a) the scale was translated from English into Romanian by an expert in the field of temperament and development; b) the Romanian translation was back translated to English by a different expert to verify that the original conceptual content has been preserved in the Romanian version; c) the Romanian translation of the EATQ-R was employed in a pilot study with children aged between 9 and 14 to verify that the language used was accessible to them.

In the present study we used only the fear subscale of EATQ-R and this subscale showed good internal consistency, α= .69 in our sample of children.

The ACS-C is a 20 item-scale measuring the children's ability to focus and shift attention when needed. Half of the items measure the focusing component of attention ("When I concentrate myself, I do not notice what is happening in the room around me") and the other half measure the shifting of attentional resources ("When I am doing something, I can easily stop and switch to some other task"). Children are asked how frequently certain things happen to them and they respond on a 4-point Likert scale. High scores on this scale indicate a good capacity of attentional control. Studies conducted with different populations report good internal consistency of the ACS-C (Muris, De Jong, & Engelen, 2004; Muris, Meesters, & Rompelberg, 2007). The ACS-C has been adapted for use with Romanian children following the same procedure described in the case of EATQ-R adaptation.

In the present study the ACS-C showed a good internal consistency as Cronbach's Alpha coefficient reached 0.80.

The SCAS is a 38 item-scale assessing a wide range of anxiety symptoms in children. This questionnaire asks children to rate how frequently they experience the situations described by each item using a 4 -point Likert scale: 1- Never, 2- Sometimes, 3- Often, and 4- Always. The SCAS offers a total score and subscale scores based on the anxiety disorders symptom clusters specified in the Diagnostic and Statistical Manual for Mental Disorders IV (American Psychiatric Association, 1994). The subscales assess separation anxiety, social anxiety, obsessive-compulsive disorder, panic and agoraphobia, physical injury fears, and generalized anxiety. The Romanian version of the SCAS is currently under validation (Benga, Tincas, Visu-Petra, Pitica, & Susa, in press). In the current study we obtained good internal consistency for the global scale. Cronbach's Alpha coefficient reached 0.85.

Attentional biases were measured with a dot-probe task following the guidelines offered by Mogg and Bradley in their studies (ex: Bradley, Mogg, Falla, & Hamilton, 1998). The dot-probe task consisted of a series of trials appearing on the computer screen, each trial with 4 sequential events: the fixation point in the center of the screen for 500 milliseconds, a pair of pictures showing human facial expressions for 500 milliseconds, the probe (in this case shaped as a black star) taking the place of one of the pictures and a blank white screen as a pause for 500 milliseconds. The probe was displayed on the screen until a response was made. The picture pairs were positioned horizontally at equal distances from the fixation point and participants were instructed to press key A when the probe took the place of the picture on the left side of the screen and key L when the probe took the place of the picture on the right side of the screen.

The stimuli were 64 images of facial expressions selected from a pool of 96 images from the following image sets: 22 from the NimStim (Tottenham et al., 2009), 5 from the Ekman stimuli set (Ekman & Friesen, 1976) and 37 from the stimuli developed by Mogg and Bradley (Bradley et al. 1998). Such a combination of stimuli from different sets was needed due to the fact that Romanian children are familiar mostly with Caucasian faces therefore it was important to have a set of 64 pictures of Caucasian persons. All images were edited in order to be on a grey scale, with similar levels of brightness and contrast and to have the same size (270 x 400 pixels). The experimental block of the task consisted in 160 trials.

The practice phase consisted of 8 trials. In this phase pictures representing neutral objects from the IAPS (Lang, Bradley, & Cuthbert, 2005) were used.

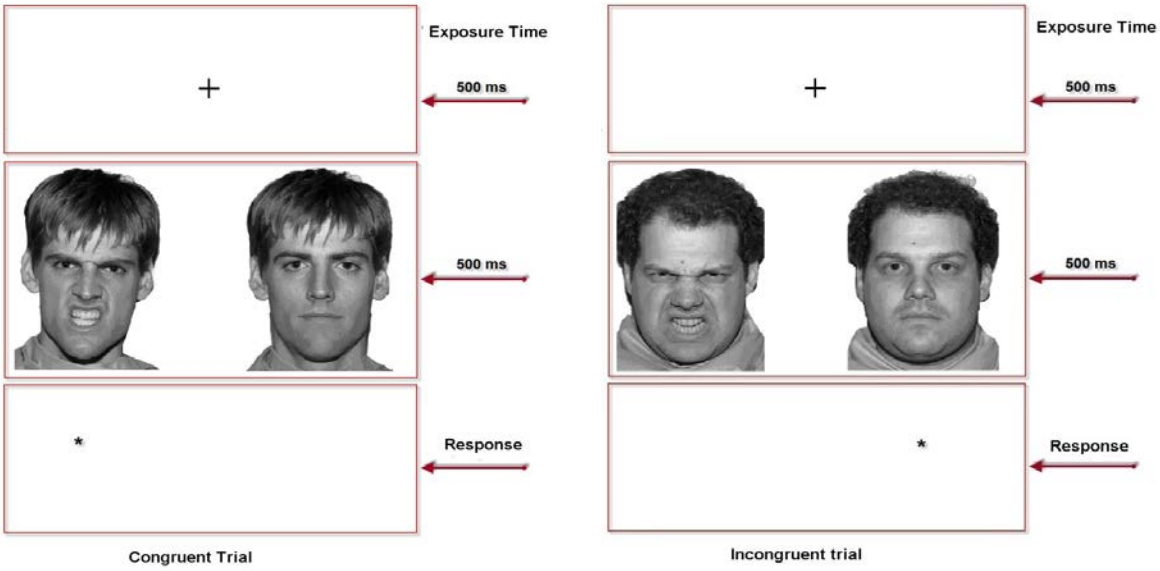


Figure 1 Events during a dot-probe trial with neutral-angry faces pairs

5.2.3 Procedure

Data from both the questionnaires and the dot-probe task was collected from two schools. Children completed first the three questionnaires. The dot-probe task was completed at a 2 weeks interval. The computerized task was carried out with each child, individually, in a separate room. The task took 20 minutes on average.

5.3 Results

5.3.1 Main analysis for the effect of temperamental traits on attention orienting to angry and happy faces

As we opted to calculate bias scores separately for angry-neutral and happy-neutral pairs we also chose to conduct separate analyses with these two dependent variables.

5.3.1.1 Angry bias scores

Analysis of covariance

As our hypotheses are concerned with differences between groups we conducted an ANCOVA with attentional bias scores for the angry-neutral stimuli pairs as dependent variable, Fear and Attentional Control levels as between-subject factors and Age (in months) and Anxiety as covariates. Results indicated a significant interaction effect of Fear and Attentional Control levels on bias scores, $F(3,157) = 5.58$, $p = .01$, partial $\eta^2 = .03$. No main effects of Fear, $F(3, 157) = 1.22$, *ns*., Attentional Control, $F(3, 157) = .05$, *ns*., Age, $F(3, 157) = .002$, *ns*., or Anxiety, $F(3, 157) = .20$, *ns*., reached significance. As such, highly fearful children who also have high levels of attentional control seem to have weaker attentional biases related towards threat compared to highly fearful children with low levels of attentional control.

Interestingly, as it can be seen from Figure 2, high levels of attentional control and high levels of fear seem to be associated with a tendency to avoid threat, whereas low levels of attentional control and high levels of fear are associated with a strong vigilance for threat.

We also ran several one-sample t tests in order to compare bias scores for each group to 0. When bias scores are significantly different from 0 they indicate a clear attentional bias. For the low fear, low attentional control group the mean bias score was significantly different from 0, $t(40)=1.98$, $p=0.05$. The same was true for the high fear, low attentional control group, $t(45)=1.78$, $p=0.05$. In the low fear, high attentional control group the mean bias score was not significantly different from 0, $t(53)=0.04$, *ns.* Also, the mean bias score did not significantly differ from 0 in the high fear, high attentional control groups, $t(24)=0.24$, *ns*. Consequently, attentional biases appear to be present in the two groups of children that have low attentional control, at both high and low levels of fear. Specifically, children with high fear and low attentional control are significantly vigilant towards angry faces, whereas children with low fear and low attentional control present a significant attentional avoidance of angry faces. Children high in attentional control, with either low or high levels of fear, are not significantly biased in their attentional responses when confronted with an angry face. Therefore, the observed tendency of children with high levels of fear and attentional control to avoid angry faces (see Figure 2) is not a significant one.

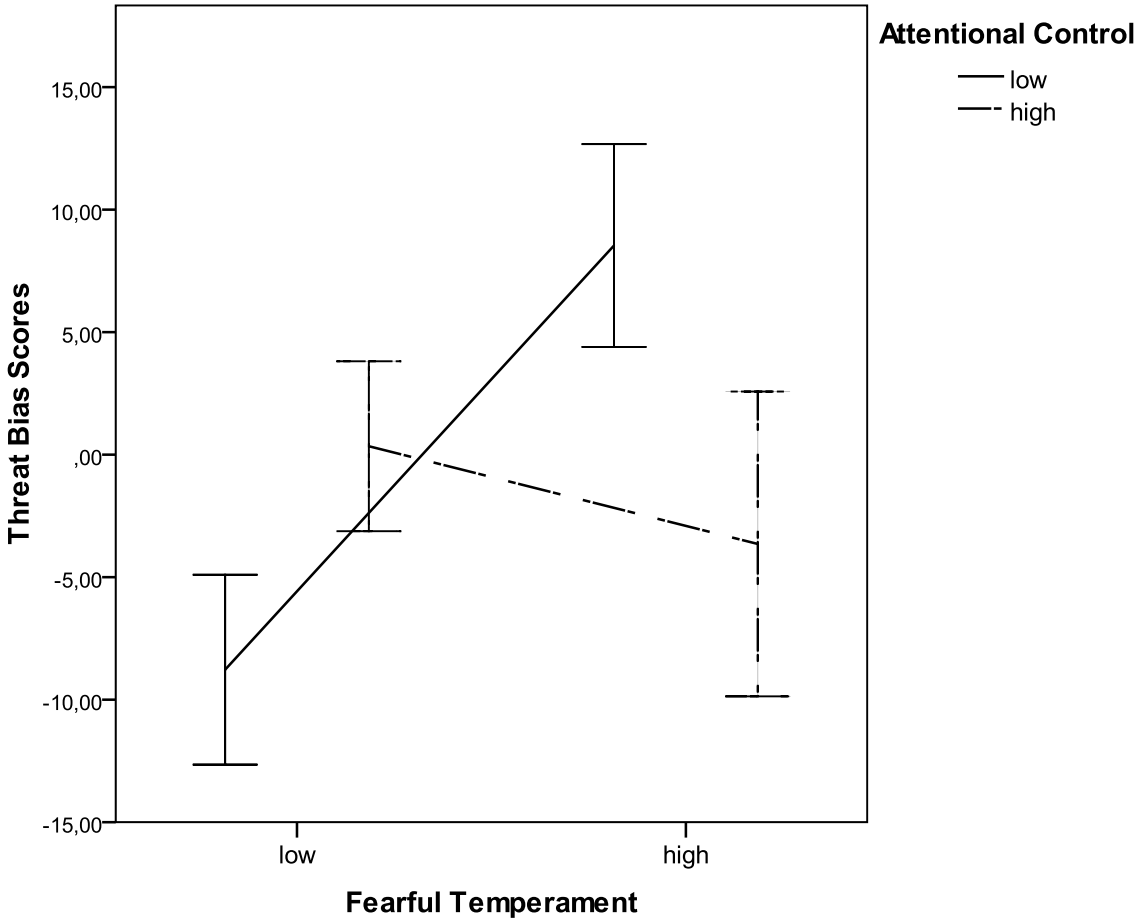


Figure 2. Interaction effect of fearful temperament and attentional control on threat bias scores

Regression analysis

Because both attentional control and fearful temperament were measured on a continuous scale we conducted an additional analysis based on hierarchical regression, in order to test the interaction between fearful temperament and attentional control in predicting attentional biases towards angry faces. In addition, another potential difficulty in using ANCOVA arises from the use of correlated fearful and attentional control measures (r = - .30 in this sample), which may lead to inflated ANCOVA interaction if dichotomous groups are formed through median splits (Derryberry & Reed, 2002).

Therefore, hierarchical regression has the advantage of overcoming the problems of dichotomization of continuous variables based on median split procedures (Cohen, Cohen, West, & Aiken, 2003). Following Aiken & West (1991) guidelines all variables (Fearful temperament, Attentional control and Anxiety) were first centered and the interaction term (Fearful temperament x Attentional control) was computed as the multiplicative product of these two centered variables. Fearful temperament was first entered. Anxiety was entered in the second step, followed by the Attentional control in the third step. The interaction term was entered in the forth step.

Consistent with the results from ANCOVA, this analysis yielded a significant Fearful temperament x Attentional control interaction on step forth (b = -1.37, p=.01). However, steps 1-4 were not significant (all ps > .05). We examined the particular form of this interaction by plotting the regression of threat bias scores on fearful temperament at high (one standard deviation above the mean), medium, and low (one standard deviation below the mean) levels of fearful temperament and attentional control. As shown in Figure 3, the slope was significantly different from zero only at low levels of attentional control, $t(154) = 2.73$, $p < .01$. More specifically, there was a significant positive association between fearful temperament and attentional biases towards angry faces only for children with low attentional control. At high or medium values the slopes were not significantly different from zero, $t(154) = -.55$, $p = .57$ and $t(154) = 1.63$, $p = .10$. These results indicate that there is no significant relation between fearful temperament and attentional vigilance towards threatening stimuli for children with good ability to control their attention allocation.

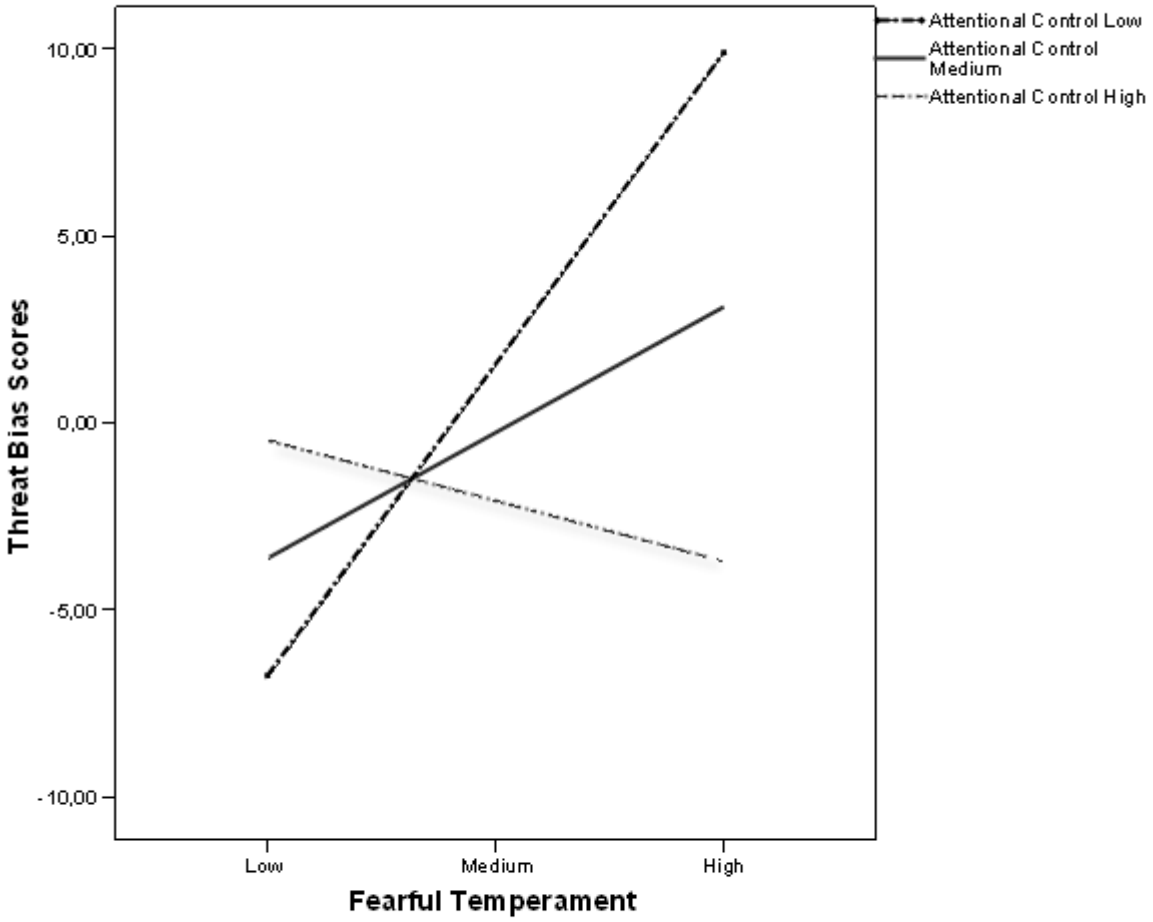


Figure 3: The regression of threat bias scores on fearful temperament and attentional control

5.3.1.2 Happy bias scores

Analysis of covariance

In order to control for the possible effect of emotionality in general in the dot-probe task we conducted a second ANCOVA for the happy-neutral trials. We looked for possible effects of Fear and Attentional Control on bias scores for the happy-neutral stimuli, also controlling for the effects of Age and Anxiety. Results indicated no main effect of Fear, $F(3, 157) = .004$, *ns*., Attentional Control, $F(3, 157) = 2.99$, *ns*., and no interaction effect, $F(3, 157) = .23$, *ns*. Also, the effects of Age $F(3, 157) = .19$, *ns*., and Anxiety $F(3, 157) = .24$, *ns*., did not reach significance. Therefore, it seems that the relation between fear, attentional control and attentional biases is specific to angry faces.

Regression analysis

As for the angry-neutral trials we also conducted an additional hierarchical regression analysis in order to investigate the effect of temperamental variables on attention allocation towards happy faces.

Consistent with the results from ANCOVA, no significant results were found for fear (b = 2.81, p= .41), attentional control (b = - .30, p=.52), or interaction term (Fearful temperament x Attentional control b = .70, p=.21) in explaining attentional biases towards happy faces.

5.4 Analyses for individual differences in attentional control as a moderator of relations between attention orienting to threat and anxiety

Regression analysis

In order to investigate the prediction that attentional control moderates the association between attentional biases and anxiety symptoms we conducted a hierarchical regression analysis. We chose multiple regression instead of an analysis of variance (ANOVA) procedure because both attentional biases and attentional control were measured on a continuous scale (Cohen, Cohen, West, & Aiken, 2003). In this regression analysis, attentional bias score for angry faces was the predictor variable, the total score on the ACS-C was the moderator, whereas the total score on the SCAS served as the outcome variable. Before performing the analysis, the predictor and moderator were centered to maximize interpretability and to reduce multicollinearity (Fraizer, Tix, & Barron, 2004). In the first step of the hierarchical multiple regression we entered attentional bias score for angry faces and attentional control. In the final step we entered the product term representing the interaction between attentional bias score and attentional control. Table 1 presents the results of the regression analysis. The model in which we included all the factors explained 21% (R^2 =.21, f^2 = .26) of the variance in anxious symptoms. This result indicates that the entire model has a medium-large effect upon the outcome variable. Moreover, in both models attentional bias was not a significant independent predictor of anxiety symptoms. Also, results indicate that attentional control acts as a significant predictor of anxiety (b = -1.28, p < .001).

Table 1

Summary of hierarchical regression analysis for variables predicting children's anxiety Symptoms

Predictor	ΔR^2	*B*	SE *B*	β
Step 1	.16*			
Attentional biases		0.03	.04	.06
Attentional control		-1.28	.24	-.39*
Step 2	.05*			
Attentional biases		0.04	.04	.07
Attentional control		-1.19	.23	-.36*
Attentional bias x attentional control		-0.03	.00	-.23*
Total R^2	.21*			
N	161			

*$p < .05$

In other words, children with high attentional control experienced lower levels of anxiety. As expected, the interaction between attentional bias for threat and attentional control was significant (b = - .03, p < .001), indicating the presence of a moderation effect. The interaction term explained 5 % of the variance in anxiety (ΔR^2 = .05, f^2 = .05). The same regression analysis was conducted with the attentional bias score for happy faces replacing the threat bias score as a predictor. Attentional bias for happy faces was not a significant predictor for anxiety (b = .01, p = .7). Also, the interaction between attentional bias for happy faces and attentional control was not significant (b = .007, p = .4). Therefore, we did not include happy bias scores any further in the analysis as it seems that the observed associations between attentional biases in interaction with attention control and anxiety are restricted to threatening stimuli.

We further examined the particular form of the interaction effect of attentional biases for threat and attentional control by plotting the regression of anxiety symptoms on attentional biases at high (one standard deviation above the mean) and low (one standard deviation below the mean) levels of attentional biases and attentional control. As shown in Figure 4, the slope was significantly different from zero only at low levels of attentional control, $t(157) = 2.85$, p < .001. More specifically, there was a significant positive association between attentional biases and anxiety symptoms only for children with low attentional control. At high or medium values the slopes were not significantly different from zero, $t(157) = -1.67$, p = .09 and $t(157) = 0.89$, p = .37. These results indicate that there is no relationship between attentional biases and anxiety for children with good ability to control their attention allocation.

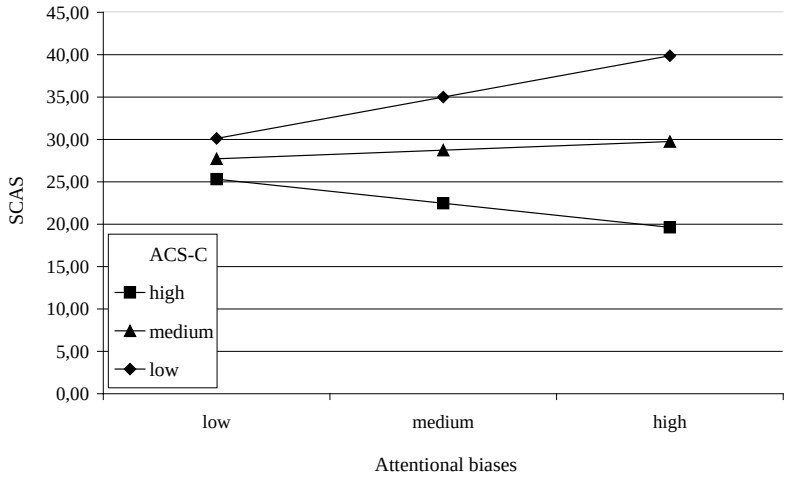


Figure 4. Interaction between attentional biases and attentional control in the prediction of anxiety symptoms.

5.5 Discussion

5.5.1 Temperament and attention orienting to threat

The first goal of the present study was to investigate the effects of individual differences in fearful temperament and attentional control processes on attention orienting towards threat.

In relation to the first aim, several findings relevant to this goal emerged. First, with regard to the main effects of temperamental variables on attentional biases toward angry faces, neither fearful temperament nor attentional controls were significantly related with attentional biases. However, consistent with our prediction, we found a significant interaction effect of fearful temperament and attentional control on attention orienting toward threat. Specifically, children with high levels of fearful temperament and low levels of attentional control demonstrated significantly higher vigilance for angry faces, compared with children that have low levels of attentional control and also low levels of fear. As such, this result replicated earlier findings that attentional biases towards threat were present only in children who had both high levels of negative affectivity such as fear and low levels of regulative temperamental traits such as attentional control (Lonigan & Vasey, 2009; Helzer et al., 2009).

Also, even though the bias of children with high attentional control and high fear was not significantly different from 0 it is worth mentioning that they displayed the opposite pattern of attentional allocation (avoidance) compared to children with low attentional control and high fear. To be more precise, children with high attentional control and high fear were able to shift attention away from angry faces and to orient attentional resources toward neutral faces. Such an attentional pattern would be consistent with dot-probe findings interpreted as reflecting avoidant response which could be seen as a coping mechanism which allows keeping anxiety low (Derryberry & Reed, 2002). In contrast, children with low attentional control and high fear oriented their attention toward angry faces, showing the greatest difficulties disengaging attention from threatening stimuli.

Thus, these results revealed that in highly fearful children the modulating role of high attentional control is reflected by a tendency to display attentional avoidance in the presence of threatening information. This attentional avoidance may involve a substantial voluntary

component, relative to attentional vigilance toward threatening stimuli that accompanied the response of highly fearful children with low abilities to control attention. Fearful children might be thought of as being particularly vulnerable to automatically orient their attention toward threatening stimuli in the environment. Despite this, our results point out that in circumstances in which it is possible to employ attentional control to inhibit the orientation of attentional resources toward threat, only a subset of fearful children (those with low attentional control) go on to exhibit this reactive attentional response.

Another important aspect was the lack of any moderating effects of age or anxiety symptoms. This result demonstrated that the observed interaction effect between fear and attentional control on attentional bias scores was on the one hand, independent of children's age, and on the other hand, independent of group differences in anxiety level.

It is important to note, however, that in the present study anxiety symptoms did not influence attentional bias scores. There is the possibility that the lack of association between anxiety and attentional biases was due to the fact that our study was conducted with a nonclinical sample. This explanation is supported by the failure of some previous studies conducted with non-clinical samples to find evidence for an association between high levels of subclinical anxiety (e.g. high levels of trait anxiety) and biases toward threat (Eschenbeck et al., 2004; Helzer et al., 2009). Also there are studies which suggest that moderate to severe levels of clinical anxiety in children are reliably associated with increased attentional biases towards angry faces, relative to neutral faces (Waters et al., 2010). An alternative explanation is that, for children with non-clinical anxiety symptoms the emotional reactivity related to anticipation of stress, derived from fearful temperament might influence the direction of attention in relation to threatening information more than anxiety like symptoms. This finding requires replication by including the assessment of both reactive temperament and anxiety symptoms in future studies that investigate attentional biases with subclinical samples.

This study also examined attentional biases for happy faces. However, we did not formulate any specific predictions regarding the direction of attentional processes for happy faces, given that some studies conducted in children but also in adults have found a bias toward happy faces (Waters et al., 2008), whereas others have not (Telzer et al., 2008). The analysis of happy-neutral trials revealed no relation between attentional biases for happy faces and temperamental traits. This result was in line with previous childhood studies in anxious youths or in children with underlying anxiety predispositions that revealed the attentional biases to be specific for angry faces (Roy et al. 2008; Telzer et al., 2008).

5.5.2 Individual differences in attentional control as a moderator of relations between attention orienting to threat and anxiety

The second aim of this study was to test the possibility of an interaction effect between attention orienting towards threat and attentional control in predicting anxiety. Specifically, we looked whether attentional control could moderate the relation between attentional biases and anxiety.

Our results indicate that attention orienting to threat was not directly associated with anxiety symptoms. Contrary to the widely accepted hypothesis stating that as anxiety levels rise children should show larger attentional biases towards threat, this association was not significant in the present study.

Instead, we found a significant interaction effect of attentional biases to threat (but not to positive stimuli) and attentional control in predicting anxiety symptoms. This

interaction effect showed that, for children with low capacity to regulate attention, attentional biases for angry faces were significantly related with anxiety. Specifically, children with attentional biases and poor attentional control reported greater anxiety. In contrast, for children with high attentional control, attentional biases for threat were unrelated to anxiety. Note that in the case of attentional biases for happy faces, the interaction with attentional control was not significant, ruling out an interpretation of the results in terms of emotionality effects.

The lack of a direct association between attentional biases and anxiety symptoms has been previously reported in the literature. In a study using the dot-probe task with samples of children with and without a clinical diagnosis of anxiety disorder, attentional biases towards threat were significantly larger in the clinical group but the association between attentional biases and self-report measures of anxiety did not reach significance (Roy et al., 2008). The lack of association between the two variables even in the clinical sample is attributed to a possible presence of co-morbid symptoms that were not ruled out. Similarly, in our study, we did not measure other symptoms, like depressive ones that are known to frequently co-occur with anxious phenomena. The presence of high levels of depressive symptoms in our sample of children could account for diminished attentional biases and the weak association with anxiety levels. Still, it is worth mentioning that the hypothesized positive relation between these two variables is also challenged by data showing a negative relation between attentional biases to threat and anxiety in children (Stirling, Eley, & Clark, 2006). Such inconsistent results could indicate that this relation between anxiety and attentional biases is not a straightforward one.

In light of this evidence, our data add to the small number of studies on attentional biases and anxiety in children that include a measure of attentional control. The pattern of our results seems to demonstrate that attentional biases for threat are more evident in anxious children who have poor attentional control, as they may be less able to shift attention away from threat once drawn to its spatial location (Waters et al., 2008).

5.5.3 Limitations and future research

The current findings should be considered in the light of several limitations. First, temperamental traits, attentional biases and anxiety were assessed concurrently. Therefore, no conclusion can be inferred regarding the directionality of the observed effects. From a developmental perspective it is important to determine the time sequence of these variables, such that longitudinal studies assessing these factors will be needed to address these issues. Second, as this study included only children without anxiety disorders, the observed effects cannot be generalized to clinically anxious children, for whom the nature of attentional processes and their relations with temperamental traits may be different (Vervoort et al., 2011). Also, we did not control for pre-existing differences in depressive symptoms. For example a study comparing children with different anxiety disorders, with depressive disorders, respectively a control group, reported non-significant tendencies of depressed participants to orient their attention away from negative stimuli, either threatening or depressive (Dalgleish et al., 2003). Therefore, future studies should control for depressive symptoms. Moreover, given that both fearful temperament and attentional control were measured through self-report and this common rater variance may have artificially inflated the correlation between those two variables, it would be extremely important for further studies to use a behavioural measure of attentional control in order to see if this effect of attentional

control and fearful temperament on threat-related attentional biases is preserved. In the present study we tried to overcome the problem of correlated fearful and attentional control measures by conducting also a hierarchical regression in order to analyze our data.

5.5.4 Conclusions

Despite these limitations the present results pointed to the importance of studying threat-related attentional biases in relation with temperamental traits. Results indicated that orientation of attention towards angry faces was characteristic for children with high fear and low attentional control, whereas stronger attentional avoidance was characteristic for children with low fear and low attentional control In addition, these findings highlighted the role of attentional control in regulating the reactivity of motivational systems related to fear.

Also, to our knowledge, this is the first study conducted with children to test the moderating role of attentional control using probe task based on pictorial stimuli. Our findings have important implications for the study of attentional biases for threatening information with non-clinical samples, namely that individual differences in attentional control are an important variable that increases the vulnerability to manifest both attentional biases and anxiety symptoms. These results are also interesting in light of possible implications for prevention and early intervention strategies. Specifically, it could be possible that children with low ability to control attention coupled with hypervigilance to threat-related information represent a risk group for anxiety-related problems. The potential implication for future intervention strategies relates to the possible benefit of using attentional control training procedures.

Therefore, from these data we advance the hypothesis that attentional control can be seen as a possible early developmental protective factor for the development of attentional biases and further for the manifestation of anxiety problems. Future work, using a longitudinal design with clinical and non-clinical samples, is required to examine this hypothesis.

Chapter 6. Study 2: Anxiety and inhibition of threatening distracters: An investigation using the visual search paradigm

In the present chapter we investigated in middle childhood the impact of trait anxiety on the ability to inhibit the processing of emotionally distracters.

Introduction

Emotionally salient stimuli, especially threatening stimuli capture attention more strongly than neutral stimuli do. This is an adaptive response because it may serve to prepare the persons to respond fast to threatening situations. However, facilitated attentional processing of threat stimuli (attentional biases) becomes less adaptive when these stimuli continue to capture attention even if further processing indicates that they are irrelevant to the current goals of the person or when they currently pose no realistic threat (Balgrove, Derrick, Watson, 2010).

It is predicted that anxious individuals have greater difficulty to inhibit the processing of threatening distracters. Therefore, when threatening and task relevant stimuli compete for attentional resources, attentional interference occurs and this effect might be greater for anxious individuals compared to nonanxious ones (Klumpp et al., 2011).

6.1 Anxiety and ability to inhibit the processing of threatening distracters

Attentional Control Theory (Eysenck et al., 2007) is a recent theoretical framework developed to understand attention in anxiety. This theory predicts that anxiety has an impact on the ability to inhibit the processing of emotional distracters and to perform the task relevant to the current goals. In the presence of threat, anxious individuals have the tendency to orient their attention to task-irrelevant threat. This attentional capture by threatening information would lead further to difficulties in disengaging attention from these stimuli and to impaired performance on the ongoing task. Therefore, a key issue to explore in the context of Attentional Control Theory (ACT) is the proposed increased influence of emotional distracter salience for high anxious individuals. The vulnerability of anxious individuals to emotional irrelevant distracters is seen as a result of an imbalance between the goal-directed and stimulus-driven attentional systems that govern attentional control. More specifically, due to increased influence of the stimulus-driven attentional system and a decreased influence of goal-directed attentional system over attentional selectivity, anxious individuals are predicted to show performance deficits in contexts in which emotional distracters such as threatening-related stimuli are presented (Sadeh & Bredemeier, 2011).

6.2 The effects of anxiety on the ability to inhibit the processing of threatening distracters: Empirical evidence

Empirical evidence for attentional interference from emotional information in anxiety includes behavioural measures such as the time it takes to respond for a neutral stimulus which competes for attentional resources with distracting emotional information. Most of the research in this domain has been conducted in adults, and there are few studies with children investigating the relationship between anxiety and the way emotional information influences attentional processes when this information acts as a distracter.

In children, evidence for attentional interference associated with anxiety comes from studies employing emotional Stroop paradigm. In this task, emotional words or faces are presented in various colours and the participant task is to name the colour of the stimulus as quickly as possible while inhibiting the affective content of the face or word.

Despite its widespread use with both adults and children, due to the ambiguity of the inferences that can be made from emotional Stroop interference, it has been suggested that this task is not suited for testing the ability to inhibit the processing of threatening distracters. This is because the fundamental nature of the cognitive processes giving rise to the emotional Stroop effect continues to be debated (Yiend, 2009).

6.3 Visual search paradigm

Another experimental paradigm that might be suited to evaluate the ability of emotional stimuli to capture attention is visual search task. In this task, an array of faces (real photographic faces or schematic faces) is presented and the participant is required to search for and indicate the presence or absence of a face target stimulus which can be presented with different distracter face stimuli. Many combinations of target and distracters are possible, but the most frequently used is the one that presents target faces with different emotional expressions (ex. angry or happy) within neutral – distracter arrays (ex. neutral faces distracters). This type of combination between target faces and distracters allows the investigation of facilitated detection of different emotional expression. In contrast, a neutral face target embedded in a valenced array (angry or happy crowed) provides a good measure of emotional distraction. Therefore, by manipulating the emotional expression of the target face and the crowd it is possible to investigate threat detection as well as impaired disengagement from threatening face distracters (Derakshan, 2010).

In adults, data from visual search studies have indicated that high trait anxious individuals are faster compared to nonanxious persons at detecting threatening targets such as angry faces among array of neutral faces distracters. Also, there is evidence for impaired disengagement from threatening information when targets are to be searched in arrays of emotional faces distracters (angry, happy). For example, Rink et al. (2003) found evidence for both faster detection and difficulty in disengagement attention from threat in adults with generalized anxiety disorder, though the facilitated attention effect was not as large as the effect for difficulty in disengagement. The same pattern of results was obtained by Byrne & Eysenck (1995) among individuals with high trait anxiety. Moreover, Giboa-Schechtman et al., (1999) demonstrated that compared to nonanxious adults, those who suffered from social phobia were more slowed down to search for a target face in the presence of happy or angry face distracters compared to neutral face distracters.

In summary, there is accumulating evidence from studies using visual search task with adults that anxiety is associated with delayed disengagement from threatening distracters such as angry faces (Rink et al., 2003; Byrne & Eysenck, 1995; Juth et al., 2005).

Few visual search studies were conducted with children and the ones that were carried out tested whether children in general, regardless of their anxiety level, manifest enhanced threat detection as adults do (Waters & Lipp, 2008; LoBue, 2009; Waters, Lipp & Spence, 2008).

There are (to our knowledge) three studies that were looking at individual differences in searching for (detecting) a threatening target (angry face or animal fear-relevant stimuli such as spiders and snakes; Hadwin et al. 2003; Waters & Lipp, 2008; Visu-Petra, Țincaș, Cheie, & Benga, 2010) but no published research regarding the way anxious children search for a neutral face target presented among an angry crowd.

6.4 Individual differences in attentional control

Compared with Eysenck's theory which suggests that anxiety is associated with a general deficit in attentional control, others consider that there are individual differences in attentional control within an anxious population (Derryberry & Reed, 2002; Lonigan et al., 2004).

According to this latter view, attentional control can be seen as a self-regulative temperamental trait that moderates the relationship between anxiety and attentional biases. Specifically, an anxious person that is able to use efficiently the processes associated with attentional control, such as the ability to focus on task relevant goals, to filter out distracter information and to flexible shift attention when needed, might be able to modulate anxiety-related attentional biases towards threatening information (e.g. Reinholdt-Dunne et al., 2009; Peers & Lawrence, 2009). Also, it is important to mention that contradictory findings were reported by Perez-Edgar and Fox (2007) in a study with 7 years old children. Specifically, children whose mother rated them as being high in attentional control had significantly slower reaction times to social negative words when performing an emotional Stroop task.

However, in general, these results seem to indicate that at least, within nonclinical samples, impaired ability to inhibit the processing of threat is only present in a subset of the anxious persons.

6.5 Present study

The first aim was to investigate the effects of trait anxiety on the ability to inhibit the processing of threatening distracters in middle childhood. Additionally, we were interested in analyzing whether the relationship between anxiety and attentional interference from angry faces distracters is modulated by self-regulative temperamental trait of attentional control.

Attentional interference from angry faces was assessed with the visual search task in which we presented real photographic faces. In order to investigate the effect of attentional distractibility form angry faces we chose to present neutral face targets among crowds of angry or happy faces. By keeping the target face always constant (ex. neutral faces) and by varying only the emotional expression of distracter faces (happy or angry) we tried to overcome one important limit of most research using this task for the evaluation of distraction effects in adults. Specifically, with adults, this effect was measured with so - called search asymmetry designs (ex. searching for an angry face target embedded in an array of happy faces distracters or vice versa). The data from this type of target / distracter combination is hard to interpret because any observed RT differences in searches are not simply a function of the extent to which distracter faces hold attention but they are also a function of the extent to which target face captures attention. In order to avoid this potential confound, the present study asked children to search in a display of 9 faces a discrepant face (neutral face target) presented among emotional distracters (happy or angry faces).

Therefore, in the visual search task, employed in this study, we used as a baseline condition the happy face distracters. This allowed having a direct comparison between angry and happy facial expression in holding attentional resources. Although this comparison is not a common one (since past research found a stronger ability for angry faces to capture attention compared to neutral faces) we believe that it is also important to analyze whether the angry

faces preserve this attentional capture effect when they are compared to different emotional expressions such as happy faces.

For the present study our hypotheses were as follows: firstly, we expected that higher levels of trait anxiety will be associated with greater distractibility by angry faces compared to happy faces. Secondly, we predicted that this effect will be modulated by individual differences in attentional control.

6.6 Method

6.6.1 Participants

The study comprised 49 children ranging in age from 9 to 11 years (M = 122.72 month, SD = 6.63). Of these, 25 were girls and 24 were boys. All children had normal or corrected vision and had no clinical diagnosis to indicate the presence of psychopathology. Also, only children who provided a signed informed consent form were included in the study.

6.6.2 Measures

The questionnaires employed in this study were the child version of the Attention Control Scale (ACS-C; Derryberry & Reed, 2002) and the Spence Child Anxiety Scale (SCAS; Spence, 1998). These instruments have been described in detail in Study 1. In the current sample, internal consistency for the ACS-C was $\alpha = .84$, respectively $\alpha = .90$ for the SCAS.

Materials and apparatus

The stimuli consisted of black – and – white photographs taken from the NimStim face set (Tottenham et al., 2009). The photographs represented 2 individuals, one male and one female. Each of the two individuals displayed an expression of neutrality, one of anger and one of happiness. We selected the most intense expressions for anger and happiness. Also, to control the possible confound of teeth contrasting strongly to the rest of the photograph in the case of the happy expressions we used for both happy and angry faces the images with an open mouth in which teeth were visible. In addition, all photographs were cropped in order to remove external features insignificant for the emotional expression such as hair. Also, all faces were presented on black backgrounds and luminance and contrast were matched between the different photos. Therefore, all images were edited in order to be on a grey scale, with similar levels of brightness and contrast and to have the same size (497 x 606 pixels). For the practice phase of the task we used the photographs of two individuals from the Ekman stimuli set (Ekman & Freisen, 1976), displaying expressions of anger, happiness and neutrality. The visual search task was created and run using E-Prime® version 1.2. Two Acer Extensa 5220 laptops with screens of 15.4 inches were used for data collection. Display refresh rate of laptops was 60 Hz.

The visual search task

The visual search task consisted of 120 trials (90 trails were experimental and 30 trials were practice). During each experimental trial, nine photos either male or female of the same

individual were presented simultaneously in a 3 x 3 matrix. Each trial started with a fixation point displayed for 500 ms, followed by the presentation of the 3x3 matrix until participant response, and ended with a blank screen for 500ms. The design of this task included 2 types of target present trials (Neutral face target and Angry distracters; Neutral face target and Happy distracters) and 3 types of same trials (Angry / Angry, Happy / Happy and Neutral / Neutral).

Children were asked to press one button on the computer keyboard when the faces were the same, and to push another button if one of the faces was different from the others. The effect of angry faces distracters on attention was operationalized by comparing reaction times (RTs) and the accuracy to detect a neutral face among angry distracters to RTs and accuracy for the detection of neutral faces among happy distracters.

Figure 1. Example stimulus matrices from the visual search task. In the left side a neutral target face among angry distracters and in the right side a neutral target face among happy distracters

6.6.3 Procedure

Children from two schools were introduced to the research in the classroom, and those who verbally consented to participate were asked to have their parents sign the informed consent form. Only children who had provided a signed informed consent form were included in the study. Also, children who participated in this study were given prior approval from their teachers.

Data from both the visual search task and the questionnaire was collected at the schools in two phases. Firstly, children completed both the SCAS and ACS-C during a one hour whole classroom administration session. Secondly, the visual search task was completed individually, in a separate room. All children completed the training phase and understood the rules they had to follow. For each child the program presented the trials in random order. At the end, each child received positive feedback and a sticker as reward. The task took 20 minutes on average.

6.6.4 Results

Reaction time

In order to investigate the effects of trait anxiety, attentional control and their interaction upon attentional distractibility we conducted a repeated-measure ANCOVA with distracter type (angry or happy faces) as within variable and anxiety, attentional control and interaction term (anxiety x attentional control) as covariates. This GLM analysis is considered to be the equivalent of a moderation analysis and its major advantage is that allows testing the interaction between categorical and continuous variables (Tincas, Phd. thesis, 2010; Field, 2009). Anxiety and attentional control were centred to reduce multicoliniarity, and the interaction term was computed as the multiplicative product of the two centred variables. Repeated measure ANCOVA was run in three steps, entering anxiety in the first step, attentional control in the second, and the interaction term in the third step. We did not include in this analysis gender or age since preliminary results did not reveal significant associations between this variables and reaction time data.

Overall there was a significant main effect of distracter type, F (1,47) = 15.02; $p < .05$, partial $\eta^2 = .24$. Estimated marginal means indicated that children in the whole sample, regardless of their anxiety and attentional control levels, were significantly more distracted by happy faces (M = 2502.37, SD = 389.11) compared to angry faces (M = 2348.62, SD = 404.5).

Also, we found a marginally significant two-way interaction between distracter type and attentional control, F (1,46) = 3.13; $p = .08$, partial $\eta^2 = .06$. To further analyze this potential interaction we looked for the effect of distracter type at low (one standard deviation below the mean) and high (one standard deviation above the mean) levels of attentional control. As it can be seen in Figure 2, children with high attentional control have a tendency to be distracted by both angry (M = 2517, SE =87.19) and happy faces (M = 2587, SE =87.95). Estimated marginal means indicated a tendency for children with low attentional control to be more distracted by happy faces (M = 2406.62, SE = 94.63) compared to angry faces (M = 2159.15, SE = 93.82) (see Figure 2)

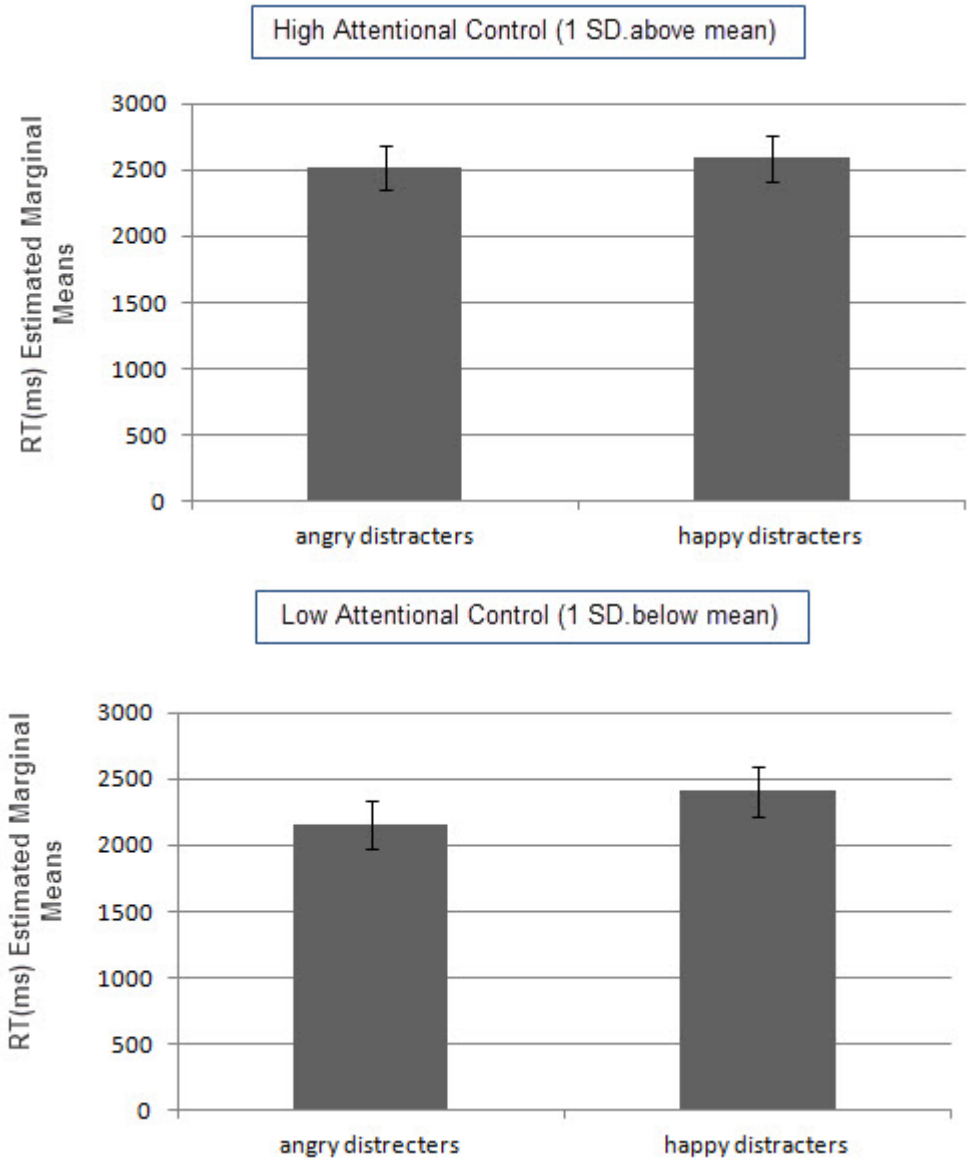
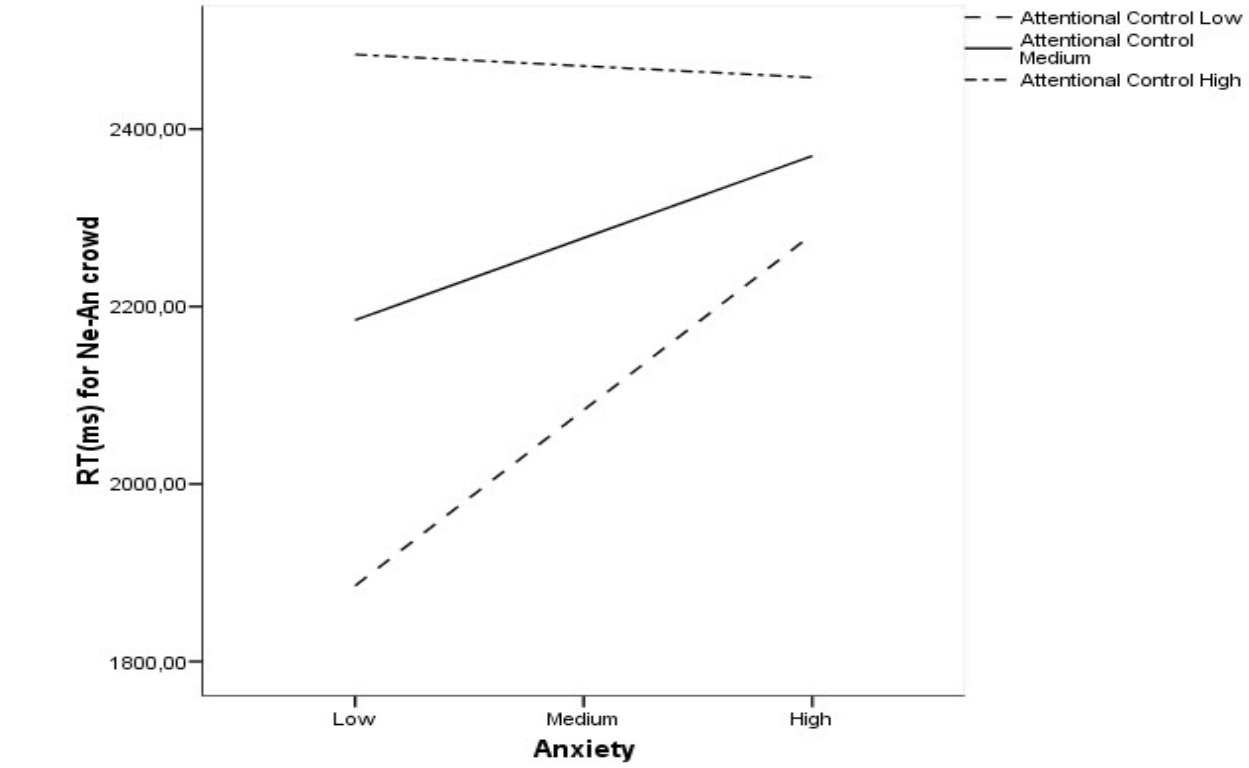


Figure 2. RTs estimated marginal means for low and high attentional control

In addition, the analysis revealed a significant three-way interaction between distracter type x attentional control x anxiety F (1,45) = 8.75, p < .05, partial η^2 = .16. This indicates that the effect of distracter type was modulated by the interaction between anxiety and attentional control. Further analysis of this interaction revealed that the interactive effect of anxiety and attentional control was statistically significant only for angry faces distracters (B = - 0.58, p < .05, η_p^2 = .08). Moreover, we examined the particular form of this interaction effect of anxiety and attentional control by plotting the regression of RTs for angry distracters on anxiety symptoms at high (one standard deviation above the mean), medium, and low (one standard deviation below the mean) levels of anxiety symptoms and attentional control. As it can be seen if Figure 3, the slope was significantly different from zero only at low levels of attentional control, t(49) = 2.01, p < .05. At high or medium values the slopes were not significantly different from zero, t(49) = -.07, p > .05 and t(49) = 1.28, p >.05. These results demonstrated that as anxiety increases and attentional control is low it is harder for children to

search for a neutral face when distracters are angry faces. This pattern was not observed in the case of happy faces distracters (see Figure 3).



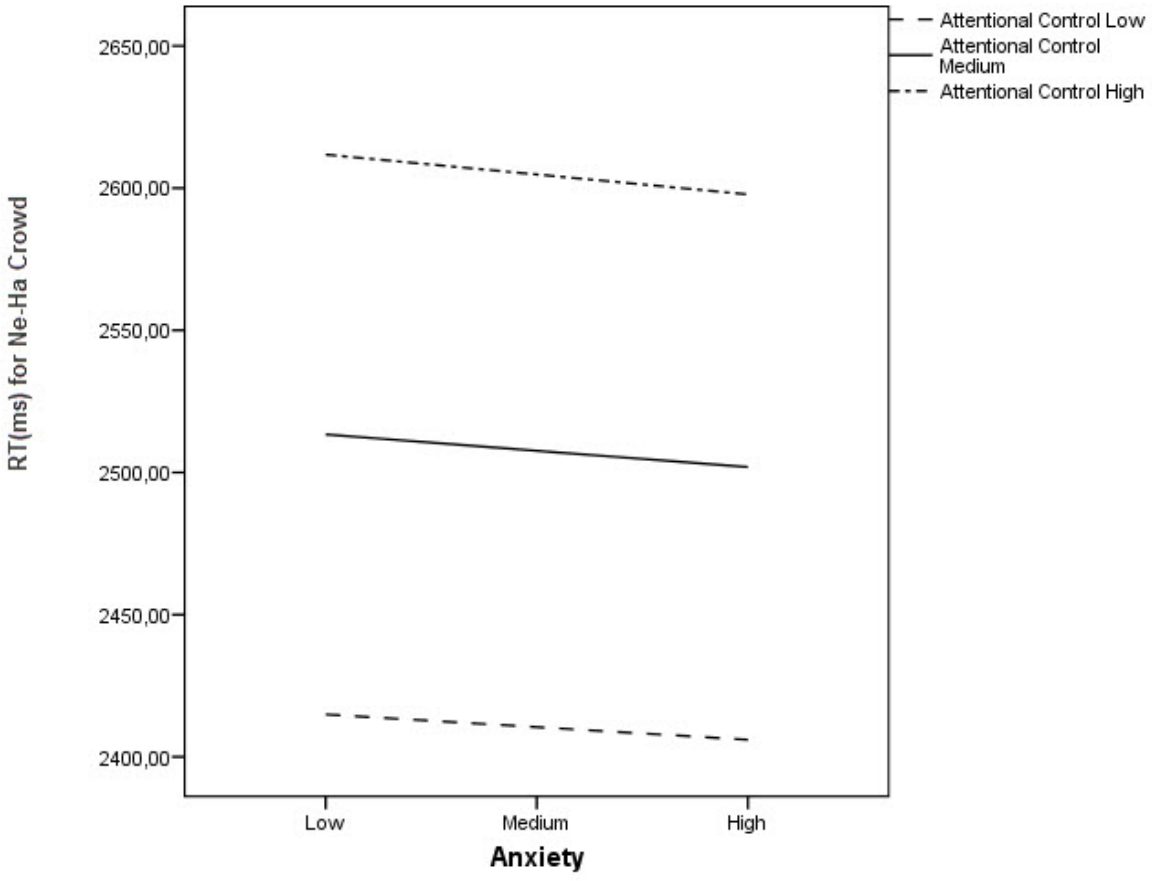


Figure 3. Interaction between anxiety and attentional control on RTs for Ne-An crowd and for Ne-Ha crowd

Accuracy

The analysis of the effects of anxiety, attentional control and the interaction term (anxiety x attentional control) on accuracy did not reveal any significant results.

6.7 Discussion

In this study our aim was to investigate the effects of trait anxiety on the ability to inhibit the processing of threatening distracters in middle childhood. In addition, we were interested in analyzing whether the relationship between anxiety and attentional interference from angry faces distracters is modulated by self-regulative temperamental trait of attentional control.

The results demonstrated that children in the whole sample, regardless of their anxiety and attentional control levels, were distracted more by happy faces compared to angry faces. This effect is in line with other studies conducted with visual search task that found either fast detection of happy faces or greater distractibility form these stimuli in samples selected from general population (Becker et al., 2011). Also, there are fMRI studies on face processing conducted with children that showed that children, compared to adults, had greater amygdale activation to happy than angry faces (Todd et al., 2010). This pattern of results might suggest that, in general, children find happy faces more salient or meaningful than angry faces.

Moreover, contrary to our expectation, in this study, greater capacity to control attention, such as the tendency to focus attention on information relevant to observer's goals, translated into increased sensitivity towards emotional distracters (both angry and happy faces). Similar pattern of results were reported by Perez-Edgar and Fox (2007) in a study with 7 years old children. Specifically, children whose mother rated them as being high in attentional control had significantly slower reaction times to social negative words when performing an emotional Stroop task.

One possible explanation for this unexpected result is that maybe children high in attentional control, in order to avoid the possibility of making errors in searching for the target face (the discrepant face from the display) adopted a cautious strategy such as a close examination of all faces presented in the array. Other explanations might be related to characteristics of the visual search task used in this study. First, in this version of visual search task, the search for the target was easy (was not demanding on executive or perceptual level) and it might be that children with high levels of attentional control, because they have greater attentional resources, set a larger attentional window so that it encompasses the whole display, which further included the emotional faces distracters inside of this attentional window. Also, recent researchers suggest that attentional window can be adjusted in line with task demands but it is not possible to exert top-down control within the attentional window (Belopolsky et al., 2007). Therefore, salient stimuli such as emotional distracters will capture attention if they are located within the attentional window and this is particularly likely to occur when attention is distributed widely. We believe that it might be possible that in the visual search task employed in the present study, attention was allocated broadly (in a distributed manner) because the position of the target was randomized and could not be

predicted. Thus, it is reasonable to assume that in this context of a task that encouraged attention to be broadly allocated toward the whole display, children with higher levels of attentional control could be more susceptible to process distracting information. Second, in this task the difference between target and distracters was related to emotional content, so in a certain way emotionality was task-relevant because the search for finding a discrepant face in the array was based on emotional information. Therefore, it might be the case that, the processing of emotional distracters was enhanced in children with high attentional control in a top-down fashion.

Finally, our analysis revealed a significant three-way interaction between distracter type x attentional control x anxiety. This interaction demonstrated that, as anxiety increases and attentional control is low, it is harder for children to search for a neutral face when distracters are angry faces. Therefore, this study revealed that the impaired ability to inhibit the processing of threatening distracters (angry faces) is only characteristic for children with both higher levels of trait anxiety and low levels of temperamental attentional control.

Typically, in attentional biases literature this type of result is interpreted in terms of attentional disengagement. Therefore, this result is in line with studies conducted with adults that have investigated individual differences in attentional disengagement from threat-related stimuli. In general, these studies have found that anxious individuals are slower to detect a target when the display contains threatening distracters (Rinck et al. 2005; Pineles et al., 2007).

To sum up, the present data demonstrated that in a visual search task in which emotional faces (angry and happy facial expressions) were distracters, for the children from this sample, irrespective of their anxiety and attentional control level, it was harder to respond to a neutral face target (slower RTs) in the presence of happy faces distracters. Furthermore, there was a tendency for children with higher levels of attentional control to manifest increased sensitivity towards emotional distracters. However, in line with our expectations, impaired ability to inhibit the processing of angry distracters was modulated by anxiety and individual differences in attentional control, namely, for children with higher levels of anxiety and lower levels of attentional control it was harder to identify the presence of a neutral target face in the context of angry faces distracters.

Chapter 7. Anxiety and attentional control processes in the presence of emotional faces distracters

In the present chapter we were interested to investigate the efficiency of both inhibition and attention shifting in the context of facing emotional distracters. Additionally, we analyzed whether in the context of performing a task that engaged and imposed a load on the attentional control processes (attentional shifting and inhibition), individual differences in attentional control might still modulate the effect of anxiety on attentional distractibility from angry faces.

7.1 Introduction

In study 2 we found several interesting results, regarding the effect of anxiety on attention processing when threatening stimuli are task-irrelevant, which we further explore in this study. Specifically, in study 2 it was demonstrated that, in general (in the whole sample), happy faces distracters captured attentional resources more than angry faces distracters did. Thus, in the current study we were interested in seeing whether we can replicate this effect using a different experimental paradigm.

Furthermore, there was a tendency, in the previous study (study 2) with children having higher attentional control abilities to manifest greater distractibility from emotional faces. One of our hypotheses regarding this unexpected result was that in the visual search task that we designed, even though the emotional faces were not the targets to which the children had to respond, emotionality was some way relevant to the task and this facilitated the processing of emotional distracters, in a top-down fashion, in children with high attentional control. Particularly, children's task was to find the presence of a discrepant face in the crowd, which was defined as being such by its emotional expression (Hodsoll, Viding, Lavie, 2011). Therefore, emotional stimuli may have drawn attention through top-down attentional control because their emotional content was task-relevant. In order to test this hypothesis, in this study, the target stimuli to which children were responding, were different from the emotional faces distracters in perceptual features and emotional content.

Moreover, in study 1 and study 2 we demonstrated that individual differences in attentional control modulate both the attention orienting to angry faces (study 1) and the effect of anxiety on the ability to inhibit the processing of angry faces distracters (study 2). We believe that this modulation was possible due to the experimental tasks used in these studies (e.g. dot-probe task in study 1 and visual search task in study 2) that were not demanding and challenging for the attentional control processes. It might be argued that, in the context of these tasks, that put no demands on the goal-directed attentional resources, anxious children with higher levels of trait attentional control are able to employ effortful control strategies in order to override attention orienting and attention distractibility from angry faces. In relation with these results, we were interested in investigating in the current study, whether in the context of performing a task that engaged and imposed a load on the attentional control processes (attentional shifting and inhibition), individual differences in attentional control might still modulate attentional distractibility from angry faces.

7.2 Top-down attentional control processes: general aspects

Given the potential overlap between attention, working memory and executive control systems in basic cognitive and cognitive neuroscience literature, theorists seem unable to define the attentional control concept in a way that entirely satisfies any two of their colleagues (Astle, Scerif, 2009; Nuechterlin, Luck, Lustig, & Sarter, 2009).

Control of attention is defined by some researches as the ability to filter out distracter information and / or shift the focus of attention in response to task demands. The output of these two mechanisms (e.g. filtering out distracters and attentional shifting) is believed to be attentional selectivity, namely, the ability to select from the environment the relevant information that helps us to pursuit goal-driven behaviour (Yantis, 1998). Therefore, attentional control biases the processing of incoming input to select information appropriately in the face of competing stimuli and / or responses (Astle, Nobre, Scerif, 2010). Top-down selection is under the control of intentions of the observer, compared to bottom-up selection which is determined by the feature properties of a stimulus or when selection is driven against the intentions of the observer by other factors such as the emotional content of stimuli.

Top-down attentional control of attention resembles the executive network of attention proposed by Posner & Peterson (1990). Therefore, many researches have used interchangeably the concept of attentional control and executive attention. The executive network is believed to be involved in the resolution of conflict between neural systems and regulating thoughts and feelings (Posner, Sheese, Odludas, & Tang, 2006). The brain network that underlines top-down control of visual attention / executive network is the frontoparietal network (e.g. intraparietal sulcus, the superior parietal lobule, the prefrontal cortex). Experimentally, the top-down control of attention was illustrated in endogenous cueing procedure (Posner & Cohen, 1984) and in experimental tasks that involve the direct competition between bottom-up (stimulus-driven) and top-down (goal-directed) control mechanisms. In the endogenous cueing procedure the typical finding is that participants are faster and make fewer errors when the target appears at the cued location relative to when it appears at an uncued location. Therefore, participants direct their attention *at will* to a particular location in space and this represents a clear example of top-down selection (Theeuwes, 2010). In tasks that assess attentional control processes by placing in direct competition stimulus-driven and goal-directed control mechanisms task-irrelevant information is presented while participants perform the ongoing task. In these experimental conditions it is required to activate top-down attentional control in order to be able to focus attentional resources on the task at hand and ignore task-irrelevant information (distracters).

7.3 Neural correlates of cognitive and affective control: age-related and individual differences

This section provides a brief overview of the electrophysiological and neuroimaging studies that indexed age-related and individual differences in neural responses associated with top-down attentional control, in particular those neural correlates associated with overriding the influence of interfering emotional information.

Recent work has begun to document the neural substrates that mediate aspects of attentional control involved in overriding and regulating emotional interference in children. Reciprocal connections between prefrontal cortical (e.g. anterior cingulated cortex, lateral prefrontal cortex) and subcortical regions involved in emotion processing, in particular amygdala and nucleus accumbens are important in cognitive control of emotional distracting

information. For example, neuroimaging studies of affective control in adults suggest a role for top-down prefrontal modulation of subcortical regions associated with emotion processing (Hare & Casey, 2005).

Several studies have examined the N2 event-related brain potential in relation to emotional and non-emotional distarcetrs. The N2 is a negative-going waveform that appears between 200 and 400 ms after the onset of a stimulus. N2 amplitudes are believed to reflect the degree to which cognitive control resources (e.g. attentional control) are recruited to resolve conflict and inhibit incorrect responses (Buss, Dennis, Brooker, & Sippel, 2010). The N2 has been linked to activity of the anterior cingulated cortex (ACC) which is a key region of the medial frontal cortex involved in the processing of both cognitive and affective conflict (Ladouceur, Conway, & Dahl, 2010).

Although few studies have investigated in children the link between N2 and emotional conflict there is some evidence showing larger N2 in response to negative emotional information (e.g. angry faces; Lamm & Lewis, 2010; Todd, Lewis, Meusel, & Zelazo, 2008). For example, Lewis, Todd & Honsberger (2007) have demonstrated in 4-6 years old children using an emotional Go / No-go task that angry faces generated the greatest fronto-central N2 amplitudes and fastest N2 latencies. These effects were observed in the Go condition and they were explained in terms of greater effortful attention required when children must override a prepotent response to stop an action or withdraw when presented with facial angry expression. Additionally, in this study the authors examined correlations of N2 magnitude and timing with individual differences in child temperament (e.g. fearful temperament) and they found that fearful children showed more rapid N2s to angry faces when they appeared in the Go condition. Faster N2s may reflect the rapid registration of negative emotional content that characterizes the vigilant appraisal style of fearful children.

Moreover, even fewer studies have investigated in children the N2 effect in relation to individual differences in both negative affect and self-regulation. In addition, these studies have yielded inconsistent results. While some authors reported that larger N2 amplitudes in conflict trials (e.g. incongruent trials in a flanker task) were associated with low levels of temperamental effortful control (Buss et al., 2011) others reported the opposite (e.g. Perez-Edgar & Fox, 2007). Methodological aspects such as the use of emotional versus non-emotional conflict task, the age range of the children could account for the differences in findings.

Furthermore, in relation to individual differences in negative affect Ladouceur et al., (2010) used EEG measures while participants (adolescents) performed an arrow version of the Eriksen flanker task and they found, contrary to their expectations, that adolescents with higher levels of negative affect and higher levels of temperamental attentional control had greater N2 amplitudes. This result was interpreted as indicating that the possibility of making an error, such as when participants process stimuli containing incongruent information, is emotionally salient and in this situation it is possible that higher levels of temperamental attentional control might become a liability when negative affect is also high. Thus, adolescents rated high in negative affect and high in attentional control may tend to over-rely on a conflict evaluation system that prioritizes ongoing conflict information.

Other investigators have used clinical samples to investigate neural correlates of cognitive control and affective control. For example, in children with anxiety disorder, error signals in the brain (ERN) are generated during the course of doing a flanker task. In control children, there is no appearance of these error signals (Ladouceur, Dahl, Birmaher, Axelson, & Ryan, 2006).

In clinically anxious adults, such as patients with generalized anxiety disorder (GAD), empirical results point to a diminished recruitment of attentional control. For example, fMRI data indicate that GAD patients have a diminished activation of the lateral prefrontal cortex, a

brain area which has been linked to the recruitment of top-down control (Etkin & Schatzberg, 2011; Etkin, Prater, Hoeft, Menon, & Schatzberg, 2010).

From the above summary, it is clear that the results of all these studies which have investigated in adults and children the neural underpinnings of the influence of emotional states (e.g. trait anxiety, anxiety disorders) and emotional stimuli on the top-down attentional control is not in agreement. In contrast, as we will review next, the literature examining the behavioural effects of emotional stimuli on attentional control processes and their modulation by individual differences in anxiety, have obtained, particularly in adults, more homogenous results.

7.4 The efficiency of top-down attentional control processes in the presence of threatening distracters in anxiety: behavioral evidence

Eysenck et al. (2007), hypothesize that the deficit in attentional control in anxious individuals should affect at the behavioural level processing efficiency (as typically indexed as reaction times) rather than effectiveness (as typically indexed by error-rates).

Adult studies have investigated the assumption according to which high trait anxious individuals are characterized by deficient attentional control, particularly when the inhibition of threatening information is required (Eysenck, Derakshan, Santos, & Calvo, 2007). The key feature of these studies is that threatening stimuli such as angry faces were presented as distracters in demanding cognitive tasks (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Wieser, Pauli, & Mühlberger, 2009). These studies provide evidence that both high-trait anxious persons and persons with anxiety disorders have difficulties in inhibiting the processing of threat when performing a cognitive task that overwhelms cognitive resources. In this case, there are less cognitive resources to overcome interference from threat (Mathews & MacLeod, 2005).

Another important aspect that was explored by studies investigating the effects of anxiety on task performance when distracting stimuli are presented was whether attentional control deficits associated with anxiety are modulated by level of perceptual and cognitive load during task performance. For example, it is known that perceptual demands of a task (the number of task relevant items in the display) affect the extent to which irrelevant information is processed and influences behaviour (Lavie, 1995). Specifically, the perceptual load theory posits that when distracters are perceived under conditions of low perceptual load, executive functions, such as attentional control, working memory are required to suppress the effects of distracters on behaviour by activating and maintaining task relevant information. In contrast, under conditions of high perceptual load, early selection occurs and distracters are not perceived because perceptual resources are taxed and insufficient capacity remains to process task-irrelevant information (Sadeh & Brademeier, 2011).

A similar perspective comes from Mathews & Mackintosh (1998). According to their view, voluntary effort elicited by the main task demands can override interference from threatening irrelevant information. The support of this prediction comes from neuroscience data proving that performing an attention-demanding task has been found to attenuate the emotional impact of negative stimuli (Pessoa et al., 2002; Dillen, Heslenfeld, Koole, 2009). Specifically, task-load down-regulate the brain's response to negative stimuli in emotional regions (e.g. the amygdalae and the right insula) and increased activation in cognitive regions (e.g. right dorsolateral prefrontal cortex, right superior parietal cortex).

The aspects mentioned above with respect to perceptual and cognitive load characterize non-anxious individuals, however in contrast, anxious individuals are predicted to show performance deficits in tasks that place demands on goal-directed mechanisms because in

these conditions top-down attentional control processes are strained. At low perceptual loads high anxious individuals should be able to compensate for attentional control deficits by expending additional attentional resources to overcome interference from distracting information (Sadeh & Brademeier; Cronwell. Alvarez, Lissck, & Ernest, 2011). For example, Sadeh & Brademeier (2011) employed a non-emotional visual task search that indexed processing of distracters across four levels of perceptual load. Results showed that high levels of trait anxiety was related to difficulty suppressing the behavioural effects of irrelevant distracters (decreased reaction times) under high, but not low, perceptual load. However, it is important to mention that in the literature different patterns of results are also reported (see Bishop et al., 2007; Dvorak-Bertsch, Curtin, Rubinstein, Newman, 2007).

Regarding the effect of childhood anxiety on attentional control processes in the presence of threatening material the very few studies that have been reported in the literature varied enormously in the way they defined and measured attentioanl control. For example, Ladoucer et al., (2009) designed a working memory task in order to investigate the effects of trait anxiety on attentional control processes in the context of emotion. Their findings suggested that anxious children exhibit difficulty resisting interference from threat-related stimuli when greater attentional resources are being recruited by the main task. Moreover, studies have examined whether emotional context affects attentional control processes in paediatric anxiety disorders also by using the emotional version of the Go / No Go task with angry or fearful, neutral and happy faces. Waters & Valvoi (2009) have used this task in order to examine whether emotional context created by the emotional faces affect the control of attention in children with anxiety disorders. The demands on children's attentional control were increased by making the probability of interference by emotional faces low (e.g. 70% Go trail probability vs. 25 % Go trial probability condition). Thus, with a lower presentation rate of No Go trials, greater demand was placed on children's attention to avoid responding on infrequent No Go trials. Results of this study pointed that anxious girls were slower responding to neutral faces with embedded angry faces compared with happy face No Go trials whereas non-anxious girls were slower responding to neutral faces with embedded happy versus angry No Go trials. No other significant group differences were found in this study. Interesting data were reported by Benga (2007) who used the emotional spatial conflict task in order to analyze the impact of emotional face processing on executive attention in preschool children. In this study anxious children presented a reverse threat processing bias. Specifically, children with anxiety showed shorter latency and reduced number of errors during fearful incongruent trials from the emotional spatial conflict task compared to congruent fearful trials. This reverse threat bias was interpreted as a strategy of avoiding the threatening stimuli but also as a sign of hipervigilence for threat-related stimuli such as fearful faces.

Collectively, these findings summarized above, regarding the behavioral evidence of the efficiency of top-down attentional control processes in the presence of threatening distracters in anxiety suggest several aspects. First, in adults it seems that anxiety-related differences in threat processing are reliable observed when threat stimuli (e.g. angry or fearful faces) are presented in direct competition with task-relevant stimuli. In those situations it is likely to observe that in the case of anxious individuals threat stimuli will interfere with their efficiency in performing the task at hand (e.g. higher RTs). Second, as it was presented above, more heterogeneous results are reported by studies investigating whether the impairments of attentional control processes in the presence of threat-related information, associated with anxiety, are modulated by the level of perceptual and cognitive load during task performance. Moreover, less evidence is available for the efficiency of attentional control processes in emotional context in anxious children and this raises the need to explore whether difficulty controlling attention in threatening contexts is also a characteristic of anxious children. This

can be particularly important since in real-world situations we must constantly perform goal-related behaviours in the presence of emotional stimuli.

7.5 Current study

Taking into consideration all these aspects mentioned above, in the present study we investigated the effects of trait anxiety on attentional control processes (e.g. inhibition and shifting) in the context of emotional distracters by designing a letter discrimination task in which the relevant target stimuli were in direct competition with the emotional faces distracters. Moreover, the demands on children's attentional control were increased by loading both the inhibition and shifting components (functions) of attentional control. In addition, as in our previous studies (study 1 and study 2), we were interested in seeing whether individual differences in attentional control might still modulate attentional distractibility from angry faces in this attentional demanding task.

Based on the research previously discussed, we predicted that in the presence of threatening distracters (angry faces) higher anxiety would be associated with less efficient attentional control. Specifically, we expected that when threatening information is present heightened trait anxiety will be associated with greater impairment in the inhibition function of attentional control (e.g. higher RTs for the incongruent trials compared to congruent trials in the letter discrimination task) and also with greater impairment in the shifting function of attentional control. In the letter discrimination task that we used, the shifting function was defined as involving both the ability to switch attention from the previous attentional set (switch costs) and the ability to coordinate and maintain two attentional sets (mixing costs). Therefore, in relation to the shifting function of attentional control we expected to find higher RTs for the trials that involved a switch from the previous attentional set (switch costs) and / or higher RTs for the situations that reflected the need to coordinate and maintain two attentional sets (mixing costs). We also predicted that individual differences in attentional control might moderate the relationship between anxiety and impairments of attentional control processes in the presence of threatening distracters.

7.6 Method

7.6.1 Participants

Our sample in this study consisted of 113 children (61girls) aged 9-11 (M = 122.04 months, SD = 9.02). We obtained written parental informed consent and verbal consent from each child before the testing. All children had normal or corrected vision and did not have a psychiatric diagnosis.

7.6.2 Measures

Questionnaires

The questionnaires employed in this study were the child version of the Attention Control Scale (ACS-C; Derryberry & Reed, 2002) and the Spence Child Anxiety Scale (SCAS; Spence, 1998). These instruments have been described in detail in Study 1. In the

current sample, internal consistency for the ACS-C was α = .83, respectively α = .89 for the SCAS.

The emotional letter discrimination task

Children perform a letter discrimination reaction time task that required attention switching and the ability to filter out irrelevant information. This task was designed, based on the protocol described by Ghering & Knight (2002) in their non-emotional version of this task. We programmed our emotional version of this task using E-Prime version 1.2. During the letter discrimination task, concurrently we presented emotional faces that children were instructed to ignore (see Figure 1). Therefore, during the practice phase of this experiment, children were told that their task was to press as fast and accurate as they could one button from the mouse pad when the target letter was H and another button when the target letter was S. These two letters appeared for 200 ms on each trial, with one letter appearing in green and the other one in red. The letter pair was preceded by a precue indicating which letter in the pair was the target letter. The precue was the word GREEN or RED and it was displayed for 1000 ms. If the precue was the word RED than the red letter in the subsequent pair would be the target letter, to which the participant must respond and the other letter, in this case the green one, would be the distracter letter.

The task consisted of four experimental blocks (two pure blocks and two mixed blocks) and three practice blocks composed of 96 trials each. During the practice trials the distracter emotional faces were not presented (to prevent familiarity) but the child was informed that faces would appear during experimental trials.

In order to load attentional processes two manipulations were the central focus: first, in some blocks of trails (pure blocks) the precue was always the same word. Thus, participants could maintain attention to a particular colour from one trial to another. In the mixed conditions the precue changed randomly from trial to trial, changing the attentional set of the participants. Thus, this first manipulation attempted to load the **shifting component** of attentional control. The costs involved in switching attentional sets are assessed in two ways. First, we compared performance on No-Switch trials in the Mixed Blocks to performance in the Pure Blocks (mixing costs). Because both are non-switch trials, the reaction time effect will reflect costs associated with the need to coordinate and maintain two attentional sets, to encode the precue and to select and update the currently relevant task-set (Ghering & Knight, 2002; Manzi, Nessler, Czernochowski & Friedman, 2011). Second, within the Mixed Blocks, we compared performance on trials that required a switch from the previous attentional set (target colour) to trials where no switch was required (switch costs). This comparison is believed to capture the time it takes to switch attention from one colour to another.

The second manipulation was distracter compatibility, namely distracter letter could have the same identity as the target (HH, SS – Compatible trials) or distracter could had opposite identity (e.g. HS, SH – Incompatible trials). This manipulation attempted to load the **inhibition component** of attentional control. To examine the ability to inhibit the processing of distracter letters we compared Compatible and Incompatible trials.

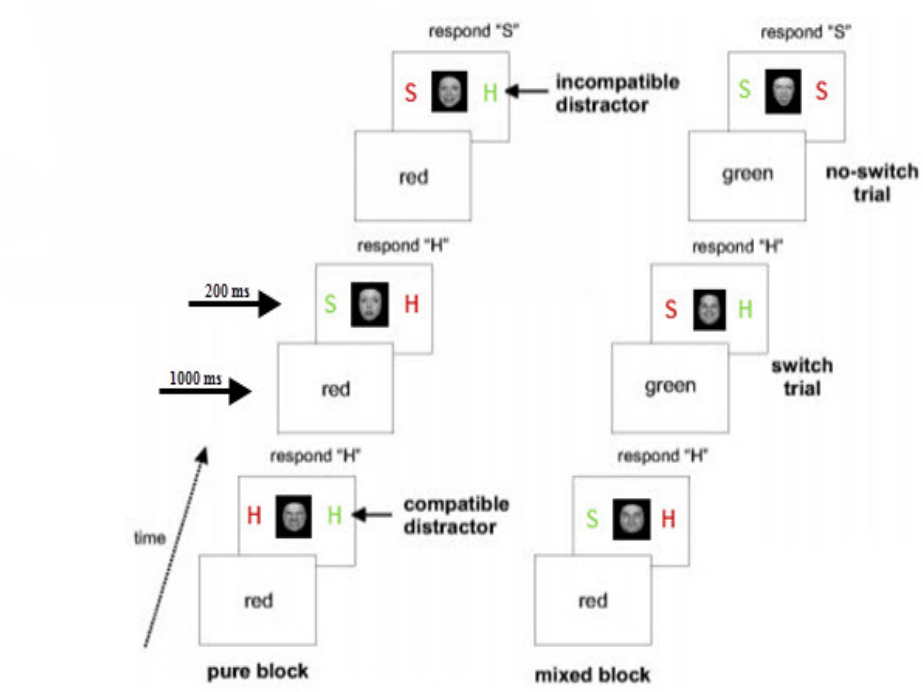


Figure 1. Sequences from the experimental task. The left side of the figure displays the events from trials in the Pure, No-Switch Block. The right side of the figure represents trials from the Mixed Block.

7.6.3 Procedure

In this study were included only children who provided by their parents a signed informed consent. Data from both the letter discrimination task and questionnaires was collected at two schools. In the first phase children completed the SCAS and the Attention Control Scale. The letter discrimination task was completed after a one week interval. The task was completed individually, in a separate room, inside the school. The task was run with the E-Prime on a laptop with a 15-inch display, with the screen resolution set to 1024 × 768. Children were requested to read the instructions displayed at the beginning of the task and were shown by the experimenter on which buttons they should press in order to indicate their response (e.g. the left and the right buttons of the mouse pad were used to collect their response). After children read the instructions displayed on the computer screen, the experimenter summarized one more time for each child what he or she was asked to do by verbally, using cards with examples of possible stimulus displays. The letter discrimination task started with a practice phase and if children understood what they had to do they were asked to continue with the experimental phase. All children included in the final analysis completed the training phase and understood the rules they had to follow. At the end each child received positive feedback and a sticker or a badge as reward. The task took 20 minutes on average.

7.7 Results

Reaction time

In order to determine whether, for anxious children emotional faces distracters had an impact on attentional control processes (inhibition and attentional shifting), and whether these effects might be modulated by individual differences in attentional control, we performed a 2 (compatibility) x 2 (shifting) x 3 (face valance) repeated measure ANCOVA with gender, age (in months), anxiety, temperamental attentional control, and the interaction term (anxiety x attentional control) as covariates and reaction time data as the dependent measure. Anxiety and attentional control were centred to reduce multicoliniarity, and the interaction term was computed as the multiplicative product of the two centred variables. Repeated measure ANCOVA was run in four steps, entering gender and age in the first step, anxiety in the second, attentional control in the third and the interaction term in the forth step.

In line with our expectations, we found a significant four-way interaction between compatibility x face valance x anxiety x attentional control, F (2, 98) = 3.35, $p < .05$ $\eta_p^2 = .06$. To further clarify this interaction, we analyzed separately for the high attentional group and low attentional group (the groups were formed based on median split of the ratings of children's attentional control level) the interaction between compatibility x face valance x anxiety. For children with high levels of attentional control the interaction between compatibility x face valance x anxiety was not significant, F (2, 45) =. 21, ns. However, for those with low attentional control there was a marginally significant interaction between compatibility x face valance x anxiety, F (2, 50) = 2.65, $p = .08$, $\eta_p^2 = .10$. This interaction showed that, in the presence of happy faces distracters, F (1, 51) = 5.37, $p < .05$ $\eta_p^2 = .09$, for children with low attentional control, higher levels of anxiety (1 standard deviation above the mean) were associated with greater impairment in the ability to filter out incompatible distracters (e.g. higher RTs for the incongruent trials compared to congruent trials) (see Figure 2).

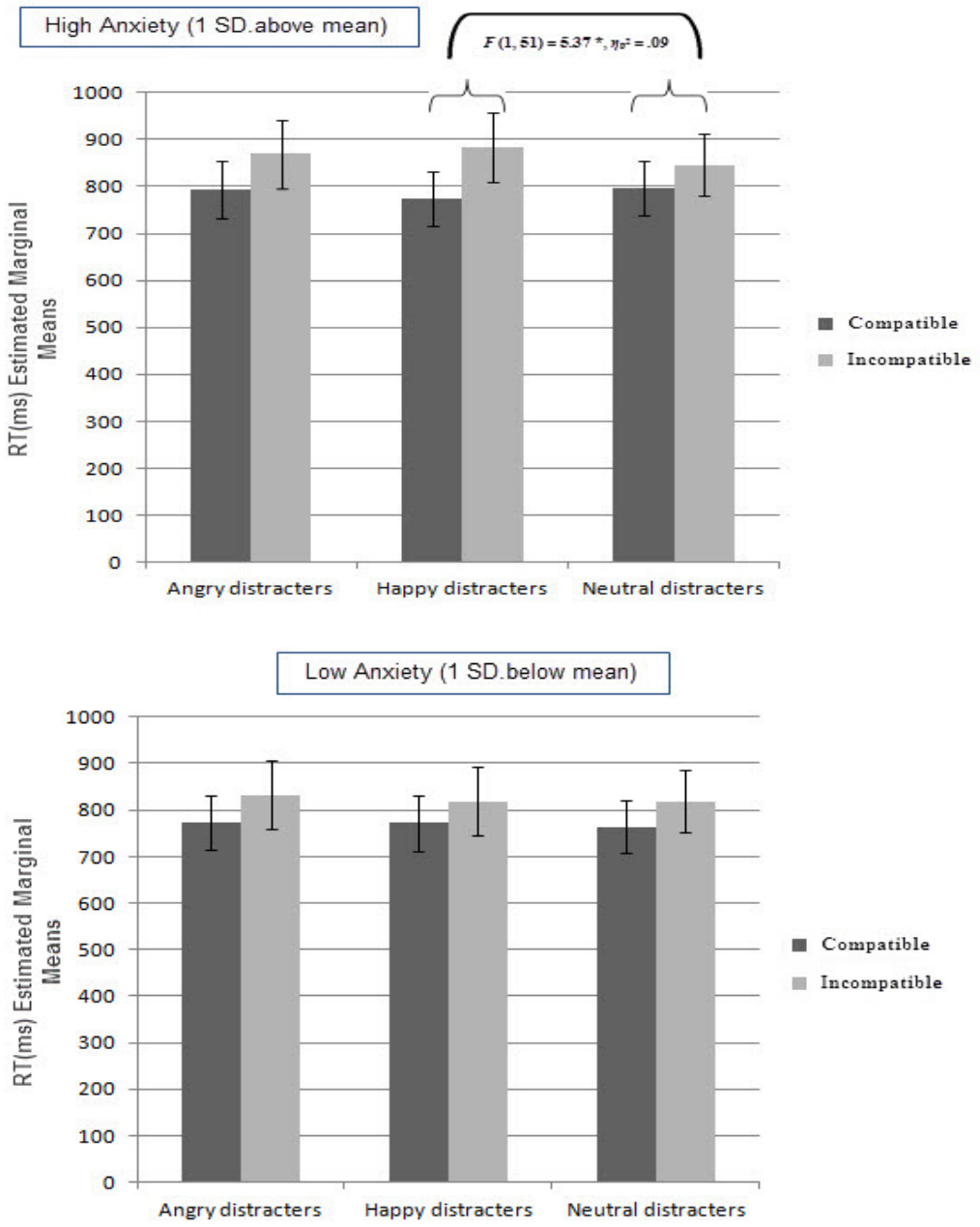


Figure 2. RT for Compatible and Incompatible trials as a function of anxiety and face valance for children with low attentional control

We did not find any significant effect of anxiety, attentional control, face valance or interaction term (anxiety x attentional control) on the mixing costs (the difference between reaction times on no switch trials in mixed blocks and pure blocks), $F < 1$, *ns*.

However, with respect to switching costs (difference in performance between switch and no-switch trials in mixed blocks) we found a significant two way interaction between switching costs and emotional face valance, F (2, 99) = 3.36, $p < .05$ $\eta_p^2 = .06$. Breaking down this interaction using simple contrast analysis we observed that irrespective of anxiety or attentional control levels, children manifested greater impairment in the ability to shift

attentional set in the presence of emotional faces distracters compared to neutral faces distracters (see Figure 3).

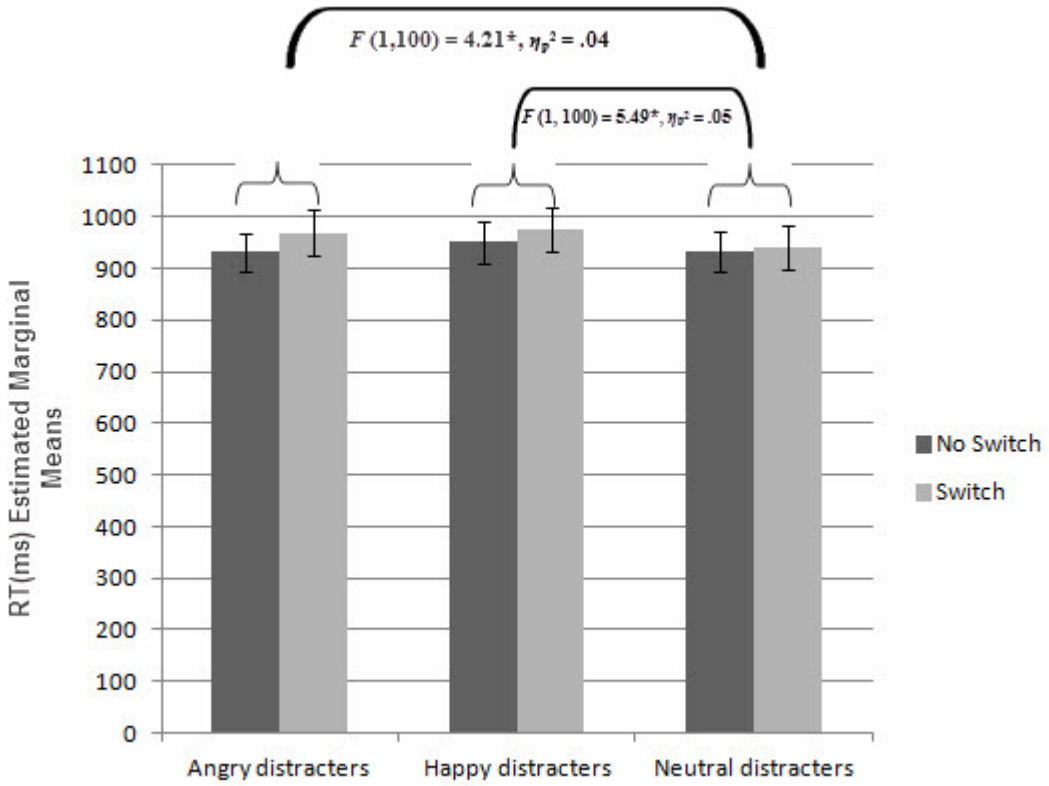


Figure 3. RTs estimated marginal means comparing No-Switch trials versus Switch trials from the Mixed Blocks for angry, happy, and neutral faces distracters

7.8 Discussion

The central finding of this study was that during letter discrimination task, children with low levels of self-reported attentional control and high levels of trait anxiety were slower to inhibit the processing of the incompatible letter distracter in the presence of task- irrelevant happy faces. Thus, this result can be interpreted as showing that for these children positive emotional information (happy faces) impaired the efficiency of inhibition function.

In relation to this result, there are several aspects that are important to be addressed. Firstly, the effect of self-reported attentional control in modulating the effect of anxiety on the ability to inhibit the processing of happy faces is in line with the theoretical view according to which, temperamental attentional control underlines the ability to regulate distracter interference (Derryberry & Reed, 2002). Secondly, this finding is consistent with data from adult studies that have demonstrated that anxious individuals had greater impairment in the inhibitory mechanism of attentional control in the presence of emotional faces. (Derakshan et al., 2009; Wieser, Pauli, & Mühlberger, 2009). However, in contrast with these findings, for the anxious children from the present study, it was harder to regulate attentional processes (e.g. to regulate distracter interference) in the presence of happy faces not angry faces, as in the previous studies. Since research into the processing of emotional face distracters is lacking in children, our explanations regarding the power of happy faces to

capture attention resources and to take them away from the main task that children should be focusing on, are highly speculative. One potential explanation for such a result it might be the effect of the positive nature of happy facial expression. Specifically, since happy faces are positive approach-related stimuli it might be more difficult to suppress attentional orienting towards them when they act as distracters in a task. Support for this explanation comes from studies conducted with adult samples selected from the general population (e. g. Hare et al., 2005). Another possible explanation concerns the fact that among anxious individuals happy faces might activate negative face processing attributes. Indirect evidence for the assumption according to which positive social feedback (e.g. happy facial expression) might be interpreted as less positive or even negatively among anxious persons comes from studies conducted with socially anxious persons. For example, it was demonstrated that social anxiety moderated the recognition of happy faces. Specifically, people high in social anxiety took longer to recognize happy faces. Furthermore, there is evidence that individuals with social phobia judge happy faces as less approachable than healthy participants (Campbell et al., 2009). Although, it is difficult to compare our results with this data, since, high levels of anxiety were not defined in our sample based on social anxiety scores, it might also be possible that anxious children from our sample interpreted negatively happy facial expressions.

With respect to attention shifting the current study revealed that, in the presence of emotional face distracters, in the presence of both angry faces and happy faces, switch costs were larger for all children, irrespective of their anxiety and temperamental attentional control levels. This greater difficulty manifested by all children in switching attention from one task to another in the presence of emotional face distracters might suggest that, for the children from this age range, the letter discrimination task was more demanding on the shifting component of attentional control. Therefore, this task difficulty on switching function led to fewer resources available to regulate distracter interference from emotional faces. This explanation might be supported by theoretical models which emphasises that both, the ability to perform attentional demanding tasks and the ability to regulate distracter interference from emotional faces engage common-pool resources such as the prefrontal neural structures from the anterior attentional system (Pessoa, 2009).

A potential question that may arise at this point is why inhibitory mechanism of attentional control is impaired in the presence of emotional faces only in children with high levels of anxiety and low levels of self-reported attentional control, while in the presence of emotional face distracters switch costs were longer for all children. A potential answer to this question comes from developmental literature on executive function showing that the ability to shift task set does not reach young-adult level until adolescence (Cepeda et al., 2001). In contrast, some aspects of inhibitory control such as the ability to control response competition on incongruent trials of the Eriksen Flanker task – our manipulation regarding distracter compatibility in the letter discrimination task was a version of the flanker compatibility manipulation - improve rapidly until the age of 11 (Huizinga et al., 2006). This different developmental timeline regarding the maturation of inhibitory and shifting mechanism might be a potential candidate in explaining the differential influences of anxiety and emotional faces on these two mechanisms of attentional control.

There are several limitations of the present study that warrant discussion before addressing the conclusions and implications that derivate from this data.

First, the letter discrimination task employed in the present study did not provide a measure of the temporal dynamics of attentional control. Specifically, we used an overall effect (we compared congruent and incongruent trials and shifting versus non-shifting trials) to index attentional control and we did not provide an assessment of possible trial-to-trial fluctuations of attentional control.

Second, in the present study, performance in the letter discrimination task was analyzed based on individual differences in trait anxiety but not by state anxiety alone or in conjunction with trait anxiety. Future studies should clarify the roles of trait and state anxiety by using a design in which groups low and high in trait anxiety are being exposed to low- and high-stress conditions designed to manipulate state anxiety levels.

Another limitation of this study is the absence of a no face distracter baseline comparison and the use of the neutral face distracters as a baseline condition. We believe it is important to take this aspect into consideration since it is known that neutral faces might be more ambiguous for children, as they are not yet perceived as signals of neutrality (Tincas, 2010). A related limitation is the use of only angry facial expressions as threat-related stimuli. Given that it is suggested by some authors (e.g. Davidson, 2002) that fearful faces are more anxiety-provoking stimuli than angry faces future work should also include in the design also different negative valence stimuli such as fearful emotional expressions.

In sum, we have shown that emotional information affected differentially attentional control processes / mechanisms (inhibition and shifting). Our results suggest that individual differences in trait anxiety and temperamental attentional control can modulate the impact of emotional facial distracters (happy faces) on inhibition mechanism of attentional control. In relation to the shifting mechanism of attentional control no such modulator effect was observed because switch costs were larger, in the presence of emotional faces distracters (both happy and angry facial expressions) for all children, irrespective of their anxiety and temperamental attentional control levels.

In conclusion, the present findings encourage further research into the effects of emotional distracting information on attentional control mechanisms in anxious children. This is important given that the ability to regulate behaviour in the context of emotional distracting information is one of several aspects that contributes to emotion regulation and any perturbation in this ability might increase the vulnerability for the development and maintenance of anxiety disorders.

Chapter 8. General discussions and implications

8.1 General conclusions

The present thesis focused on attentional processes that occur in the presence of threatening stimuli in anxious children and adolescents. The primary motivation for investigating threat-related attentional processing in anxiety was that cognitive models of anxiety postulate that the processing of threatening information from the environment might be a significant contributor to the development and maintenance of anxiety disorders (Williams, Mathews & MacLeod, 1996). In pursuing this goal we employed a mechanistic account of threat-related attentional processes, specifically, we attempted to go beyond the broad concept of attentional biases (the tendency of anxious persons to preferentially allocate their attentional resources towards threatening information in the environment), and to focus on distinguishing different attentional mechanisms that might underline the preferential processing of threat in anxiety.

Based on, the theoretical assumptions postulated by theoretical frameworks of anxiety and attention and on the controversies that have emerged after reviewing the empirical evidence reported in the literature regarding the relation between childhood anxiety and threat-related attentional biases, we formulated a set of specific objectives that were investigated in studies 1-3.

Study 1 addressed two issues: first, the proposition that temperamental factors might influence initial orienting to threat (Pine, Helfinstein, Bar-Haim, Nelson, & Fox, 2009) and second, the proposition that attention orienting towards threat has an impact on anxiety symptoms (Beck & Clark, 1997). It was predicted that higher levels of temperamental traits involving sensitivity towards threat (e.g. fearful temperament) in conjunction with lower levels of regulative temperamental traits such as attentional control would be associated with attention orienting towards threat. A pictorial version of the dot-probe task was used in order to assess the attention orienting towards threat-related stimuli. These results indicated that children with high levels of fearful temperament and low levels of attentional control demonstrated greater attention orienting towards angry faces compared with children who have high fearful temperament and high attentional control. Moreover, the results provided no evidence of a direct association between attentional biases and anxiety symptoms in children.

Study 2 examined whether anxiety is characterized by impairments in the ability to inhibit the processing of threatening distracters (Eysenck et al., 2007). Additionally, we were interested in analyzing whether the relationship between anxiety and attentional interference from angry faces distracters is modulated by self-regulative temperamental trait of attentional control. The visual search paradigm was used to assess the ability to inhibit the processing of threatening distracters. Findings from this study showed that impaired ability to inhibit the processing of angry distracters was present only in a subset of anxious children, namely those with low self-reported attentional control. Furthermore, for all children from this sample, irrespective of their anxiety and attentional control level, it was harder to respond to a neutral face target (slower RTs) in the presence of happy faces distracters.

Study 3 extended the results obtained in study 2 by further looking into the possibility that in the context of performing an attentional demanding task that engaged attentional control processes (ability to filter out distracter information and shift the focus of attention in response to task demands) anxious children would be more affected by task-irrelevant emotional faces. Specifically, they would present greater impairments in the mechanisms underlying attentional control (e.g. inhibition and attentional shifting). Several findings relevant to this goal emerged. First, children with low levels of self-reported attentional control and high levels of trait anxiety were characterized, while performing the discrimination letter task in the presence of happy faces distracters, by greater impairments in the inhibition mechanism of attentional control. Second, switch costs were larger, in the presence of emotional faces distracters (both happy and angry facial expressions) for all children, irrespective of their anxiety and temperamental attentional control levels. Therefore, this study demonstrated that emotional faces distracters impaired shifting mechanism of attentional control in all children, whereas inhibition mechanism was impaired in a subset of children (e.g. those with high levels of trait anxiety and low levels of temperamental attentional control) and it was emotion specific (it only occurred for happy faces).

In the following section we attempted to consider the empirical findings from studies 1-3 in the light of the larger context of the theories of anxiety and attention outlined in the first chapter of the present thesis.

In Chapter 1 we attempted to evaluate theoretical models of anxiety and attention through the lens of attentional mechanisms underlining the preferential processing of threat in anxiety. All these models predict the component of rapid, attention orienting towards threat (Williams et al., 1988; Beck & Clark, 1997; Mogg and Bradley, 1998). The component of more effortful control processes such as inhibition and shifting is less consistent across the models with only two models (Eysenck et al., 2007; Matthews & Mackintosh, 1998) accounting for and explaining attentional biases phenomenon by focusing on these effortful processes.

As already mentioned above, several conceptual frameworks suggested that anxiety is characterized at an early stage of information processing by fast attention orienting towards threat. Results from a meta-analytic study in 2007 show that attentional biases, in the form of attention orienting towards threat, can be observed consistently in individuals with high levels of anxiety and in those with anxiety disorders (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). Even though this meta-analytic study concludes that, in children, data point to a very similar picture, the findings form Study 1 presented in this thesis, question this conclusion by showing that high levels of trait anxiety were not directly associated with initial orienting towards threat. These results were consistent with other studies conducted in children reporting the lack of a direct association between attention orienting and anxiety symptoms (Roy et al., 2008).

However, in study 1 we found a significant relation between temperament and attention orienting towards threat. Specifically, children with high levels of fearful temperament and low levels of attentional control demonstrated significantly greater attention orienting towards angry faces. Interestingly, children with high fear and good attentional control were able to orient attention away from angry faces. Therefore, these results seem to indicate that for children with non-clinical anxiety symptoms temperamental traits might influence the direction of attention in relation to threatening information more than anxiety like symptoms.

Moreover, recent conceptual frameworks (Eysenck et al., 2007; Fox et al., 2001) postulated that anxiety is characterized by impairments in the ability to use goal-directed processes to inhibit threat processing. Results from study 2 found a partial support for this assumption by demonstrating that, indeed, anxious children manifested impaired ability to inhibit the processing of threatening distracters (angry faces) but this effect was modulated by individual differences in attentional control. This modulator role played by temperamental attentional control is in contrast with Eysenck's theory which suggests that anxiety is associated with a general deficit in attentional control. However, it supports others theoretical views which consider that there are individual differences in attentional control within an anxious population (Derryberry & Reed, 2002; Lonigan et al., 2004).

In addition, empirical findings reported in study 3 provided evidence that in the presence of emotional distracters the ability to shift attentional set was impaired in all children. Therefore, these results pointed the need to place attentional mechanism underlying the preferential processing of threat in anxiety within the context of child development. Specifically, results from study 3 can be considered to reflect an indirect evidence for the idea that child development (e.g. the development of executive functions such as inhibition and shifting) influences the expression of attentional processes that occur in the presence of threatening stimuli.

8.2 Implications of the present findings

Results from the studies presented in this thesis have several implications. At the theoretical level, the current work implies that in the presence of emotional stimuli several attentional mechanisms differ as a function of both anxiety and others temperamental traits (e.g. fearful temperament and attentional control). Therefore, the theoretical frameworks that focused only on automatic processing of threat in anxiety, such as the initial orienting of attention to threat (Mogg & Bradley, 1998; Williams et al., 1988), or focused predominantly on strategic, effortful processing of threat-related material (Eysenck et al., 2007; Matthews & Mackintosh, 1998) need to reconsider their position. Furthermore, while Eysenck et al. (2007)

suggested that greater impairments in attentional control should be present in all anxious persons in the context of threat-related stimuli, results from the present thesis highlighted that in children with subclinical levels of anxiety there are individual differences in attentional control that can regulate the effect of emotion on attentional processes. Moreover, our data indicated that angry faces affect attentional processes of anxious children (e.g. greater attention orienting towards angry faces) when emotional faces are in a certain way task-relevant such in the dot-probe task, while happy faces capture attentional resources when emotional faces are task-irrelevant and are in direct competition with relevant target stimuli (see Study 3). In consequence, we believe that these results raise the importance of contextualizing and nuancing the effects of both negative and positive information on attentional processing in anxious children.

The clinical implications of the current results can be summarized as follows. First, the mechanistic account of threat-related attentional processes employed in this thesis might help therapeutic interventions that serve to reduce attentional biases to threat. For example, an important finding of the present thesis is that impaired ability to inhibit threatening distracters is one of the mechanisms that underline threat-related biased attentional processes in anxiety. This result might suggest the benefit of using attentional training procedures that enhance the ability to filter out distracting information and shift flexible attention in accordance to current goals.

Second, the inclusion of temperamental factors in our attempt to understand anxiety-related attentional processes that occur in the presence of threatening stimuli offered us on the one hand, a more complete view of the potential vulnerability markers that might be present in children before the development of anxiety disorders, and on the other hand, a larger window for prevention or early intervention. Findings from study 1 fit well with this potential implication because they demonstrated that attention orienting to threat was associated with a negative consequence (higher levels of anxiety symptoms) only for children with low levels of temperamental attentional control. Moreover, individual differences in attentional control were also an important variable that was associated with increased vulnerability to manifest heightened attention orienting towards threat in fearful children.

In conclusion, the results presented in this thesis offer new developmental data for theories and research on the relation between childhood anxiety and threat-related attentional biases by emphasizing attentional mechanisms that underline the attentional biases phenomenon.

8.3 Contributions of the current thesis

The present thesis extends the previous developmental research on anxiety and attention by adding several contributions to the study of attentional processing of emotional information in anxious children and adolescents.

First, even though we investigated attention-anxiety relation from the perspective of threat-related biases, our approach was to go beyond this broad concept of threat-related attentional biases. This approach was motivated by the view according to which attentional biases are an umbrella term that includes a variety of attentional mechanisms that underlie biased attention phenomena. Moreover, two major limits of the previous research regarding the relation between trait anxiety or clinical anxiety and attention to threatening information, were revealed after reviewing the available data in the literature. Namely, in general, previous studies considered attention as a unitary system and often attention was operationalized in different ways, which makes it difficult to see how different attentional mechanisms are affected by anxiety in the context of emotional information. For instance, several traditional attentional tasks such as dot-probe task, Stroop task, cueing task, flanker task each tapping

into different aspects of attention were adapted by adding emotional information and were used interchangeably in attentional biases literature as tasks that measure attentional allocation toward emotional information. However, we were able to identify some recent data in adults (e.g. Finucane, Whiteman, & Power, 2009; Pacheco-Unguetti, Acosta, Callejas, & Lupianez, 2010) that analyzed the impact of anxiety on attention by operationalizing attention as a set of distinct networks. However, while these studies investigated the influence of anxiety (see Pacheco-Unguetti et al., 2010) or happiness and sadness (see Finucane et al., 2009) on different attentional networks by means of a task (Attention network task –ANT) that used emotionally neutral information there have been fewer studies focusing on anxiety-attentional networks relation using emotional attentional tasks (see Dennis, Chen, & McCandliss, 2008; Birk, Dennis, Shin, & Urry, 2011). Research in children that have looked into the effects of anxiety on attentional networks is much more limited (for an exception see Tincas, 2010). Therefore, in this thesis we tried to overcome this limits by viewing attention in terms of at least three functionally and neuroanatomically distinct networks. These are known as alerting, orienting, and executive attention (Posner & Fan, 2007). Specifically, we looked to the impact of anxiety on two diffrent attentional networks (orienting and executive attention) and we employed distinct attentional paradigms in order to assess the functioning, in the presence of emotional information, of these two attentional networks in highly trait anxious children. This approach helped us to provide a clearer understanding of the influence of anxiety on the functioning, in the context of emotional information, of orienting and executive attentional networks.

Second, although the studies that have considered in anxious children and adolescents the influence of emotional information on attention, have been mostly concerned with attention orienting network their inconsistent results have raised questions about the nature of the relation between anxiety and attention orienting to emotional stimuli (see the review summarized in subchapter 3.1 in the present study). Our investigation regarding the relation between attention orienting toward threat-related information and childhood anxiety (see Chapter 5) is to our knowledge one of the first demonstrating in children that individual differences in attentional control moderates the link between biased attention orienting to angry emotional faces and anxiety symptoms. Thus, this finding offers an answer to previous studies that did not find a significant relation between anxiety, particularly subclinical levels of anxiety, and attention orienting toward threatening information. Furthermore, in this thesis we also analyzed how temperamental traits influence biased attention orienting toward threat. Our results with respect to temperamental factors highlight the need to consider specific temperamental traits such as fear and attentional control when researching the link between biased attention orienting toward threat and anxiety. Such a focus on temperamental vulnerability markers provides a unique window on the factors responsible for the acquisition of biased attentional processing of threat and further on the development of childhood anxiety.

Third, as we mentioned above, in this thesis we also examined in children the effect of trait anxiety on attentional control processes (also referred to as executive attention network by Posner & Peterson, 1990) in the presence of emotional distracting information (see Chapters 6 and 7). We consider this as being another important contribution of the thesis since in children there is a lack of data regarding the impact of emotional distracters on the efficiency of the executive attentional control processes. Therefore, our findings regarding these aspects were one of the first demonstrating that anxiety affects differentially, in the presence of emotional distracters, the processes / mechanisms that underline attentional control, namely inhibition and shifting. Additionally, we adapted and developed attention tasks that allowed us to assess separately the functioning of inhibition and shifting. Specifically, we designed and used for the first time with children one the one hand, a version

of the emotional visual search task that assessed children's capacity to inhibit the processing of irrelevant threat-related information and on the other hand, an emotional version of a letter discrimination task that it proved itself to be a useful tool for evaluating the efficiency of both inhibition and shifting in the presence of task-irrelevant emotional information. As we already discussed in Chapter 7 we consider that this should encourage further research to investigate how anxiety modultates the effects of emotional distracting information on attentional control mechanisms seeing that the ability to regulate behaviour in the context of emotional distracting information is one of several aspects that contributes to emotion regulation and any perturbation in this ability might increase the vulnerability for the development and maintenance of anxiety disorders.

Forth, the thesis went beyond a traditional focus on biased processing of threats in anxiety and also considered biased processing of positive information. Therefore, while our data revealed that positive emotional information (happy faces) impaired executive attentional control processes and that in the case of inhibition this impairment was modulated by trait anxiety and individual differences in attentional control, our data did not revealed any impact of happy faces on orienting network. In consequence, we believe that these results raise the importance of taking into consideration biased processing of positive emotional information by further exploring the effects of positive information on orienting and executive attention.

Finally, through the three studies conducted in the thesis we demonstrated that individual differences in attentional control modulated the relation between anxiety and attentional processing (both orienting and executive attentional control) of emotional information. This consistent result proves that temperamental attentional control it might be seen as a protective factor for the development of both biased attentional processing and anxiety. This has an important practical relevance since there are recent data showing that, especially in children, attentional control processes can be trainable. For example, several studies have reported that cognitive training in adults does not lead to generalized performance improvements (Owen et al., 2010; Dahlin, Nyberg, Backman, & Neely, 2008), whereas many studies with children have reported distal transfer (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005; Thorell, Lindqvist, Bergman, & Bohlin, 2009). This is consistent with convergent evidence for greater neural and behavioural plasticity earlier in development.

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