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INTERFERENCE AND BIAS PARADIGMS IN ANXIETY RESEARCH: A THEORETICAL OVERVIEW

Juan Ramos-Cejudo¹ & Florian Schmitz²

¹Complutense University of Madrid (Spain)

²University of Ulm (Germany)

Resumen: Una gran cantidad de investigaciones demuestran la existencia de sesgos atencionales hacia la amenaza en la respuesta de ansiedad, habiéndose desarrollado diferentes modelos para explicar estos sesgos. En el presente artículo se revisa la evidencia acerca de los mecanismos de los procesos de atención a través de un examen cuidadoso de los componentes de los modelos cognitivos y los mecanismos que subyacen a estos componentes. En primer lugar, se abordan los conceptos de esquema, control, y sesgo en la interacción de los procesos automáticos y controlados, y se discuten cómo estas funciones pueden contrarrestar los sesgos en las diferentes etapas de procesamiento. Se describen brevemente los sesgos en los paradigmas mencionados y se discuten los procesos y resultados que sí se pueden aprovechar. Por último, se analizan las influencias situacionales y se discuten los factores que moderan en la aparición de dichos resultados. Se discuten los resultados y se plantean recomendaciones para futuras investigaciones.

Palabras clave: Ansiedad, Sesgos Atencionales, Procesamiento de la Información, Revisión Teórica.

Abstract: A wealth of research demonstrates attentional biases toward threat in people with elevated levels of anxiety and anxiety disorders. Several models have been developed to explain these biases. In the present article, evidence regarding the mechanisms of attentional processes is reviewed by carefully examining the components of cognitive models and the mechanisms underlying these components. First, the concepts of schema, control, and bias in the interplay of automatic and controlled processes are introduced. Then, a theoretical fractionation of control functions is described, and it is pointed out how these functions could counteract biases at different processing stages. Next, some of the most frequently used bias paradigms in anxiety research are outlined, and it is discussed which processes they may tap. Finally, situational influences and moderators of cognitive biases are considered and recommendations for future research are offered.

Key words: Anxiety, Attentional Bias, Information Processing, Theoretical Overview.

Title: *Paradigmas de investigación de los sesgos atencionales en la ansiedad: Una revisión teórica*

Anxiety is an aversive emotional and motivational state occurring in threatening circumstances. In general, the level of state anxiety is considered as being jointly determined by situational factors, cognitive processes and trait anxiety (Eysenck, 1992,

1997) as well as other personality factors (e.g., neuroticism, perfectionism, need for control). From a cognitive perspective, situational factors interact with the representation of knowledge in the individual and elicit a reaction. For instance, encountering a phobic object in the environment may activate a related schema or network, resulting in an experience of anxiety, comprising feelings, cognitions, and bodily reactions. These reactions, in turn, may be inhibited or modified by controlled resources. According to most theoretical models of anxiety, the nature of these processes is

*Dirigir la correspondencia a:

Dr. Juan Ramos-Cejudo
Faculty of Psychology
Campus de Somosaguas, s/n
28223. Pozuelo de Alarcón.
Madrid. Spain.
juanramoscejudo@psi.ucm.es

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comparable in all people. However, anxious individuals seem to be governed by an overactivation of “normal” reactions to danger, resulting in hypervigilance for threatening stimuli (e.g., Barlow, 2002). Most cognitive accounts converge in their prediction that information processing in anxious people is biased towards threatening information or anxiety-related cognitions. This notion is supported by numerous findings of biases, both in non-clinical samples of individuals with high trait or state anxiety (e.g., Eysenck & Eysenck, 2007), as well as in specific anxiety disorders, including generalized anxiety disorder (Mathews & MacLeod, 1985), animal phobia (Watts, McKenna, Sharrock, & Trezise, 1986), obsessive-compulsive disorder (Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996), posttraumatic stress disorder (Foa, Feske, Murdock, Kozak, & McCarthy, 1991), as well as in social and panic disorder (McNally, et al., 1994). Accordingly, biased information processing has been deemed a vulnerability factor in the genesis of anxiety disorders (Cisler & Koster, 2010; Ouimet, Gawronski, & Dozois, 2009). However, it is still debated at which processing stages biases exert their influence. Considerable research supports the existence of “attentional biases” at the early stage of stimulus processing (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), whereas other studies have identified “interpretive biases” at a later processing stage as relevant factors (e.g., Amir, Beard, & Bower, 2005). Additionally, there is controversy regarding the relative impact of automatic processes such as stimulus engagement vs. controlled processes such as stimulus-disengagement (Fox, Russo, Bowles, & Dutton, 2001).

To date, a number of experimental paradigms exist that may be suited to measure and tease apart some of these

processes (Bar-Haim, et al., 2007; Eysenck & Eysenck, 2007; Ramos-Cejudo, 2011; Ramos-Cejudo, Salguero, & Cano-Vindel, in press; Williams, Watts, MacLeod, & Mathews, 1997). Generally, evidence obtained with these paradigms supports the existence of a bias in information processing in anxious individuals. For instance, in a recent meta-analysis on the basis of 172 studies (Bar-Haim, et al., 2007), an attentional bias of medium magnitude ($d = .45$) was confirmed. However, the authors also point to differences in the analyzed studies. These include the choice of the specific paradigm as well as its procedural details (e.g., stimuli visible or masked), but also the investigated populations (either with a specific anxiety disorder, or with generally elevated levels of trait anxiety), among others. Another issue is that some of the findings can be reconciled with different theories.

Thus, it can be argued that experimental paradigms in anxiety research are important, because they can contribute to a better theoretical understanding of anxiety disorders. At the same time, a more profound knowledge of the underlying cognitive mechanisms can elucidate, as well, promising ways of intervention, such as in cognitive behavioral therapy (CBT, e.g. Wells, 2000). However, the value of using experimental tasks critically depends on whether any possibly observed “bias” can be interpreted from a theoretical perspective. Hence, the goal of the current paper is to discuss the suitability of interference and bias paradigms in anxiety research in the light of current theories. Problems and limitations of the paradigms are pointed out and possible workarounds are outlined. To this end, the concepts of schema, control, and bias will be introduced. This will also comprise a short discussion of the interplay of automatic and controlled processes. Next, a theoretical

fractionation of control functions is outlined, and it is pointed out how these functions can counteract biases at different stages. Then, some of the most popular bias paradigms are described, and it is discussed which processes they may tap. Finally, situational influences and moderators of cognitive biases are considered.

Schema, Control, and Time Course in the Anxiety Response

A schema is “a functional structure of relatively permanent representations of knowledge and previous experiences” (Bartlett, 1932). According to schema theories, this memory structure can comprise stimulus characteristics and associated responses, among others. When an appropriate stimulus is encountered, the schema is activated and a response tendency is elicited. It is assumed that schema-congruent information is preferentially encoded and processed. Accordingly, schemata will influence our

perception and behavior, and this will happen largely in an automated fashion without the explicit requirement of cognitive control.

One of the classic models describing how automatic and controlled processes can influence our behavior was offered by Norman and Shallice (1980). Their Supervisory Attentional System (SAS) model describes both situations in which activated schemata can automatically draw responses as well as under which circumstances executive control comes into play (s. Figure 1).

According to the SAS model, environmental stimuli can trigger an appropriate schema or response. Under routine conditions and in well-learned situations, contention scheduling will take care of this in an automated fashion. Lateral inhibition of schemata will additionally contribute to that the most appropriate response will be selectively retrieved. However, in novel and non-routine situations, the SAS comes

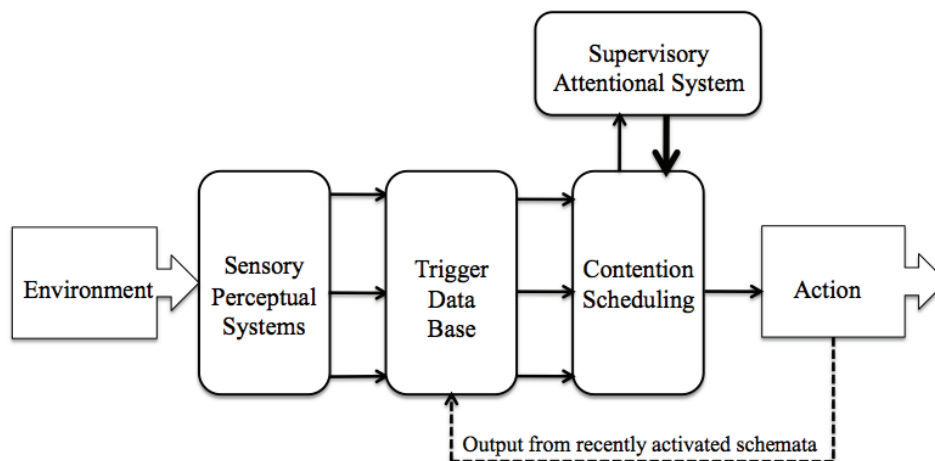


Figure 1. The Supervisory Attentional System (SAS) Model (adapted from Norman & Shallice, 1980).

additionally into play, and exerts an executive influence onto schema selection. The SAS will also provide help when conflicting schemata are activated or when the situation requires responding in a schema-incongruent fashion. Automatic processes do not require conscious control and are triggered in response to familiar, environmental stimuli. In contrast, supervisory/executive processes require conscious control in order to respond to unique situations or to overcome an automatic response tendency. In this sense, the SAS is representative of a family of currently popular two-system models in psychology that posit a major distinction in attention and action processes (Casey, Getz, & Galvan, 2008; Gladwin, Figner, Crone, & Wiers, 2011).

Also emotions are seen as action dispositions. According to the bio-informational theory (Lang, 1995), emotion-eliciting stimuli are linked with nodes representing physiological manifestations and action dispositions. Hence, certain stimuli can trigger a number of different reactions, comprising somatovisceral activation, as well as the preparation of templates for overt behavior. Of course, also in this account, control can be exerted by means of inhibition or delaying a response. As a consequence, perceived emotion and emotional behavior is a function of an automatic reaction triggered by specific stimuli and the efficiency of controlled resources.

It is important to note that both (1) automatic schemata-driven processes and (2) (impaired) control processes may contribute to the bias towards threatening stimuli usually observed in anxious people: First, schemata for personally relevant stimuli may be more easily accessible than for other categories of stimuli. For instance, encountering threatening stimuli (e.g., snakes, spiders, a person with an angry face) may generally activate

according schemata more easily than neutral stimuli (e.g., household utensils, a person with a neutral face). Second, the control of schemata or schema-based reactions may be a function of the relevance of the schema, which may correspond with its level of activation. For instance, the inhibition of a highly activated “fear network” (Foa & Kozak, 1986) or an associated response may be more difficult than it would be with any other activated network. To conclude, a bias towards threatening stimuli in anxious persons may reflect the joint effects of automatic as well as controlled processes. In any case, the existence of an attentional bias directed toward threatening information has been one of the most strongly demonstrated, both in patients with clinically significant anxiety (Mathews & MacLeod, 1985; McNally, et al., 1994) and people reporting high trait anxiety (Mogg, et al., 2000).

Anxiety may as well impose adverse effects on control functions. The consequences may be a general impairment in cognitive control and performance decrements. Additionally, impaired control will make it more difficult to release attention from threatening stimuli and cognitions, hence closing a vicious circle. For example, processing efficiency theory (PET, Eysenck & Calvo, 1992) and its more recent development, attentional control theory (ACT, Eysenck, Derakshan, Santos, & Calvo, 2007), particularly seek to explain the detrimental effects of anxiety on processing efficiency. Part of these effects is postulated to be mediated by the impairment of executive functions that serve the allocation of attention. According to PET (Eysenck & Calvo, 1992), worry is elicited in stressful situations (especially in test, evaluative, or competitive conditions) and is most likely to occur in individuals high in trait anxiety. It is assumed that worrisome thoughts consume the limited

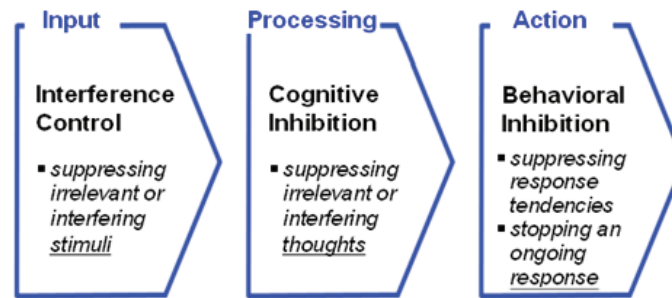


Figure 2. Stages of Processing and Interference Control.

attentional resources of working memory, which are therefore less available for concurrent task processing. As a consequence, storage capacity of working memory should be reduced and interference should be more likely to occur. Similarly, attentional control theory (ACT, Eysenck, et al., 2007) predicts that anxiety has adverse effects on inhibition and shifting. In fact, it was shown that anxiety impairs the inhibition function (Derakshan & Eysenck, 2009; Pacheco-Unguetti, Acosta, Callejas, & Lupianez, 2010) as well as the shifting function (Ansari, Derakshan, & Richards, 2008; Derakshan & Eysenck, 2009; Wilson, Vine, & Wood, 2009).

One of the most recent lines of research in the study of anxiety has been to focus on how stimuli are detected, perceived, and interpreted in the course of time (Frewen, Dozois, Joanisse, & Neufeld, 2008; Gladwin, et al., 2011). In line with two-systems models of information processing it is assumed that an automatic process rapidly evaluates stimuli. The automatic process is considered as schema-driven and supplies the person with a fast response tendency. However, a somewhat slower, intentional or strategic process is initiated slightly delayed, which may help the individual counteract the initial response

tendency. As a consequence, a single person may display quite contradicting response tendencies in face of the same stimulus as a function of elapsed time and the processing of the stimulus. For instance, an anxious person may, first, automatically direct attention towards a threatening stimulus. But with the rise of the controlled response tendency, release attention from the stimulus and shift away from it. In fact, the vigilance-avoidance hypothesis (Mogg, Bradley, Miles, & Dixon, 2004) postulates that anxious individuals initially orient their attention to threat, but subsequently direct attention away from threat, and has been supported by many studies (Koster, Verschuere, Crombez, & Van Damme, 2005; Rinck & Becker, 2006; Rohner, 2002).

Separable Control Functions and Threat Processing

Given the impact of control functions in bias paradigms, it seems to be indicated to have a closer look at their structure and functioning. It is important to recognize, that attention is not a unitary construct (see Posner, 1980). Instead, attention can be divided into four distinct stages: (1) orientation of attention toward a given stimulus; (2) attentional engagement with

that stimulus; (3) disengagement from the stimulus; and (4) avoidance of attention to the stimulus, as a coping strategy. Additionally, Miyake and colleagues argued for a fractionated executive, with updating, shifting, and inhibition as correlated but separable executive functions (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). The updating function is closely linked with the contents of working memory. It comprises as well monitoring and copes with the affordance to replace old items not relevant any more with newer and actually relevant items. The shifting function is used to allocate attention in a flexible manner to the task stimulus or stimulus attributes currently most relevant. The inhibition function is used to resist interference from task irrelevant stimuli and responses. More recently, it was argued that the broad inhibition function should be further subdivided into a number of more specific functions serving interference control at successive stages of processing, namely input, processing and action (cf. Friedman & Miyake, 2004; Nigg, 2000).

As previously discussed, the three major executive functions, updating, shifting, and inhibition were shown to be impaired as a function of state anxiety (e.g., Ansari, et al., 2008; Derakshan & Eysenck, 2009). However, as these functions are moderately inter-correlated it is not completely clear whether the effects of anxiety are mediated by a common underlying mechanism or by independent, function-specific mechanisms. Additionally, and independent of the effects of anxiety on executive control (cf. PET and ACT models), it is also important to improve our understanding to what extent control functions are involved in the processing of threatening stimuli and how and when they interact with more automatic processes (cf. the vigilance-avoidance hypothesis). It can be assumed

that a biasing of schemata already takes place in many anxious individuals, however in an undesired direction: Cognitive worry and rumination would activate anxiety-related schemata and influence the automatic processing of later encountered stimuli (s. Figure 3).

The Assessment of Attentional Biases

As summarized, there is considerable support in the literature that anxious people have an attentional bias towards threatening stimuli (MacLeod, Mathews, & Tata, 1986; Mathews, May, Mogg, & Eysenck, 1990; Matthews & Wells, 2000). Additionally, attentional biases have been observed in patients characterized by clinically significant anxiety (Mathews & MacLeod, 1985) as well as in people reporting high levels of trait anxiety (Mogg, et al., 2000). The observed effects are conventionally accounted for in terms of biased detection and processing of threat-related stimuli as a function of automatic schemata. However, it can be assumed that controlled processes can modify the resulting effects, either by exerting an influence at early stages when the stimulus is processed or later when a response-tendency is formed (cf. the taxonomies by Friedman & Miyake, 2004; Nigg, 2000).

The exact mechanisms underlying the observed biases are still subject to debate. But there is an emerging line of research investigating and dissociating the individual components of attentional biases (Cisler, Bacon, & Williams, 2009; Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, & De Houwer, 2004). For instance, the finding that threatening information is processed more readily when both, threatening and neutral stimuli, are presented can be accounted for by engagement and disengagement processes (e.g., Posner, 1980): On the one hand,

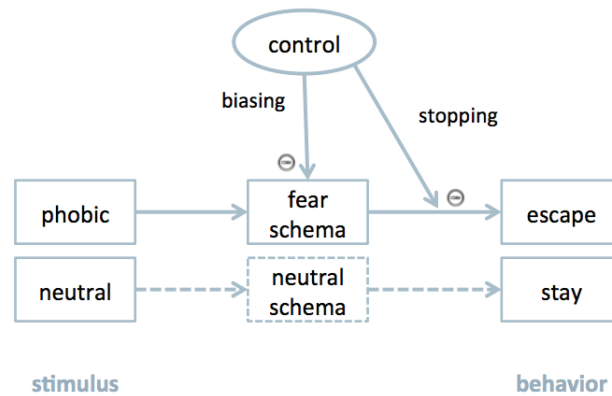


Figure 3. Early and late stage control automatic schema-driven responses.

threatening stimuli may easily capture attention, on the other hand, it may be difficult to disengage attention away from them. The first may be stimulus-driven by an automatic schema, the latter may reflect a lack of attentional control (inhibition and shifting). Additionally, models of selective attention vary in their focus on different phases of processing, namely orientation (e.g., <30 ms), engagement (e.g., 30-500 ms), disengagement (e.g., 500-1000 ms), and avoidance (see Fox, et al., 2001). In particular, there is strong evidence of attentional avoidance in anxious people, i.e. they preferentially allocate their attention away from a threat cue given sufficient time for controlled processes to take place (Koster, et al., 2005; Mogg, et al., 2004).

Attentional biases towards threat have been investigated with numerous variants of experimental paradigms. We will describe the most relevant in the following.

Modified Stroop Task. This task may be the most frequently used bias paradigm in anxiety research (Cisler & Koster, 2010). It builds on the classical Stroop task in which series of letter strings or words are presented in different ink colors. The subject's task is to name the ink color as

fast as possible but not to read the word (Stroop, 1935). The classical Stroop effect has been accounted for by interference between different stimulus attributes such as ink color and semantic meaning (see Cohen, Aston-Jones, & Gilzenrat, 2004, for a review). An informative finding was also that response times can be delayed when neutral words are presented relative to non-readable letter strings (e.g., Monsell, Taylor, & Murphy, 2001). The latter was interpreted as evidence of a stimulus-driven activation of a (reading) task-set that can interfere when an appropriate (readable) stimulus is encountered. Hence, an important affordance of the classical Stroop task seems to be to stay in the relevant task-set and to attend to the relevant stimulus dimension (i.e., the ink color) and to ignore other stimulus dimensions (e.g., its semantic meaning) or to inhibit stimulus-driven competing processes.

The modified Stroop (or emotional Stroop / e-Stroop) task is a close variant of the classical Stroop task. The participant is also asked to name the ink color of presented stimulus words. However, some of the words are anxiety-related (or otherwise relevant to the participant) whereas other words are neutral. The core

finding is that response times are delayed when the semantic meaning of the presented word is anxiety-related relative to when it is neutral. The difference in response times between anxiety-related and neutral words has been considered as reflecting the degree to which anxiety-related stimuli, relative to neutral stimuli, capture attention and interfere with the instructed task-performance. The magnitude of the effect has been considered to reflect an attentional bias. In fact, this bias was found to be increased in participants with anxiety disorders relative to controls (Mathews & MacLeod, 1994).

Numerous experimental studies using this paradigm have shown that people with high levels of anxiety or anxiety disorders respond more slowly when naming the color of anxiety-related words compared with neutral words (Bar-Haim, et al., 2007; Calvo, Avero, Castillo, & Miguel-Tobal, 2003; Matthews & Wells, 2000; Mogg, et al., 2000; Mogg, Mathews, Eysenck, & May, 1991). The absence of an apparent overlap (Kornblum & Lee, 1995) between the anxiety-related semantic meaning of the stimulus and the afforded ink-naming response rules likely that interference does not take place at the stage of response selection, suggesting the modified Stroop task is an adequate measure of attentional biases. However, additional processes such as inhibiting ongoing stimulus driven processes (cf. Monsell, et al., 2001) or a threat-driven generic slowdown (Algom, Chajut, & Lev, 2004) may also contribute to the observed effect. Additionally, it was questioned to what extent the slow-down observed with anxiety-related words was driven by automatic, involuntary processes.

To address this problem it was suggested (MacLeod & Mathews, 1991) to present all stimuli only very briefly (e.g., for 25-30 ms) before masking them, e.g., with a letter string such as "XXXXXX". This should prevent conscious processing

of the stimulus so that stimulus-induced processes can be considered automatic. However, even then, interference control is likely to take place at a later stage when the participant shifts back attention to process task-relevant stimulus attributes.

Dot-Probe Task. Each trial starts with a fixation cross in the center of the screen. Next, two stimulus pictures are presented simultaneously, one on the left and one on the right of the fixation cross. In other variants of this task, words may be used as stimuli, and the stimuli may appear above and below the fixation cross. Importantly, one stimulus is anxiety related, whereas the other is neutral. After a short duration (e.g., 100 - 500 ms), the stimuli are removed from screen and a dot appears in one of the two places where stimuli have been presented before. Participants are instructed to identify the location of the dot as fast as possible by pressing one of two assigned buttons. It is usually found that response times are shorter when the dot appears in the place where the anxiety-related stimulus has been presented relative to when the dot appears in the place where the neutral stimulus has been shown (MacLeod, et al., 1986; see also Williams, et al., 1997, for a review). The difference between both conditions is interpreted as a measure of attentional bias.

In fact, this bias was shown to be increased in anxious individuals, whereas non-anxious individuals were shown to have very small to virtually absent effects (Koster, Crombez, Verschuere, et al., 2004; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; Mogg & Bradley, 1998; Mogg, et al., 2000). The observed effect is conventionally interpreted as reflecting the attention capturing effect of threatening stimuli: Given that the anxiety-related stimulus attracts attention to its location, the dot will be quickly noticed when it appears in the same place. However, the difficulty to

disengage attention from the threatening stimulus or from the location where it has been presented will also lead to slow responding if the dot appears in the opposite location. Hence, the difference in response times between both conditions will likely reflect the joint effects of stimulus engagement and impaired disengagement (inhibition and shifting). Additionally, the facilitating effects of the threatening stimulus will likely occur only at short stimulus presentation intervals, whereas the effect flips around for long presentation intervals (Koster, et al., 2005; Mogg, et al., 2004). In line with the vigilance-avoidance hypothesis, it is assumed that the threatening stimulus captures attention to its location fast and automatically. However, given enough time, controlled processes will lead to an avoidance of the threatening information, shifting attention away from its location.

Spatial Cueing Task. The spatial cueing task (Fox, et al., 2001; Koster, Crombez, Verschuere, et al., 2004; Posner, 1980) is similar to the dot-probe task and also allows for the assessment of spatial allocation of attention. However, variants of this task allow teasing apart the effects of capture (stimulus engagement) and holding (stimulus disengagement). To this end, each trial starts with a fixation cross in the middle of two rectangles. Next, a stimulus appears briefly in only one of these rectangles. After a short presentation interval (ca. 100-500 ms) the stimulus is removed, and a dot appears in either the same or in the opposite rectangle. Participants are asked to press a key indicating the rectangle in which the dot is located. Responses are usually faster when the dot appears in the same rectangle where the stimulus has been presented before. Importantly, this cue-validity effect is moderated by the nature of the cue that can be either threatening or neutral. Trials with spatially valid cues are used to estimate a

capture (stimulus engagement) effect: Faster responses are expected, if the cue is a threatening stimulus, then if the cue is neutral, and this difference serves as the score for the capture effect. Conversely, trials with spatially invalid cues are used to estimate a holding (stimulus disengagement) effect: Slower responses are expected if the cue is threatening then if it is neutral, and this difference effect is taken as an indicator of the holding effect.

The spatial cueing task has also revealed a robust attentional bias effect (Bar-Haim, et al., 2007; Cisler, et al., 2009). Additionally, findings with this paradigm suggest that the attentional bias effect observed in anxious people in dot-probe type paradigms, may be less driven by vigilance effects (capture by a threatening stimulus), but by the difficulty to disengage attention from a threatening stimulus (Koster, Crombez, Verschuere, et al., 2004). In line with the vigilance-avoidance hypothesis, there is also evidence in the spatial cueing task that bias effects are only observed at short cue presentation times. In contrast, at long cue presentation times, effects were found to be absent or even inverted (Koster, Crombez, Verschuere, Vanvolsem, & De Houwer, 2007).

Visual Search Task. This task (e.g., Öhman, Flykt, & Esteves, 2001; Rinck, Becker, Kellermann, & Roth, 2003) also allows for a dissociation of capture (stimulus engagement) and holding (stimulus disengagement) effects. In this paradigm, participants are usually asked to detect one target stimulus among a number of distracting stimuli. In a highly controlled version of this task, all stimuli are presented in a matrix (e.g., 3 x 3 cells) with each cell containing one stimulus. The stimulus feature that distinguishes the target stimulus from the distractors is usually arbitrarily chosen (e.g., color or shape of the picture) and hence not related

to the threatening vs. neutral distinction. In this paradigm, it is usually found that detecting a threatening target among a number of neutral distractors is particularly fast whereas it takes a particularly long time to detect a neutral stimulus among a number of threatening distractors. Hence, the difference between both conditions is particularly large and reliable. However, some specific contrasts are more informative in order to tease apart the effects of capture (stimulus engagement) and holding (stimulus disengagement). Attentional capture is assessed in trials with only neutral distractors. It is usually found that an arbitrarily defined target stimulus is detected faster if it is the only threatening stimulus in the matrix than if the target stimulus is also neutral. Hence, the difference between both conditions is considered a measure of attentional capture. Conversely, attentional holding may be inferred from detecting neutral stimuli in a matrix of either threatening distractors or neutral distractors. It usually takes longer to detect the one neutral target in a matrix of threatening distractors than in a condition where all stimuli are neutral. Hence the difference between these conditions can be taken as a measure of attentional holding.

Also, the visual search task has been successfully used to demonstrate attentional biases in anxiety disorders (Cisler, et al., 2009; Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004; Öhman, et al., 2001; Rinck, et al., 2003) with some positive results.

Situational Influences and Moderators in Attentional Biases

The magnitude of an observed attentional bias can be moderated by a number of factors. Situational factors may interact with personality characteristics to exert an influence on biased information

processing. The most important factors figured out in research are the level of state stress in the current situation, the type and level of threat experienced, and the awareness of threat.

Level of Stress. A number of factors can contribute to the level of stress in daily life. In some studies, hazardous and aversive images were presented (Green, Elliman, & Rogers, 1995; Richards, French, Johnson, Naparstek, & Williams, 1992) or they were conducted in the presence of phobic objects (Chen & Craske, 1998; Mathews & Klug, 1993). In fact, it appears that the obtained effects are largely consistent with the handling of the stress effects. Additionally, effects of (anticipated) academic evaluation were investigated by conducting studies either in close proximity to a major exam or by giving faked feedback concerning a previous test (MacLeod & Mathews, 1988). The importance of state stress was further corroborated in a study in which the level of acute state stress was manipulated giving faked feedback concerning a previous test prior to administering a modified Stroop test and an attention deployment paradigm (Mogg, Mathews, Bird, & Macgregor-Morris, 1990). These results support the view that an attentional bias reflects the level of the current state stress or anxiety, or the activation of related schemata in the individual person.

Type of Threat. Another line of research investigates which situational factors can lead to biased information processing. In the laboratory, this question is usually addressed by investigating the effects of different stimulus types (Martin, Williams, & Clark, 1991). For instance, such studies are concerned with the question of whether extreme valence of an emotional stimulus alone is sufficient, or whether biased processing will only take place if the stimulus belongs to a narrow category corresponding with a relevant schema. For instance, in the above-

mentioned study by MacLeod and Mathews (1988) in the context of an academic test situation, they presented specific academic-threat stimuli (e.g., "examination", "rejection", "error"), stimuli representing general, unspecific threat (e.g., "injury", "infection", "robbery"), and neutral stimuli. It turned out that participants with high trait anxiety revealed an increased attentional bias towards all threat stimuli compared with controls. More importantly, there was a specific interaction in the high stress condition (i.e., one week prior to the exam), revealing that high trait anxious participants paid particular attention to the specific academic-threat stimuli, whereas attention to these stimuli was reduced in the low trait anxious participants. This finding suggests that the specific situation (expecting a major examination) induced or strengthened a specific bias towards academic-failure information, possibly by making relevant, specific schemata more readily accessible.

Level of Threat. Another line of research on the contribution of stimulus characteristics on biased reactions has investigated the level of threat. In fact, there is evidence that only strongly threatening stimuli but not mildly threatening stimuli will elicit an effect in the spatial cueing task among high trait anxious participants (Koster, et al., 2006). In a similar vein, it was found that stimuli experimentally conditioned to predict immediate threat (e.g., burst of noise, see Moratti & Keil, 2009) specifically revealed an attentional bias in the spatial cueing task (Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006). In sum, it appears that biased reactions depend on stimulus characteristics: they only occur with stimuli belonging to specific classes and they also

depend on the level of threat inherent in a stimulus.

Awareness. In line with the vigilance-avoidance hypothesis (Mogg, et al., 2004) it was found that anxious individuals initially orient their attention to threat, but subsequently direct attention away from threat (Koster, et al., 2005; Rinck & Becker, 2006; Rohner, 2002). It was argued that this first attention to threat reflects an automatic stimulus-elicited or schema-driven effect, whereas the avoidance reaction reflects conscious control processes. In fact, if the initial biased reaction was automatic, it should also be elicited when the stimulus is only subliminally presented. This has been investigated in a number of studies (MacLeod & Hagan, 1992; MacLeod & Rutherford, 1992; Mogg, Bradley, & Hallowell, 1994; Mogg, Bradley, & Williams, 1995). It appears to be that an attentional bias can be elicited automatically, even when stimuli are presented subconsciously. However, information processing at this stage does not seem to be very specific and is only refined when more time is given to analyze encountered stimuli.

Attention Strategies as Emotion Regulation

Emotion regulation refers to "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998, p. 275). Consequently, emotion regulation may help reduce attentional biases towards threat.

It has been strongly suggested that the allocation of attention is a core mechanism underlying emotion regulation (Gross, 1998; Koole, 2009). Dysregulation of attention has long been implicated in the pathogenesis and maintenance of emotional disorders (Mathews & MacLeod, 2005).

For instance, an individual may allocate attention onto a distracting stimulus (e.g., a picture on the wall) while receiving an injection at the doctor's office in order to reduce negative affect during the injection. In a recent study, Johnson (2009) presented participants in a dot probe task (explained in more detail below) displaying pairs of angry and happy faces and instructed participants to either focus attention on the happy faces or provided no instruction. Stimuli were presented for 17 ms, 500 ms, and 1250 ms. It turned out that participants were able to allocate their attention to the happy faces only in the longest presentation interval. However, more importantly, those who were instructed to attend the happy faces demonstrated less frustration and negative emotions during a subsequent difficult anagram task. The findings support the notion that goal-setting is efficient at a later, strategic stage of processing (cf. Frewen, et al., 2008; Gladwin, et al., 2011). Additionally, allocating attention to positive stimuli seems to lead to less frustration, indicative of better emotion regulation.

The efficiency of directing one's attention away from threatening aspects of presented stimuli was further corroborated in an EEG study (Dunning & Hajack, 2009): Those participants instructed to attend to less distressing aspects of unpleasant pictures showed a reduced late positive potential, indicative of reduced attention to motivationally salient stimuli. Additionally, it was found that distraction results in reduced memory for threatening stimuli (Sheppes & Meiran, 2008).

To conclude, emotion regulation goals may reduce attention towards threat at later, more strategic phases after stimulus encountering. Additionally, directing attention away from threatening stimuli (i.e., attentional avoidance) can be beneficial for emotion regulation. These observations rule likely that late-stage

attentional avoidance among anxious participants (cf. Koster, et al., 2005; Rinck & Becker, 2006; Rohner, 2002) may occur because these participants attempt to strategically regulate negative affect via distraction.

Note that emotion regulation goal-setting as well as the previously discussed biasing of schemata are forms of top-down control that can be exerted prior to encountering a threatening stimulus. Whereas schema-biasing may directly affect the fast, automatic schema-driven processing (as far as this is possible), emotion regulation goal-setting will serve to voluntarily counteract a bias at strategic processing phases. This is also the stage at which late-stage stopping of a response is elicited. However, attentional control ability and emotion regulation strategies likely draw on separate mechanisms, and moderate attentional biases in distinct manners. Additionally, emotion regulation may not be an ability per se but the reflection of an individual's strategy of coping with negative emotion.

Discussion

The present paper is concerned with attentional biases in anxiety and their assessment with experimental paradigms. Some emphasis is put on the theoretical underpinnings of the experimental assessment tools which seems to be essential for the interpretation of the experimental tasks. Additionally, situational factors and moderators are considered.

A number of theories posit that threatening information is processed differently in anxious individuals (Bar-Haim, et al., 2007; Eysenck & Calvo, 1992; Eysenck, et al., 2007; Mogg & Bradley, 1998; Wells & Matthews, 1994). This finding was attributed to an attentional bias for threatening information. In order to

measure this predicted bias, a number of experimental paradigms were construed, among the most prominent, the modified Stroop task, the dot-probe task, the spatial cueing paradigm, and the visual search task. Using these experimental tasks, evidence of attentional biases was obtained in individuals with clinically relevant anxiety disorders as well as in participants with high trait anxiety (Bar-Haim, et al., 2007; Eysenck & Eysenck, 2007; Ramos-Cejudo, et al., in press).

Two-system models were suggested to understand the interplay of automatic and controlled processes in biased information processing (Casey, et al., 2008; Frewen, et al., 2008; Gladwin, et al., 2011). Most of these models assume that specific stimuli can automatically activate corresponding schemata or networks in our brain. These, in turn, can mediate stimulus-driven effects and elicit specific cognitions, physiological reactions, and response tendencies (e.g., Foa & Kozak, 1986; Lang, 1995; Norman & Shallice, 1980). However, control can be elicited as a means of intervention, so that automatic processes can be stopped or modified. However, control needs time and will, thus, arrive later than the automatic response.

In attentional bias research this interplay of automatic and controlled processes has been incorporated in the vigilance-avoidance hypothesis which states that (anxious) participants will immediately direct their attention towards threat encountered, but that they will redirect their attention away from threat shortly after that (Mogg, et al., 2004). These predictions have been well supported with strong results (Koster, et al., 2005; Rinck & Becker, 2006; Rohner, 2002).

Despite that controlled processes are conventionally assigned to a relatively late stage (Frewen, et al., 2008; Gladwin, et al., 2011), it should be considered that control

could influence information processing on different stages, directly or indirectly. Additionally, prominent models of interference control functions posit a fractionation into several, only moderately correlated interference control functions that broadly correspond with stages of processing: interference control, cognitive inhibition, and behavioral inhibition (Friedman & Miyake, 2004; Nigg, 2000). This suggests relatively independent effects of control, when threatening stimuli are perceived and processed, and when an appropriate response is selected. Not much research has addressed these tentative dissociable control effects in the context of threat processing (but see Klauer, Schmitz, Teige-Mocigemba, & Voss, 2010, for an example with the Implicit Association Test).

In regards to the assessment difficulties of attentional bias, the discussed experimental tasks may offer a unique insight into cognitive processes that may be difficult or impossible to assess by means of self-report, either because the participant is not willing or simply not aware of them. Additionally, the computerized administration of stimuli and the millisecond precision of response collection suggest high reliability of the experimental tasks.

However, scores derived from experimental paradigms should be interpreted with caution. There is still debate, which processes contribute to the observed effect in “attentional bias” paradigms, including automatic and controlled effects at different processing stages. Hence, there is no 1:1 mapping of scores and theoretical constructs. One problem of the experimental tasks is their insufficient process purity. This means, score may be driven by a number of factors other than attentional biases. In a related area of research it was recently shown that the score in the Implicit Association Test

was not only driven by automatic associations, but as well by control functions and strategic processes (e.g., Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005; Klauer, et al., 2010). Such confounding factors have not been systematically investigated in most of the experimental paradigms used in anxiety research.

One other problem of the experimental tasks is their paradigm specificity. This means, they seem to have specific affordances not shared with other paradigms theoretically assumed to tap the same bias. The use of more than one experimental paradigm could help tease apart specific components from a general bias. However, the use of more than one paradigm was only reported in a limited number of studies (Ramos-Cejudo, 2011), and those tend to find low to absent correlations between experimental tasks (e.g., Mogg, et al., 2000). However, despite all procedural differences, attentional biases of at least of moderate magnitude have been observed in anxious participants across different paradigms or between variants of the same paradigms with different parameter settings (Bar-Haim, et al., 2007; Cisler & Koster, 2010). Hence, the presence of an effect that distinguishes people with anxiety disorders from controls is difficult to account for in terms of paradigm-specificity or confounds alone.

Additionally, attentional biases have been found in patients with diagnosed anxiety disorders as well as in people with increased trait anxiety (see Ramos-Cejudo, 2011, for a review), supporting a general underlying mechanism or susceptibility factor (Cisler & Koster, 2010; Ouimet, et al., 2009).

One other aspect that deserves discussion is the suitability of the discussed paradigms for the assessment of individual differences. Especially the low reliabilities

of the obtained scores seem to be problematic. In part, this low reliability is a consequence of computing scores as the difference in test performance between two experimental conditions, particularly when the performance in both conditions is highly correlated (Lord & Novick, 1968; Spreng, 1994). Of course, reliability can be improved by increasing the number of trials. However, if the task gets too long, it bears the danger that participants develop idiosyncratic strategies to cope with its specific affordances. In turn, this will affect what the task measures, the validity of the paradigm.

Finally, individual differences in speed-accuracy trade-offs can affect whether biases are reflected in response times or errors. One possible solution in this respect could be to model response caution (e.g., Klauer, Voss, Schmitz, & Teige-Mocigemba, 2007) or to use process dissociation techniques (Conrey, et al., 2005). At least, trade-offs and confounding factors should be considered when interpreting individual scores. Generally, it can be recommended to use multi-method approaches, including more than just one experimental task, as well as self-report and behavioral data.

Even though scores obtained in bias paradigms, may reflect the interplay of both, automatic as well as controlled processes, this does not invalidate the measure per se. On the contrary, given that automatic and controlled processes also interact in real-world situations, the experimental paradigm remains predictive of real-world information processing. Nevertheless, the dissociation of component processes remains of interest from a theoretical perspective. In fact, one line of research is currently concerned with a fractionation of cognitive biases. One way of doing so is to consider the more specific component scores in some of the paradigms (e.g., capture vs. holding,

Koster, et al., 2005; Mogg, et al., 2004). Another way may be to use process dissociation techniques to statistically tease apart hidden processes (Conrey et al., 2005; Klauer, et al., 2007). Of course, a more profound understanding of the processes involved in biased information processing is also of relevance for the applied field, because it offers insight into how intervention can be best suited.

Nevertheless, caution shall be exercised when interpreting results obtained with experimental paradigms because of their insufficient process purity as well as paradigm specificity (cf. Mogg, et al., 2000). Additionally, the scores obtained tend to have low reliabilities that can turn out as a problem, at least for the assessment of individual differences. Hence, it can be recommended to use more than one paradigm and additionally consider other sources of information, including self-report and behavioral data. Finally, also situational factors shall be considered. Attentional biases are more likely observed when the participant is stressed (e.g., MacLeod & Mathews, 1988) or when specific schemata are pre-activated. Additionally, characteristics of the stimuli encountered can moderate the magnitude of an attentional bias (e.g., Koster, et al., 2006).

Emotion regulation (cf. Gross, 1998; Koole, 2009) may as well reflect the individual's personal strategy of coping with negative emotion. Given that emotion regulation can also affect the accessibility of schemata by means of goal setting, it may also indirectly affect fast and automatic stimulus processing. Attentional control appears to mediate difficulty in disengagement from threat, and emotion regulation goals may mediate attentional avoidance (Gross, 1998). In general, people try to decrease negative emotions, such as

anger, sadness and anxiety. They also try to increase positive emotions, such as love, interest, and joy. Whatever their goals, people do lots of different things to regulate their emotions. For example, people prefer reappraisal to distraction when emotion intensity is low, but prefer distraction to reappraisal when emotion intensity is high because at high intensity levels, reappraisal is often no longer effective (Gross, 2013). To conclude, the effects of control may be manifold and seem to be underspecified in current models of attentional bias. To date, there is not much research available to what extent specific control functions contribute to the observed effect in bias paradigms.

Conclusion

Interference and bias paradigm have contributed to a better understanding of cognitive processes in anxiety. Finding obtained with these paradigms supports theoretical accounts that predict a selective bias for threatening information. Particularly attentional biases (i.e. at the stage of information uptake) have been investigated and found in people with clinically relevant levels of anxiety as well as in people with high trait anxiety. Currently, this vibrant area of research focuses on a number of moderating and mediating factors to improve our understanding under which circumstances biases occur and which processes contribute to them. A number of situational factors and characteristics in the individual have been identified. Still more research is needed to decompose specific processes and to achieve a closer understanding how exactly they interact.

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