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Alterations of the attentional networks in patients with anxiety disorders

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ABSTRACT

Cognitive theories of emotion try to explain how anxious people attend to the world. Despite the increase in empirical research in this field, the specific or general attentional impairments of patients with anxiety disorder is not well defined. We decided to investigate the relationship between pathological anxiety and attentional mechanisms from the broader perspective of the attentional networks. In our study, patients with anxiety disorders and control participants carried out a task to assess efficiency of three attentional networks: orienting, alerting, and executive control. The main result was that anxiety disorders are related to both reduced effectiveness of the executive control network and difficulties in disengaging attention from invalid cues, even when using emotionally neutral information. This relationship between these attentional networks and anxiety may in part explain the problems in the day-to-day functioning of these patients.

1. Introduction

Our knowledge and understanding of emotions have advanced considerably over the last 30 years. During this time, it has become clear that emotions have an adaptive function and they are closely related to cognitive processes (see Dolan, 2002; Pessoa, 2008, for reviews). Usefulness of emotional regulation in maintaining that adaptive role has also been highlighted (Ochsner & Gross, 2008). When a person has problems in controlling emotions under specific circumstances, failing to select the most adaptive option, this can lead to a heterogeneous group of affective disorders such as bipolar affective disorder, depression, or anxiety disorders (DSM-IV-TR, 2000).

Increased prevalence of these disorders and the impairment of quality of life associated with them in both physical and social fields (Barrera & Norton, 2009), has caused a growing interest in therapeutic intervention over the past 25 years (Boschen, 2008). Many efforts have been made in developing adequate therapies and theories highlighting the factors that make us vulnerable to the above-mentioned disorders. Trait-anxiety, disgust sensitivity (McDonald, Hartman, & Vrana, 2008), the Looming Cognitive Style (Riskind, Black, & Shahar, 2010), or experiential avoidance (Berman, Wheaton, McGrath, & Abramowitz, 2010) have been considered among these factors, most of which are closely related to attentional or regulatory processes.

1.1. Anxiety and attention

Empirical research in this field has demonstrated that basic processes of regulation (i.e., attentional deployment, reappraisal, or suppression) rely on the efficiency of the attentional system, thus showing a relationship between attention, regulation deficits and anxiety disorders (Amstadter, 2008; Gross, 1999). Given the important relationship between attention and anxiety (Yiend, 2010), a large body of information-processing biases has been considered by cognitive theories of anxiety explaining how anxious people attend to the world. Specifically, most theories are based on the distinctive sensitivity to threat-related stimuli shown by anxious individuals, leading to a great amount of research using different attentional tasks (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

In general, anxiety is related to hypervigilance and to both facilitation and interference, depending on the procedure that is used to investigate attentional biases. If the negative stimuli are the target to be detected, anxious participants show better performance (Fox, Russo, Bowles, & Dutton, 2001; Öhman & Mineka, 2001; Öhman, Lundqvist, & Esteves, 2001), but when negative stimuli are distracters, performance of anxious participants is consequently impaired due to increased distractibility (Derryberry & Reed, 2002; Fenske & Eastwood, 2003). Although these assumptions are well established, effects of the different types of anxiety (state and trait) on these processes are not yet clear. Some findings

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have led researchers to propose an interaction between trait and state factors or the necessity of both (Broadbent & Broadbent, 1988). Other findings assign the same relevance to results obtained under state and trait-anxiety (Fox et al., 2001). Other authors suggest that trait-anxiety would give rise to a bias to constantly direct attention towards the source of threat, state-anxiety only increasing that threat value (Williams, Watts, MacLeod, & Mathews, 1988).

1.2. Attention and attentional networks

For more than a century, attention was identified by cognitive science as a unitary system. However, it is currently conceived as a group of systems or networks. Corbetta (1998, p. 831) defines attention as "the mental ability to select stimuli, responses, memories, or thoughts that are behaviorally relevant, among the many others that are behaviorally irrelevant." That selection process is based on two complementary and different processing systems (top-down and bottom-up). Other authors (Posner & Petersen, 1990) have proposed three specific functionally and anatomically distinct attentional networks: alerting, orienting and executive control (see Posner, Rueda, & Kanske, 2007, for a review). Therefore, it is important to understand the relationships between the different types of anxiety (state, trait, and clinical) in this broader framework of attention.

The characteristic effects of trait vs. state anxiety on the attentional system could perhaps be better understood if we take into account the Corbetta and Schulman's Neuroanatomical Model of Attention (2002). They differentiate between two distinct attentional systems. One is involved in preparing and applying goal-directed (top-down) selection of stimuli and responses, such as attitudes or strategies, possibly related to personality traits. As mentioned above, trait-anxiety gives rise to a bias to constantly direct attention towards the source of threat. The other system (bottom-up) is sensitive to stimuli salience. Given that state anxiety increases the threat-value of stimuli and/or is a consequence of the events occurring in a particular situation, this kind of anxiety should be related to the bottom-up system. Thus, we propose that it can be helpful to consider trait and state anxiety as being related to top-down and bottom-up systems, respectively. This idea is further supported by recent research (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010).

On the other hand, following Posner and Rothbart, attention can be considered a system with different functions, each subtended by a different set of brain structures (i.e., different attentional networks), all working with the goal of modulating behaviour in order to better adapt to environmental circumstances (Posner & Rothbart, 2007). Therefore the relationship between different types of anxiety and attention could undoubtedly be better understood if we consider attention from this broader perspective.

Alerting network. This alerting system is involved in establishing a vigilant state and maintaining readiness to react. Two types of alertness have been described. Phasic alertness is related to nonspecific activation as induced by warning cues, and can be measured by comparing responses after a warning cue condition providing temporal information with those in a non-cue condition. Tonic alertness refers to sustained activation over a period of time, and is traditionally measured with vigilance tasks in which participants have to maintain attention for long periods of time in order to detect infrequent stimuli. The Alerting network is implemented on brain areas in the right frontal lobe, right parietal lobe and the locus coeruleus, and is influenced by the norepinephrine system (Marrocco & Davidson, 1998).

Orienting network. Orienting refers to the selection of specific information (location or objects) from numerous sensory inputs. This function can be exerted voluntarily (i.e., endogenous orienting) or reflexively (i.e., exogenous orienting), when a salient stimulus draws attention to its location. Posner proposed three elementary orienting operations: *disengaging* attention from its current focus, *moving* to the new location, and *engaging* at the new target or focus. These operations are supposed to be implemented in the superior and inferior parietal lobe, frontal eye fields, the superior culliculus of midbrain and the pulvinar and reticular nuclei of the thalamus (Posner, Inhoff, Friedrich, & Cohen, 1987). The cholinergic system has an important role in the functioning of this network.

Executive control network. The function of this attentional network is thought to be the detection and resolution of conflicts among thoughts, feelings or responses. Different variants of the Stroop, Flanker or Simon tasks are frequently used to study the efficiency of this attentional network (Eriksen & Eriksen, 1974; Liu, Banich, Jacobson, & Tanabe, 2004). Recent studies have identified activation of the anterior cingulated cortex (ACC) and dorsolateral prefrontal cortex (DLPFC) in cognitive conflict tasks (Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Matsumoto & Tanaka, 2004), areas of the mesocortical dopaminergic system.

In this context, Fan, McCandliss, Sommer, Raz, and Posner (2002) developed the Attention Network Test (ANT) to measure the three attentional functions within a single task, combining Posner's cueing paradigm (Posner & Petersen, 1990) with a Flanker task (Eriksen & Eriksen, 1974). Applications of the traditional ANT and its modifications, have demonstrated anatomical independence but cooperation between the three networks (Fan et al., 2002, 2009). Specifically, there are inhibitory relationships between the alerting and executive control network (Posner & Dehaene, 1994), whereas the orienting network raises the efficiency of this last one. The alerting network increases the orienting effect (Callejas, Lupiáñez, & Tudela, 2004).

The attentional networks approach is useful for the exploration of symptoms and pathologies (Berger & Posner, 2000). Specifically the use of ANT and other variants has shown a selective impairment of the executive control network in Alzheimer's Disease (AD; Fernández-Duque & Black, 2006), Borderline Personality Disorder (BPD; Klein, 2003; Posner et al., 2002), Posttraumatic Stress Disorder (PTSD; Leskin & White, 2007), fibromyalgia patients (Miró et al., 2011), and Attention-Deficit Hyperactivity disorder (ADHD; Mullane, Corkum, Klein, McLaughlin, & Lawrence, 2011). Other studies had found alterations of the executive control network together with orienting in squizophrenia (Urbanek et al., 2009; Wang et al., 2005). By contrast, affective disorders such as depression have not revealed any deficit in the functioning of the attentional networks (Murphy & Alexopoulos, 2006; Preiss, Kramska, Dockalova, Holubova, & Kucerova, 2010); although a sadness state has been related to reduced intrinsic alertness (Finucane, Whiteman, & Power, 2010).

2. Antecedents and current work

Taking into account the important relationship between anxiety and attention processes, the existence of very few studies comparing trait vs. state and their role in the attentional biases or vulnerability to produce a disorder, we decided to study the relationship between anxiety (trait, state, and clinical) and the attentional networks. It is important to first investigate this relationship with neutral stimuli, in order to isolate general biases or deficits. If the goal is to understand the general attentional biases underlying anxiety, it seems reasonable to investigate these aspects under task conditions not involving affective material, before introducing the further effects of emotional variables.

In a previous study (Pacheco-Unguetti et al., 2010), a modification of the ANT task (Attentional Network Test-Interactions, ANT-I) by Callejas et al. (2004) was used, because it provides information both about the overall functioning of each network and the

Table 1
Clinical, demographic and mean scores in the questionnaires (State-Trait anxiety, Inventory-STAI, Spanish version, range 0–60; Beck Depression Inventory-BDI, range 0–63; Attentional Control Scale-ACS, range 20–80; and Mood Evaluation Subscales of EVEA, range 0–10 for each factor) for patients and controls and the differences between groups (*p* values).

Patients	Disorder	Age	Sex	Educational level	Trait-anxiety	State-anxiety	BDI	ACS	EVEA-anxiety	EVEA-hostility	EVEA-depression	EVEA-happiness
1	Generalized Anxiety Disorder (GAD) and obsessions	40	F	Medium	36	29	9	47	5.75	2	1.75	4
2	Panic, agoraphobia and GAD	29	M	Medium	26	16	12	47	3	1.75	2.25	6.25
3	Posttraumatic Stress Disorder (PTSD)	52	F	Diplomate	32	35	8	43	4.5	0	5	2.25
4	Panic	39	M	Basic	32	32	12	35	4.75	1.75	4.25	3
5	Panic with agoraphobia	29	F	Graduate	39	34	27	42	5.5	0	7.75	0.75
6	GAD and specific phobia (exams)	24	F	Graduate	24	6	12	64	0	0	2.25	5.25
7	Panic and agoraphobia	32	M	Diplomate	26	8	17	52	0.75	0.5	0.25	8.5
8	GAD	28	F	Graduate	25	26	14	39	5	3.75	7	2.75
9	Panic and agoraphobia	52	F	Medium	28	22	12	43	3.75	5	3.5	5.5
10	GAD	30	M	Graduate	23	4	7	52	0	0	0	7.5
11	Panic and agoraphobia	22	F	Diplomate	15	31	18	62	4.75	4	8.5	3
12	Obsessive disorder	36	F	Graduate	25	19	5	38	4.25	0	1	5.75
	Mean patients	34			28	22	13	47	3.50	1.56	3.62	4.54
	Mean controls	35			12	9	3	56	1	0	1	7
	Patients vs. controls (*p* value)				.000*	.001*	.000*	.005*	.001*	.026*	.006*	.005*

interactions between the networks. Furthermore, in contrast to the original ANT, the ANT-I allows the measurement of costs and benefits in the orienting network, by including a neutral orienting condition apart from the valid and invalid condition. The aim of this study was to dissociate the attentional biases specifically associated with trait vs. state-anxiety, without the implication of emotional stimuli. Results related trait-anxiety to deficiencies in the executive control network, and state-anxiety to an over-functioning of the alerting and orienting networks. This could be explained respectively by an impoverished attentional system involved in top-down control in trait anxiety, and an increased activation of the bottom-up mechanism in state anxiety, as mentioned above. (Bishop, 2009; Bishop, Jenkins, & Lawrence, 2007) found an executive control deficit related to trait-anxiety in a functional imaging study without affective manipulation.

These results suggest the need to consider not only threatening information or circumstantial factors, but also internally controlled aspects, which can be useful to cognitive therapies of clinical populations. One example of an internally controlled aspect could be the ability to deploy attention towards or away from information, or to inhibit irrelevant stimuli or intrusive thoughts.

Moving in this direction, in the current experiment we wanted to determine whether anxiety disorders are related to specific or generalized impairments in the attentional networks. Our hypothesis was that anxiety disorders would be related to a combination of the effects of dispositional and transitory forms of anxiety. Specifically and according to the literature, we predicted greater interference, i.e., reduced effectiveness of the executive control network, in clinically anxious individuals, given that trait is a vulnerability factor to produce anxiety disorders and anxiety trait was related to this deficit in our previous experiments using the same task with neutral stimuli (Pacheco-Unguetti et al., 2010; Pacheco-Unguetti, Lupiáñez, & Acosta, 2009). In addition, anxiety disorders are characterized by cognitive symptoms such as distractibility, difficulties in controlling thinking and reasoning and intrusive thoughts (Beck, Emery, & Greenberg, 2005). These disorders represent a failure to either inhibit a maladaptive response and/or to select an adaptive one (Thayer & Lane, 2000), both of these being directly related to executive functions.

On the other hand, as most patients with an anxiety disorder have higher state-anxiety levels, we also hypothesized differences between groups in the orienting network. We suggested that there would probably be a larger cost to disengaging attention from irrelevant stimuli in invalid trials, because this is a voluntary operation that requires control. Fox et al. (2001) and Fox, Russo, and Dutton (2002) have observed difficulties in disengaging attention from threatening information in anxious participants. It could be that these difficulties are present in the anxious patients even when the information presented is neutral.

Finally, we predicted similar alerting effects in patients and controls. The alerting network is more prone to be influenced by contextual sensitivity and the salience of the stimuli (which in our case have neutral valence), or by a high level of anxiety-state as in the mentioned experiment previously (a greater effect was shown after an anxious mood induction). Neither of these conditions (i.e., negative stimuli or negative mood) took place in the current study. However, the possibility of an over-functioning of the alertness network in the patients cannot entirely be ruled out because their state-anxiety level during the task performance could be higher as a consequence of the disorder.

3. Method

3.1. Participants

Twenty-six participants took part in this study, including thirteen anxiety disorder patients (mean age = 34.30, SD = 9.40, range 22–52; 9 females) who were in the first day of the second week of cognitive-behavioral therapy.[1] As their clinical data shown in Table 1, all our patients met the diagnostic criteria of DSM-IV-TR for one or two combined anxiety disorders as their main psychological disorder, although most of them were diagnosed as having panic or Generalized Anxiety Disorder (GAD). Patients with

[1] We considered the first day of the second week of cognitive-behavioral treatment to be the most appropriate time for our patients to carry out the experiment, following the established protocol for anxiety disorders in this treatment clinic, the Aaron Beck Psychology Centre. In addition, we preferred to avoid the first week of cognitive-behavioral treatment out of sensitivity for our patients and their wellbeing. This is because the technique of repeated exposure is applied about 4 times a week during the first week of their treatment and consequently the anxiety level of patients tends to increase significantly during this time. In the second week, the sessions are more spaced out and patients start to show habituation and reduce their discomfort and anxiety level. We considered, therefore, the first session of this week to be the most appropriate and representative for reflecting their real attentional performance.

comorbid diagnoses of depression did not take part in this study, despite what may appear to be a high level in one case.[2]

Each patient was matched in sex, age, computer skills, and education level with a control participant (mean age = 35.15, SD = 10.72, range 22–60; 9 females), who had never experienced anxiety problems. It should be noted that all data from one patient were lost due to a technical problem with the computer and for another patient, only RT data could be recovered.

Participants had normal or corrected-to-normal vision and were naive as to the purpose of the experiment. Informed consent was obtained from all participants prior to the task and they did not receive any payment for taking part in the experiment. The experiment was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki.

3.2. Apparatus

The experiment was programmed using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) running in a Compaq Presario C735EM laptop computer with a 15.4-in. color screen. Participant responses were collected through the keyboard and a headphone was used to present the alerting signal.

3.3. Procedure and design

The ANT-I task (Callejas et al., 2004) was individually administered to both groups. Participants with anxiety disorder were tested individually in an office located in the Aaron Beck Psychology Center, and their control participants in the Faculty of Psychology laboratory. In both cases, the task was administered under dimly lit conditions and in one session that lasted approximately 50 min. After participants signed the consent form, they read the instructions on the computer screen, which were then summarized and emphasized by the experimenter, who also clarified any questions before starting the experimental task.

Each trial began with a fixation point (a plus sign) presented for 400–1600 ms in the center of the screen. After this and only in half of the trials, an alerting tone was presented for 50 ms. In two-thirds of the trials this was followed after 400 ms by an asterisk that was presented for 50 ms either above or below the fixation point. No asterisk was presented in the remaining third of trials (neutral trials). Fifty ms after the asterisk disappeared, an arrow flanked by two distracting arrows on each side was presented, at the same location as the previous orienting cue (valid trials) or at the opposite location (invalid trials). The distractors could be pointing either in the same direction as the target arrow (congruent trial) or in the opposite direction (incongruent trial). Participants were instructed to press respectively the "z" or "m" key on the keyboard depending on whether the central arrow (i.e., the target) pointed to the left or to the right, while ignoring the flanking arrows (i.e., distractors). Fig. 1 shows the sequence of events on each trial.

Participants completed a practice block of 10 trials with the option to repeat before starting the main experiment if they had any doubts (although no participant needed extra practice). Experimental trials consisted of 6 blocks of 48 trials each, with representation of all experimental conditions, the different trial types being randomly presented within each block. Upon completing the task, participants filled out the Spanish versions[3] of the State-Trait anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1982), the Beck Depression Inventory (BDI; Beck, Rush, Shaw, & Emery, 1979), the Attentional Control Scale (ACS; Derryberry & Reed, 2002) and the Mood Evaluation Scale (EVEA; Sanz, 2001).

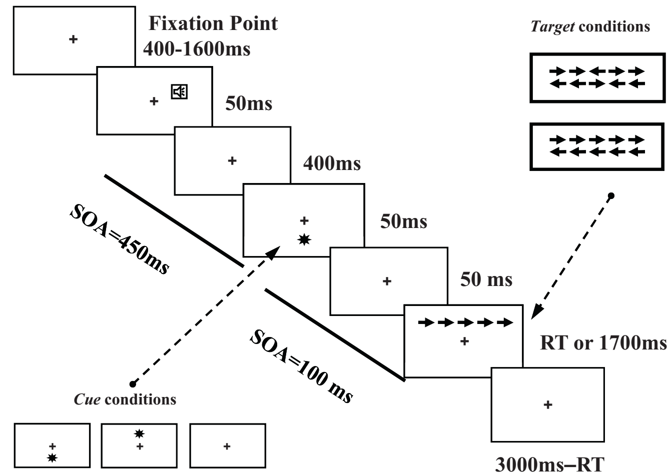

Fig. 1. Sequence of events for each trial of the attention network test-interactions (ANT-I).

The experimenter (the first author) remained in the room during the experiment and left only when the participants filled out the questionnaires. After this, the experimenter explained the aims, hypothesis and clinical implications of the study.

The experiment featured a mixed design with Group (patients vs. controls) as a between-participants factor and Alertness (presence vs. absence of tone), Orienting (neutral vs. valid vs. invalid trials) and Congruency (congruent vs. incongruent) as within participants factors.[4] Both RT and accuracy were considered as dependent variables.

4. Results

4.1. Questionnaire analysis

Unifactorial ANOVAs were carried out on the questionnaire scores for both groups as dependent variable. As shown in Table 1, patients had significantly greater *trait* $F(1,23) = 35.97$; $p < .0001$, and *state* $F(1,23) = 13.89$; $p = .0011$, anxiety levels (with the STAI subscales) than controls. The same result was obtained in the EVEA subscales of *anxiety*, $F(1,23) = 13.28$; $p = .0013$, *hostility*, $F(1,23) = 5.62$; $p = .0264$, and *depression*, $F(1,23) = 9.09$; $p = .0061$. In the subscale of *happiness*, however, the control group had significantly greater scores, $F(1,23) = 9.30$; $p = .0056$. The same analysis with the ACS demonstrated higher scores in control participants, $F(1,23) = 9.41$; $p = .0054$. The patients group achieved lower scores on the self-reported attentional control than the control group.

[2] One of our patients did have a high score in the BDI (27 out of a total of 63, in the Spanish version of this questionnaire). It should be taken into account, however, that this questionnaire was completed and the score obtained on the first day that the patient presented him or herself voluntarily for treatment. Consequently, we do not believe that this score is fully representative of their normal level of depressive symptoms. In addition, the BDI only measures depressive symptoms in the patient over the previous two weeks and does not evaluate depression as a disorder because it is not designed as a diagnostic tool.

[3] The Spanish version of the STAI includes 20 items, each scored from 0 to 3, so that the total varies from 0 to 60, rather than from 20 to 80, as in the English version. The alpha coefficients of the scale are .92 for State Anxiety and .84 for Trait Anxiety. The EVEA is a scale with four factors: Fear-Anxiety, Anger-Hostility, Sadness-Depression, and Joy-Happiness. The alpha coefficients for these factors fluctuate from .88 to .93. The correlation between the Anxiety factor of the EVEA and STAI-State was .81 in a sample of 350 participants. The EVEA includes only 16 items (adjectives referring to mood states; 4 for each factor), which are evaluated in a Likert scale (ranging from 0 to 10). The alpha coefficient of the Anxiety factor is .92.

[4] The Congruence factor (congruent vs. incongruent trials) included in the ANT-I task is a measure of interference and thus provides information about the efficiency of the executive control network. We use 'congruence' to refer to the variable we manipulate, and 'executive control' to refer to the attentional network it indexes.

Table 2
Mean reaction times (RTs) and error rates (in parentheses) for each experimental condition and groups.

Group	Without alerting tone			With alerting tone		
	Neutral	Valid	Invalid	Neutral	Valid	Invalid
Patients group						
Congruent	609(.016)	580(.009)	621(.016)	555(.003)	553(.004)	604(.012)
Incongruent	685(.012)	660(.005)	728(.009)	677(.026)	641(.015)	759(.035)
Control group						
Congruent	604(.003)	656(.012)	602(.009)	557(.009)	544(.003)	585(.003)
Incongruent	676(.012)	632(.012)	681(.050)	634(.027)	604(.019)	693(.038)

4.2. Reaction time analysis

Results were analyzed by means of a mixed ANOVA. Differences between the two groups in the functioning of each attentional network were further analyzed by computing indexes of the efficiency of each attentional network as the following subtractions (Callejas et al., 2004): Alertness = NoTone − Tone conditions (restricted to the neutral condition); Costs = Invalid − Neutral trials; Benefits = Neutral − Valid trials; and Executive control = Incongruent − Congruent. These indexes were correlated with the scores of all participants on the different questionnaires in order to better understand the factors determining the functioning of the attentional networks.

Overall effects. Mean correct RTs per experimental condition after eliminating extreme values (faster than 200 and slower than 1200 ms) were introduced into a 2 (Group) × 2 (Alertness) × 3 (Orienting) × 2 (Congruency) factorial mixed ANOVA (see Table 2). Consistent with the results of the original study (Callejas et al., 2004); and our previous studies (Pacheco-Unguetti et al., 2010, 2009), the main effect of each within-participant variable was significant, showing the effects of *Alertness*, $F(1,23) = 36.07$; $p < .0001$, *Orienting*, $F(2,46) = 141.83$; $p < .0001$, and *Congruency*, $F(1,23) = 266.65$; $p < .0001$, as well as the interactions between Alertness and Orienting, $F(2,46) = 24.64$; $p < .0001$, Alertness and Congruency, $F(1,23) = 14.51$; $p = .0009$, and Orienting and Congruency, $F(2,46) = 21.25$; $p < .0001$. All these main effects and interactions showed the pattern usually observed with this task. Thus, participants were significantly faster in responding when the tone was presented (i.e., under alertness) and on congruent trials (i.e., when less executive control was needed). Regarding orienting, the usual effect of cost and benefits were observed, as responses were faster for valid than for neutral trials, $F(1,23) = 71.19$; $p < .0001$, and slower for invalid than for neutral trials, $F(1,23) = 63.43$; $p < .0001$. Also, the interaction showed the usual reduction of congruency effect on valid trials, and the usual increase in congruency and orienting effects when the tone was presented, as compared to when it was absent. The interaction between the three within-participants factors was also significant, $F(2,46) = 4.41$; $p = .0177$, showing that alertness increased the reduction of interference on valid trials.

Group effects. Regarding the *Group* factor and confirming our hypothesis, analyses revealed a nonsignificant interaction with the *Alerting* network,[5] $F(1,23) = 1.61$; $p = .2171$, but significant interactions with *Orienting*, $F(2,46) = 5.48$; $p = .0073$, and *Congruency*, $F(1,23) = 6.16$; $p = .0207$ (see Fig. 2).

Regarding congruency, and although participants in both groups were slower with incongruent than congruent flankers, $F(1,23) = 170.13$; $p < .0001$ and $F(1,23) = 99.86$; $p < .0001$ respectively, the difference between these conditions was larger in the patients group than in the control group (105 ms vs. 77 ms). Interestingly, this interaction was modulated by alertness, $F(1,23) = 4.73$; $p = .0402$, as the increased interference shown by patients was accentuated in the presence of the tone (122 ms vs. 82 ms).

In the case of orienting, specific analyses were performed to investigate whether the group differences were due to costs or benefits in orienting attention. Costs were computed as the difference between invalid and neutral trials, and benefits as the difference between neutral and valid trials. The ANOVA that was carried out between participants to determine costs, showed significant differences, $F(1,23) = 8.0591$; $p = .0092$, showing that patients had greater cost disengaging attention from the invalidly cued location (46 ms vs. 22 ms). However, the two groups showed attentional benefits of similar magnitude, $F(1,23) = 1.74$; $p = .1989$ (23 ms vs. 32 ms).

4.3. Accuracy analysis

The percentage of incorrect responses per experimental condition was introduced into a 2 (Group) × 2 (Alertness) × 3 (Orienting) × 2 (Congruency) factorial mixed ANOVA. Consistent with the results of the original paper and our previous studies (Callejas et al., 2004; Pacheco-Unguetti et al., 2010, 2009), the main effects of *Orienting*, $F(2,44) = 4.12$; $p = .0227$ and *Congruency*, $F(1,22) = 7.92$; $p = .0101$, were significant. The main effect of *Alertness* was not significant, $F(1,22) = 1.34$; $p = .2591$, although the interaction between Alertness and Congruency was significant due to an increase in the congruency effect in the presence of the alerting tone. No interaction with the factor group was significant.

4.4. Correlations analysis

A correlational analysis was carried out with the mean RT and mean error rates, attentional indexes and the questionnaire scores (see Table 3). It is worth noting that our predictions were confirmed by the significant positive correlation between Trait-anxiety and the attentional indexes of interference and orienting ($r = .60$

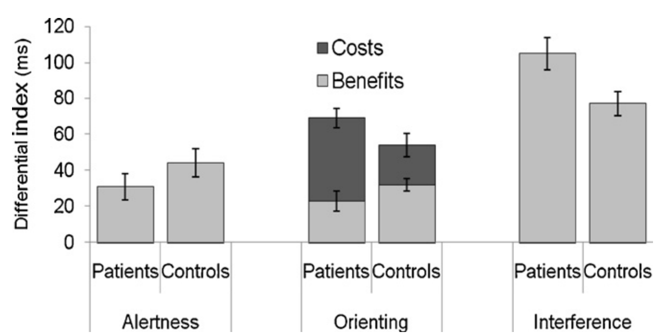

Fig. 2. RT indexes of the three attentional networks as a function of group. Alertness = NoTone − Tone conditions (restricted to the neutral condition); Costs = Invalid − Neutral trials; Benefits = Neutral − Valid trials; Interference = Incongruent − Congruent.

[5] This interaction was still non significant when the analysis was performed exclusively on neutral trials, the optimal condition to measure alertness according to Callejas et al. (2004), $F(1,23) = 1.57$; $p = .2214$.

Table 3
Correlations between RT, error rates, attentional indexes and questionnaire scores.

	Mean TR	Error rates	Attentional indexes					STAI		EVEA				BDI	ACS
			Interference	Alertness	Orienting	Costs	Benefits	Trait Anxiety	State Anxiety	Anxiety	Hostility	Depression	Happiness		
Mean TR		.29	.55**	.35	.05	.04	−.01	.34	.49*	.41*	.04	.26	−.34	.09	−.13
Error rates	.29		.36	.07	−.13	−.09	−.02	−.00	.26	.19	−.20	.07	−.17	−.11	−.21
Attentional indexes															
Interference	.55**	.36		−.01	.08	.17	−.16	.60**	.63**	.62**	.24	.50*	−.49*	.58**	−.59**
Alertness	.35	.07	−.01		.24	.02	.25	.23	.06	.06	−.20	−.10	−.14	−.18	−.18
Orienting	.05	−.13	.08	.24		.74**	.05	.53**	.16	.22	.01	.10	−.22	.30	−.25
Costs	.04	−.09	.17	.02	.74**		−.63**	.34	.27	.30	.32	.34	−.32	.29	−.12
Benefits	−.01	−.02	−.16	.25	.05	−.63**		.10	−.22	−.19	−.47*	−.39	.23	−.09	−.12
STAI															
Trait-anxiety	.34	−.00	.60**	.23	.53**	.34	.10		.66**	.68**	.29	.46*	−.63**	.73**	−.75**
State-anxiety	.49*	.26	.63**	.06	.16	.27	−.22	.66**		.93**	.52**	.83**	−.87**	.65**	−.62**
EVEA															
Anxiety	.41*	.19	.62**	.06	.22	.30	−.19	.68*	.93**		.59**	.78**	−.76**	.62**	−.68**
Hostility	.04	−.20	.24	−.20	.01	.32	−.47*	.29	.52**	.59**		.57**	−.39	.39	−.34
Depression	.26	.07	.50*	−.10	.10	.34	−.39	.46*	.83**	.78**	.57**		−.82**	.71**	−.40*
Happiness	−.34	−.17	−.49*	−.14	−.22	−.32	.23	−.63*	−.87**	−.76**	−.39	−.82**		−.64**	.52**
BDI	.09	−.11	.58**	−.18	.30	.29	−.09	.73**	.65**	.62**	.39	.71**	−.64**		−.47*
ACS	−.13	−.21	−.59**	−.18	−.25	−.12	−.12	−.75**	−.62**	−.68**	−.34	−.40*	.52**	−.47*	

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

and .53, respectively). Participants with a higher score on anxiety showed greater interference and orienting effects in general. Apart from being related to trait-anxiety, the interference factor maintained positive correlations with the state-anxiety subscales of the STAI and EVEA ($r = .63$ and .62, respectively), and the depression scales of BDI and EVEA ($r = .58$ and .50). However, its relation to the attentional control scale and hostility was also significant negative ($r = -.49$ and $-.49$). In contrast, and supporting the RT and error analyses, the alerting index was not significantly correlated with any other variable.

5. Discussion

The aim of this study was to investigate whether anxiety disorders are related to specific or generalized impairments in the attentional networks when no processing of affective information is required. As we predicted, the main findings were a greater interference effect (i.e., difference between incongruent and congruent trials) and a larger cost in disengaging attention from invalidly cued locations in participants with anxiety disorders than controls. These results together with our previous work (Pacheco-Unguetti et al., 2010), allow us to conclude that the anxiety (trait, state and clinical), each have different effects on the functioning of the attentional networks. Specifically, pathological anxiety seems to be a combination of the effects of the other forms of anxiety (dispositional and transitory).

On the one hand, and similarly to trait-anxiety participants in previous studies (Pacheco-Unguetti et al., 2010, 2009), pathological anxiety seems to be related to an impoverished functioning of the executive control network, directly related to voluntary control actions or top-down mechanisms. This might explain why patients had problems voluntarily ignoring distracters throughout the task. This can become more evident in the day-to-day difficulties associated with these disorders, such as distractibility, intrusive thoughts, difficulties in controlling thinking or staying focused on a task. On the other hand, only one specific operation of the orienting network was impaired; the disengagement of attention from invalid onset cues (costs) – a process that specifically requires the endogenous voluntary attention system. However, the automatic engagement towards external stimuli or attentional capture (facilitation effect) was equivalent to the control group.

These results highlight the decreased capacity in voluntary actions or attentional control related to anxiety (Derryberry & Reed, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007), although it is worth noting that here this was observed using only neutral information. Great difficulty to disengage attention from threat-related information in anxious participants has been shown in different studies (Fox et al., 2001, 2002; Georgiou et al., 2005). Therefore, an important contribution of our study is that we observed the effects typically expected for anxious patients dealing with threatening stimuli, in spite of using stimuli with no affective value.

Regarding the alerting network, no significant differences were observed between groups. This network is involved in automatically activating the system for perceiving and reacting to external stimuli, actions more related to the bottom-up mechanism and therefore mediated by stimulus relevance. In our previous work (Pacheco-Unguetti et al., 2010), we found an overfunctioning of this network only in participants who received an anxiety mood induction; it was not associated with trait anxiety. Most patients who suffer from an anxiety disorder have usually been suffering from it during long periods of time. Therefore, they necessarily must learn to adapt themselves to this situation, as it is unsustainable for their system to be constantly in a state of high alertness (in fact, the state-anxiety levels of our patients were below the average values of the normative sample). Consequently, only when a fearinducing stimulus or situation is detected (such as immediately after the mood induction in our study, or in stressing situations in patient's every day life), anxious people might show a higher level of activation that, together with a greater attentional capture, prioritize the detection of negative information. If our reasoning is right, the inclusion of emotional stimuli in the ANT-I with this kind of participants, would give rise also to an overfunctioning of the alerting network. In any case, we observed that the presence of the tone (warning signal) increased the control difficulties of the patients. This suggests an unnecessary reactivity to the control demands driven by alertness.

Besides characteristics or deficits mentioned above (reduced attentional control and impairment in ability to voluntarily disengage attention from an invalid cue), the correlation analyses between the attentional networks indexes, anxiety, and the rest of the variables provide valuable information about their relationship. As could be anticipated from the ANOVA, a positive relationship between the anxiety (trait and state) and the attentional interference index was found. These measures are also positively related to depression scores and negatively to happiness. Additionally, the self-reported attentional control (ACS) and the interference index correlated negatively. This result could be considered as an indirect measure of the validity of this questionnaire. In addition, some differences found in questionnaire measures between the patient and control groups ought to be mentioned. Regarding BDI scores, our findings coincide with the strong comorbidity between anxiety and depression established in the literature (Pollack, 2005). The lower ratings of attentional control (ACS) self-reported by patients are also consistent with previous results (Derryberry & Reed, 2002), corroborating the attentional control difficulties in daily situations reported by anxious patients when they demand clinical attention (DSM-IV-TR, 2000).

The similar pattern of correlations between anxiety and depression measures highlights the need for additional studies. We cannot dismiss the possibility that attentional control difficulties in patients can be explained by a general factor of 'negative affectivity.' As stated above, the comorbidity between anxiety and depression is a fact. We think, however, that the association to reduced attentional control is stronger for anxiety than for depression. The patients in our study asked for therapeutic intervention of their anxiety problems, and their depression values were not excessively high and did not require additional intervention. On the other hand, Murphy and Alexopoulos (2006) and Preiss et al. (2010) found no deficits in attentional networks in depressed participants.

Finally, we should refer to the regulatory processes. As mentioned in the introduction, basic processes of regulation such us attentional deployment or suppression are based on the efficiency of the attention system and therefore can lead to an anxiety disorder in people lacking the appropriate functioning of this attentional system. Therefore, the maladaptive nature of regulation strategies that characterizes anxious people (Amstadter, 2008; Thayer & Lane, 2000), together with the specific attentional deficits here described, seems to be crucial factors in the etiology and maintenance of anxiety disorders in general. Our results support the attentional control theory by Eysenck et al. (2007), in which anxiety is considered a factor that alters the balance between goal-driven and stimulus-driven attentional systems. In anxious patients, the control processes are not effective in maintaining this balance.

In conclusion, findings of the present study outline the specific attentional mechanisms that are involved in anxiety disorders and how they could be related to the day-to-day difficulties associated with clinical anxiety. It is also important to highlight that we have identified the effect of anxiety (trait and state) on these disorders by using neutral information. This allows a greater opportunity to generalise. These insights have substantial implications for the treatment of anxiety problems in general and for emotion regulation and attentional control strategies in particular. Although our sample size was small and the patients group consisted of different subtypes of anxiety disorders, we have provided evidence for the specific attentional alterations involved in pathological anxiety. Future research might examine more precisely the particular subtypes of anxiety disorders, in order to determine whether there are qualitative differences between specific disorders in the functioning of the attentional networks.

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