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Emotional cuing to test attentional network functioning in trait anxiety

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The Attention Networks Test (ANT) has been widely used to assess the three attentional networks proposed by Posner and his collaborators. Here we present a version of the ANT that uses emotionally laden words as cues to evaluate the functioning of the attention networks and their interactions. University students participated in the task and the results replicated those found in previous studies with the original version of the test. Then, those with extreme scores on a trait anxiety scale, STAI (State Trait Anxiety Inventory) were assigned to the low or the high anxiety group. The high anxiety group showed normal patterns in the functioning of the three attentional networks, but negative cues modulated the interaction between the orienting and the executive network. These participants failed to narrow the attention focus to cover the region containing the target, affecting conflict resolution in incongruent trials.

It is now well established that the attentional system of anxious individuals may be quite sensitive to and biased towards threat-related stimuli (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007, for a meta-analysis study; Yiend, 2010). These people

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show a tendency to direct attention toward threatening information during early automatic stages of processing (Williams, Watts, MacLeod, & Mathews, 1997), probably due to pre-attentive mechanisms (Bradley, Mogg, & Lee, 1997; Mathews & Mackintosh, 1998). This attentional bias is thought to be a survival mechanism that permits individuals to detect danger from the aversive environment and react to it very quickly (Öhman, 1997; Öhman, Flykt, & Esteves, 2001). One main function of anxiety is therefore to foster early detection of danger in potentially threatening environments. However, although this functioning might have evolutionary value, excessive detection and further elaboration of threatening material could interfere with the performance of relevant tasks (Beck & Clark, 1997).

Regarding anxiety, we can distinguish two types of attentional bias: effects of facilitation and interference effects. Facilitation effects occur when the negative stimulus functions as a target to be detected quickly (Fox, Russo, Bowles, & Dutton, 2001; Öhman & Mineka, 2001), and interference effects occur when the negative stimulus functions as a distractor (Derryberry & Reed, 2002). In the first case, a high level of anxiety facilitates performance, and in the second case, it impairs it.

Attentional bias to threat information in anxious individuals has frequently been studied with three well-known paradigms: the emotional Stroop, the dot-probe, and the emotional spatial cuing tasks. The emotional Stroop is a variant of the standard colour-word Stroop task (MacLeod, 1991), and neuroimaging studies have shown that this task activates brain areas that are part of the neural circuitry involved in the interactions between attention and emotion (Bush, Luu, & Posner, 2000). The dot-probe and the emotional spatial cuing tasks are thought to assess the way that anxious individuals orient their attention to either neutral or threat-related stimuli. However, contrary to the spatial cuing task, the standard dot-probe task does not allow us to dissociate whether threat-related stimuli engage attention faster or they hinder attention disengagement. Although the results using these tasks have revealed important information about how attention works in anxious people, they assume attention to be a unitary concept (see Broomfield & Turpin, 2005, for a similar view), without taking into consideration how the different components of attention might work in isolation or in a rather interactive way. Posner's model of attention (Posner & Petersen, 1990) might help to understand how emotionally laden stimuli might differently affect the functioning of the attentional networks and their interactions in participants that vary in anxiety.

Fan, McCandliss, Sommer, Raz, and Posner (2002) designed a model task to study the components of visual attention, the Attention Network Test

(ANT). The ANT has proved useful to decompose the attentional system into the three different attentional networks proposed by Posner and Petersen (1990): the alerting, the orienting, and the executive networks. This easy-to-use task is a combination of two other tasks broadly used in attention studies, the cuing task (Posner, 1980) and the flanker task (Eriksen & Eriksen, 1974). Participants are required to press either the left or right key of the keyboard (or mouse) depending on whether the target, a central arrow presented above or below the fixation point, points to the left or the right, respectively. Targets are flanked by four congruent arrows (pointing to the same direction as the target), four incongruent arrows (pointing to the opposite direction of the target) or four neutral lines (the head of the arrows is missing). Four types of cuing trials are used in which different cues might appear before the target display. The cue is not presented in the *no cue* trials. In the *double cue* trials, two asterisks, one above and one below the fixation point, are presented. In the *centre cue* trials, the asterisk is presented at the fixation point location. In the *spatial cue* trials, the asterisk is presented in half of the trials above and in half of the trials below the fixation point. The spatial cue perfectly predicts the target location, and its location corresponds with the location of the central arrow, the target.

The alerting network is involved in achieving and maintaining an alert state, that is, an internal state that prepares the individual to perceive and/or respond to a target. Alerting is manipulated through the use of warning signals prior to target presentation, and the results show that responses are faster when the warning signal is presented. In the ANT, subtracting reaction times (RTs) obtained in the *double cue* trials from RTs in the *no cue* trials gives a measure of alerting due to a warning signal.

The orienting network involves aligning attention with a source of sensory input. Orienting is varied through the use of spatial cues that indicate to the person where to attend to prior to target presentation. Responses are more efficient (fewer errors, shorter RTs) when the target is presented at previously cued locations compared with uncued locations. In addition, lesions of the parietal lobe and superior temporal lobe in humans have been associated with difficulties in several processes related to orienting (Losier & Klein, 2001), and these areas, along with the pulvinar, superior colliculus and frontal eye fields, form part of the orienting network. In the ANT, the orienting score is obtained by subtracting RTs in the *spatial cue* trials from the *central cue* trials.

Executive attention is required by activities that involve planning, novelty, target detection, error detection, monitoring and resolving conflict, and inhibition of automatic responses. The executive network has been extensively explored through the use of conflict tasks such as Stroop-like or flanker-like tasks (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Bush et al., 2000; MacDonald, Cohen, Stenger, & Carter, 2000). The typical result shows increased RTs when the irrelevant stimuli (the word in the Stroop task or the flankers in the flanker task) are incongruent with the response required to the target. In the ANT, the conflict score, revealing the executive attention functioning, is obtained by subtracting RTs in *congruent* trials from RTs in *incongruent* trials.

The ANT advantage over other above-mentioned tasks is that it allows measuring the performance of the three attentional networks simultaneously, within a single task, as well as possible interactions between them. The traditional version and its modifications have revealed their independence, but also the cooperation between the three networks (Fan et al., 2002; Fan, Gu, Guise, Liu, Fossella, Wangc, & Posner, 2009). In general, the studies show inhibitory relationships between the alerting and executive control network (Weinbach & Henik, 2012); the alerting network increases the orienting effect, and the orienting network raises the efficiency of the executive control network (Callejas, Lupiáñez, & Tudela, 2004).

In this context about anxiety and attention, it is important to differentiate the effects of the type of anxiety (state/trait, clinical/sub-clinical) on attentional networks. For example, Pacheco-Unguetti, Lupiáñez, and Acosta (2009), in subclinical participants, the group with a higher score on trait anxiety showed a greater interference effect, reflected in a greater number errors and reduced efficiency, than the low trait anxiety group for the execution of the ANT-I (Attentional Network Test-Interactions, a modified version of the ANT, by Callejas et al., 2004). The ANT-I uses affective sounds in the alerting network. In particular, the executive control network was impaired in high trait anxiety, regardless of the affective nature of the stimuli. The other networks, alerting and orientation, were not impaired. On the other hand, state anxiety produced a greater effect on the networks of alerting and orientation.

In the relationship between pathological anxiety and the attentional networks, the results seem to show that anxiety disorders are related to both reduced effectiveness of the executive control network and difficulty in disengaging attention from invalid cues, irrespective of the valence of the affective signal (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). In general, trait anxiety is related to deficiencies in the executive control network, and state anxiety to an over-functioning of other networks, the alerting and orienting networks (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). Similar results were obtained regarding the executive control network in other types of tasks without affective manipulation (Bishop, 2009; Bishop, Jenkins, & Lawrence, 2007).

Moreover, the ANT has been used in a diversity of studies ranging from meditation (Jha, Krompinger, & Baime, 2007; Tang et al., 2007), genetic studies (Fossella et al., Posner, 2002) and neuroimaging (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). In addition, some versions of the task have been designed to be adapted to children (the child ANT, Rueda et al., 2004), to different modalities (Roberts, Summerfield, & Hall, 2006), or to study the interactions among the three networks (the ANT-I, Callejas, Lupiañez, Funes, & Tudela, 2005; Callejas et al., 2004; Fuentes & Campoy, 2008), and for many other experimental studies (the ANTI-V, Roca et al., 2012).

In the present study, we developed a version of the ANT that uses words of emotional valence as cues (this version is illustrated in Figure 1). This emotional word Attention Network Test allows us to assess the functioning of the attention networks and their interactions in individuals who process emotionally laden stimuli, especially with negative valence. Here, we used the ANT with non-clinical participants who were classified in terms of their trait anxiety level.

The aim of this study was twofold. First, we assessed the appropriateness of this new version of the ANT to measure the three attention networks and their possible interactions. Because a numerical score for each network functioning was provided by Fan et al. (2002) in their study, we could compare the usefulness of words as cues for alerting and orienting. We sought to explore whether both alerting and orienting were affected by the verbal content of the cues compared with non-verbal stimuli (e.g., asterisk in Fan et al., 2002), and whether the negative valence of cues might further affect the networks compared with neutral words. Negative words as cues might also have an effect when participants have to deal with cognitive conflict. Cognitive performance is affected negatively under a high emotion state. For instance, some brain areas that are involved in executive attention increase their activation when participants have to perform attention-depending cognitive tasks, but activation in those areas decreases when a high emotion state is induced experimentally or in emotion-based pathology (Drevets & Raichle, 1998). The converse also occurs, as patients with emotional alteration claim that they feel better when involved in a highly demanding cognitive activity. These reciprocal negative relations between cognitive activity and emotional state are further supported by inhibitory links between some brain areas associated with each other (see Bush et al., 2000, for a review). Therefore, the ANT may help to explore specific issues concerning the mechanisms involved in the interactions between cognition and emotion.

Second, the recruitment of participants with different levels of trait anxiety would provide an excellent baseline to assess attentional network functioning with emotional stimuli in non-clinical individuals with extreme scores on trait anxiety levels, and thus to determine whether the attentional networks indices calculated from our task are effectively influenced by trait anxiety levels (low and high).

Regarding the first aim, we predict similar results in the three attentional networks as in the original version of the ANT. For this purpose, we will use the mean values in individuals with trait anxiety.

In the second aim, we expect that the high trait anxiety (HTA) group, compared with the low trait anxiety (LTA) group, will reveal a greater interference effect when the cues were negative words than neutral words, concretely, in the correct functioning of the executive control. Remember that a high level of anxiety is associated with greater difficulty disengaging attention from negative stimulation, irrelevant to the task (distractor stimulus), due to poorer cognitive control (Eysenck, Derackshan, Santos, & Calvo, 2007; Pacheco-Unguetti et al., 2010).

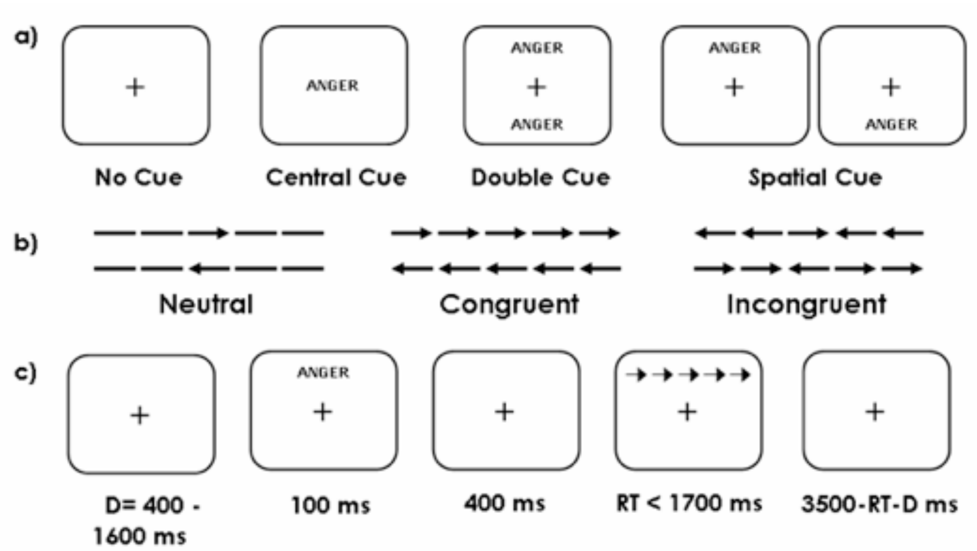
In both aims, between groups differences, HTA and LTA, were found regarding the level of state anxiety. Therefore the results obtained were attributed to the level of trait anxiety.

METHOD

Participants. Two hundred and five undergraduate students (178 females, 27 males) from the University of Murcia, ranging in age from 18 to 23 years, participated in the experiment. They received course credits for their participation. All had normal or corrected-to-normal vision. The participants completed the Spanish version of the Spielberger (1983) State Trait Anxiety Inventory (STAI), the Trait and State subscales. Those participants who scored below the percentile 40 and those who scored above the percentile 60 on the Trait Scale of the STAI formed the low (n = 89, P40 = 14.34, SD= 4.29) and high (n = 86, P60= 31.70, SD =5.4) trait anxiety groups, respectively.

Apparatus and Stimuli. Stimuli were presented on a 15´´ VGA monitor via E-Prime 1.1 installed in PCs running Windows 98. Participants viewed the screen from a distance of 53 cm approximately, and responses were collected via the two buttons of the mouse.

The ANT, as described above and used in Fan et al. (2002), served as a model to design the new test (asterisks were replaced by words, see Figure 1). The sequence of events and exposition durations were identical to those of the Fan et al. study.



Instance of a negative cue trial. a) Four types of cues, b) Six types of stimuli, c) sequence of events and exposure duration

Figure 1. The emotional word Attention Network Test.

Thirty-six Spanish words were chosen from the Redondo, Fraga, Comesaña, and Perea (2005) database about affective content of Spanish words (see Appendix). Eighteen words had negative valence (Mean valence = 2.52, *SD* = 0.49; Mean frequency of usage = 39.36, *SD* = 43.22; Mean of length = 6.06, *SD* = 0.93; range = 1.46), and 18 words were neutral (Mean valence = 5.02, *SD* = 0.07; Mean frequency of usage = 39.91, *SD* = 38.52; Mean of length = 5.89, *SD* = 1.07; range = 0.26). Words differed significantly in terms of valence, $t(34) = 20.98$, $p < .001$), but not in terms of the other variables (all *p*s > .05).

Design. We used a 3 x 3 x 2 factorial design with Cue Type (Centre Cue, Double Cue, Spatial Cue), Flanker Type (Congruent, Incongruent, Neutral) and Cue Valence (Negative, Neutral) as within-participant factors. To assess the effect of trait anxiety on attention network functioning, we included Trait Anxiety Level (Low, High) as a between-participant factor.

We had also *no cue* trials for each flanker type, but because the task did not allow a factorial cross of this cuing condition with cue valence (no words were presented in these trials) we used these trials only for analyses involving the alerting network, separated for negative and neutral double cue conditions. We recorded RTs and error percentages as dependent variables.

Procedure. First, all participants who participated in the present study filled in the STAI (the two subscales, State and Trait) at the time of the ANT session, before the task. Then, they sat in front of the computer screen and read the instructions to perform the ANT. They were encouraged to focus on the centrally located fixation cross throughout the task, and respond as quickly and accurately as possible. We did not instruct them about the emotional valence of the words that served as cues.

They ran one block of 24 trials in which they received feedback both about speed and accuracy of their responses. After practice, the participants ran three experimental blocks of trials with no feedback. Each experimental block consisted of 96 trials. Seventy-two trials used words as cues (3 Cue Conditions × 2 Target Locations × 2 Target Directions × 3 Flanker Conditions × 2 Cue Word Valences). The remaining 24 trials were for the *no cue* trials (2 Target Locations × 2 Target Directions × 3 Flanker Conditions × 2 Repetitions).

Once all participants had completed the STAI (two subscales) and ANT, we formed two extreme groups according to their trait anxiety scores: LTA, and HTA.

RESULTS

The emotional words ANT versus the original ANT

Overall analyses. Mean RTs of correct responses and percentage of errors are displayed in Table 1. We carried out a 3 (Cue Condition: Centre, Double, Spatial) × 3 (Flanker Type: Congruent, Incongruent, Neutral) × 2 (Cue Word Valence: Negative, Neutral) mixed ANOVA both on RTs and errors.

Table 1. Mean RT and error percentage (in parentheses) for each ANT conflict condition, cue type and word valence.

	Neutral Words			Negative Words			
	Cue Type						
	Centre	Double	Spatial	Centre	Double	Spatial	None
Congruency	Overall Analysis						
Congruent	495(0.6)	497(0.2)	486(0.5)	497(0.3)	498(0.4)	491(0.3)	552(0.5)
Incongruent	637(6.2)	627(5.5)	609(3.3)	633(5.4)	629(5.7)	610(4.1)	662(3.7)
Neutral	490(0.9)	489(0.5)	483(0.4)	492(0.6)	493(0.9)	481(0.5)	544(0.9)
	Low Trait Anxiety						
Congruent	503(0.4)	505(0.4)	490(0.3)	504(0.3)	510(0.4)	501(0.4)	561(0.3)
Incongruent	647(5.6)	640(5.6)	621(3.1)	643(5.7)	641(6.0)	617(4.0)	670(3.5)
Neutral	499(0.7)	495(0.6)	490(0.6)	497(0.6)	502(0.1)	485(0.3)	553(0.7)
	High Trait Anxiety						
Congruent	493(0.7)	496(0.1)	488(0.4)	495(0.5)	495(0.3)	488(0.3)	548(0.5)
Incongruent	633(6.3)	624(4.7)	601(3.5)	626(5.1)	624(5.7)	609(3.8)	658(3.7)
Neutral	485(1.1)	489(0.4)	481(0.5)	490(0.2)	489(0.8)	479(0.8)	541(0.9)

RT analysis showed that the main effects of cue type and flanker type were significant, $F(2, 408) = 71.5$, $MSe = 1031.2$, $p < .001$, $\eta_p^2 = .26$, and $F(2, 408) = 974.5$, $MSe = 7501.6$, $p < .001$, $\eta_p^2 = .82$, respectively. There were longer RTs with central and double cues than with spatial cues, and with incongruent than with congruent and neutral trials. The interaction between cue type and flanker type was also significant, $F(4, 816) = 12.7$, $MSe = 774.3$, $p < .001$, $\eta_p^2 = .06$. The main effect of cue word valence, as well as all interactions with this factor, did not reach statistical significance (all *p*s > .20).

The Cue Type × Flanker Type interaction was due to a statistically significant increase in RTs in the incongruent condition when participants were given alerting cues without spatial information (centre and double cues, 632 ms in average) compared with when they were given spatially informative cues (spatial cue, 610 ms), $t(204) = 9.53$, $p < .001$, two-tailed.

In other words, the spatial information of cues decreased the interference effect of incongruent flankers.

Error analysis showed the main effects of cue type, $F(2, 408)=14.8$, $MSe = .002$, $p < .001$, $\eta_p^2 = .07$, and flanker type, $F(2, 408) = 241.96$, $MSe = .003$, $p < .001$, $\eta_p^2 = .54$, were significant, mirroring those of RTs (cue type: centre = 2.3%, double = 2.2%, spatial = 1.5%; flanker type: congruent = 0.4%, incongruent = 5%, neutral = 0.6%). Similarly, the interaction between cue type and flanker type was also significant, $F(4, 816) = 10.2$, $MSe = .016$, $p < .001$, $\eta_p^2 = .05$ (incongruent cues without spatial information = 5.7%, incongruent cues with spatial information = 3.7%; $t(204) = 5.67$, $p < .001$, two-tailed).

Figure 2 shows the scores for each attention network. The efficiency of the alerting network was calculated by subtracting the mean RT in the double cue conditions from the mean RT in the no cue conditions, separately for negative and neutral cue words. The alerting network effects for both negative and neutral cue words were significant, $F(1, 204) = 502.1$, $MSe = 430.2$, $p < .001$, $\eta_p^2 = .72$, and $F(1, 204) = 607.0$, $MSe = 395.0$, $p <.001$, $\eta_p^2 = .76$, respectively. However, there was no statistical difference between the two, $t(204) = 1.67$, $p > .05$, two-tailed.

The efficiency of the orienting network was calculated by subtracting the mean RT in the spatial cue conditions from the mean RT in the centre cue conditions. Because both types of cue conditions used words of different emotional valence, we analyzed the orienting effect via a repeated measure ANOVA with orienting (spatial cue, centre cue) and word valence (negative, neutral) as within-participant factors. Only the main effect of orienting was significant, $F(1, 204) = 106.9$, $MSe = 384.2$, $p < .001$, $\eta_p^2 = .34$.

The efficiency of the executive network was calculated by subtracting the mean RT with congruent flankers from the mean RT with incongruent flankers. As with the alerting network, we assessed the effect of conflict separately for negative and neutral words because the no cue conditions also had to enter in the analyses. The conflict effects for both negative and neutral words were significant, $F(1, 204) = 926.3$, $MSe = 1707$, $p < .001$, $\eta_p^2 = .81$ and $F(1, 204) = 920.6$, $MSe = 1777$, $p < .001$, $\eta_p^2 = .81$. There was no statistical difference between the two, $t(204) = 1.33$, $p > .10$, two-tailed.

Interaction among the networks. For the interaction between alerting (no cue, double cue) and conflict (congruent, incongruent), we conducted separate ANOVAs for negative and neutral cue words on RTs. We found significant interactions for both negative, $F(1, 204) = 28.4$, $MSe = 766$,

$p < .001$, $\eta_p^2 = .11$, and neutral words, $F(1, 204) = 25.4$, $MSe = 792$, $p < .001$, $\eta_p^2 = .08$. In both cases, conflict was greater for the alerting (double cue) condition than for the no cue condition, although the difference was equal for both negative and neutral words (21 ms and 20 ms, respectively).

We assessed the orienting by conflict interaction through a 2 (Orienting: Centre Cue, Spatial Cue) × 2 (Conflict: Congruent, Incongruent) × 2 (Word Valence: Negative, Neutral) ANOVA. Only the Orienting × Conflict interaction reached statistical significance, $F(1, 204) = 30.3$, $MSe = 1034$, $p < .001$, $\eta_p^2 = .13$. Conflict was greater for central (139 ms) than for spatial (122 ms) cues.

In general terms, the present results replicate those of Fan et al. (2002). In the overall analyses, cue type and flanker type variables interacted in such way so that incongruent trials produced less interference when spatial cues were provided than when non-spatial cues were presented. This result was further supported by the conflict by orienting interaction. Interaction between the two networks has also been observed with other versions of the ANT (e.g., Callejas et al., 2004, 2005; Fuentes & Campoy, 2008) and when the task is designed to tap the inhibitory components of the networks (Fuentes, Vivas, & Humphreys, 1999; see Fuentes, 2004, for a review). This interaction shows that the spatial cue word, despite covering a larger area than an asterisk, helped attention to focus on the target location. However, as we will show below, words are less efficient to locate the target than asterisks.

We also observed an interaction between alerting and conflict, that is, conflict increased when warning cues were given. The interaction reflects the negative relationship between the two networks (Posner, 1994; Posner & Raichle, 1994).

Figure 2 shows a comparison of the network effects found by Fan et al. (2002) and those found in the present experiment. The alerting network effect is very similar to that of the previous study, which suggests that neither the verbal content nor the negative valence of cues influenced the efficiency of that network. However, we found important differences in the size of the other two network effects. The orienting network effect was smaller with words than with non-verbal stimuli.

A possible explanation of the reduced orienting effect compared with that observed in the Fan et al. (2002) study might be due to the target being forward masked by the spatial cue word. For instance, Broomfield and Turpin (2005) used a Posner cue-target paradigm and found no facilitation effects of semantic cues in valid trials, likely due to overlap between the cue word and target in those trials. Although overlap occurs in the task used here (the spatial cue was presented at the same location as the string of arrows), as well as in the Fan et al. (2002) study (the asterisk location coincided with the target arrow location), the inclusion of a 400-ms interval between the cue and the target displays prevented masking from occurring in the ANT studies; so masking probably cannot account for the reduced orienting effect in the spatial cue.

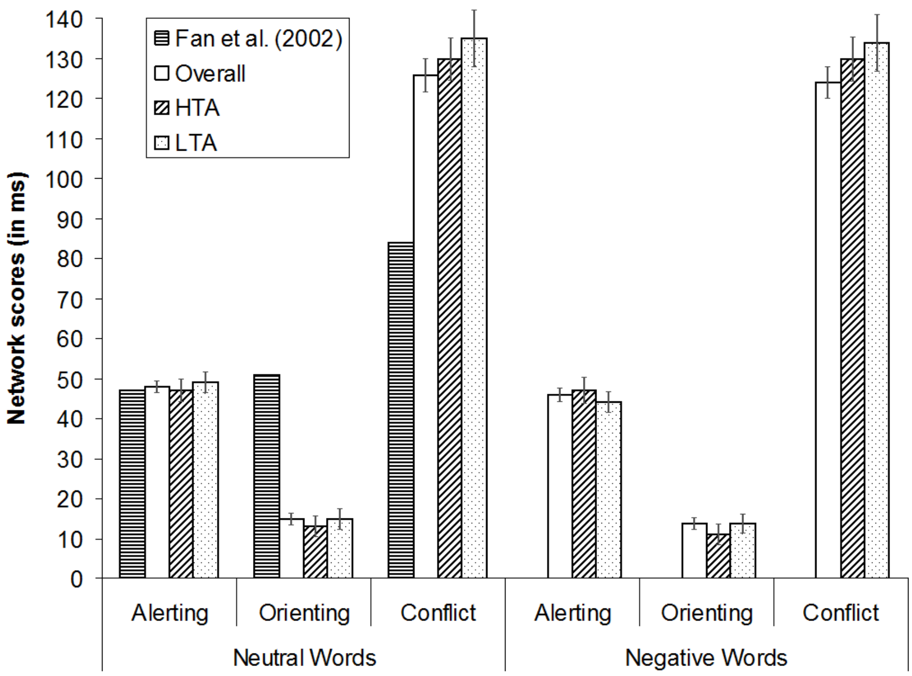


Figure 2. Attention network scores for all participants and for participants with low or high trait anxiety level (bars represent standard error). The results of the Fan et al. (2002) are also plotted for comparison.

A more likely account for the reduced spatial cuing facilitation is that, contrary to the Fan et al. (2002) study, spatial cue words did not help as much as asterisks to narrow the focus of attention to be allocated on the concrete location of the target arrow. In contrast, the word as a spatial cue might have fostered a broader attentional focus to include the whole word, reducing the differences between centre and spatial cues (see General Discussion for a discussion of this issue in more detail).

What is not clear to us is why conflict was so large compared here with that observed by Fan et al. (2002). We used the same target displays as in the original study. One possible explanation is that the use of cue words in most trials might have automatically summoned attention to the semantic domain and it might have delayed its return to a non-verbal domain to resolve the conflict produced by the incongruent arrows. In other types of tasks, the high level of anxiety impairs the phonological loop or visuo-spatial sketchpad (see Eysenck et al., 2007). In any case, these differences in the effect size of the networks, depending on the kind of cues that are used, leave open an interesting issue for further research.

The effect of anxiety on attention network functioning

We further explored whether the functioning of the attention networks, as well as their interactions, are modulated by differences in trait anxiety between the participants.

Error analyses did not detect any significant main or interactive effect involving the between-participants factor (all Fs < 1).

The attention network effects. Figure 2 shows the scores for each attention network separately for negative and neutral cue words, as a function of anxiety level. We assessed the alerting network effect through mixed ANOVAs for both negative and neutral words on RTs, with alerting (double cue, no cue) as the within-participants factor, and anxiety level as the between-participants factor. The alerting network effects for both negative and neutral cue words were significant, $F(1, 173) = 442.6$, $MSe = 402.7$, $p < .001$, $\eta_p^2 = .72$ and $F(1, 173) = 574.5$, $MSe = 341.4$, $p < .001$, $\eta_p^2 = .77$, respectively. However, there was no statistical difference between the two, $t(174) = 1.38$, $p > .10$, two-tailed. The anxiety level did not modulate the efficiency of the alerting network either with negative, $F(1, 173) < 1$, or with neutral cue words, $F(1, 173) < 1$.

We analyzed the orienting effect through a mixed ANOVA with orienting (spatial cue, centre cue) and word valence (negative, neutral) as within-participants factors, and anxiety level (high, low) as the between-participants factor. Only the main effect of orienting was significant, $F(1, 173) = 88.03$, $MSe = 367.7$, $p < .001$, $\eta_p^2 = .34$.

We assessed the efficiency of the executive network through a mixed ANOVA with congruency (congruent, incongruent) and word valence (negative, neutral) as within-participants factors, and anxiety level (high, low) as the between-participants factor. Only the main effect of congruency was significant, $F(1, 173) = 791.3$, $MSe = 3442.5$, $p < .001$, $\eta_p^2 = .82$.

Interaction among the networks. The Orienting × Conflict interaction was statistically significant, $F(1, 173) = 24.7$, $MSe = 1106$, $p < .001$, $\eta_p^2 = .13$, that is, conflict was greater for central (138 ms) than for spatial (120 ms) cues. However, this interaction was modulated by the four-way Conflict × Orienting × Valence × Anxiety interaction, $F(1, 173) = 4.3$, $MSe = 835$, $p < .05$, $\eta_p^2 = .02$. Further ANOVAs were conducted with data from participants who scored either low or high in anxiety.

For LTA participants, the Conflict × Orienting × Valence interaction was not significant, $F(1, 88) = 1.3$, $MSe = 776$, $p > .10$, $\eta_p^2 = .01$. For HTA participants, the Conflict × Orienting × Valence interaction was marginally significant, $F(1, 85) = 3.2$, $MSe = 897$, $p = .079$, $\eta_p^2 = .04$. Further analyses showed that the Conflict × Orienting interaction in the HTA group was significant only for neutral but not for negative words, $F(1, 85) = 12.6$, $MSe = 1130.2$, $p < .001$, $\eta_p^2 = .13$ and $F(1, 85) = 2.45$, $p > .10$, $\eta_p^2 = .03$, respectively. That is, for neutral words we observed the typical conflict reduction in the spatial cue condition compared with the centre cue condition (27 ms of reduction). However, conflict reduction in the spatial cue condition compared with the centre cue condition was not significant for negative words (10 ms of reduction).

The results showed that the interactive functioning of orienting and conflict networks is affected in high anxious participants. The spatial negative cues did not help as much to reduce conflict as did spatial neutral words. A possible explanation of how this negative influence of negative cue words could act in the anxious participants is addressed later on.

GENERAL DISCUSSION

In the present study, we modified the ANT to examine the effects of emotionally laden stimuli on attention network functioning in non-clinical individuals differing in their trait anxiety levels. Results with all participants showed that words with different emotional content can serve as cues for assessing the functioning of the alerting and orienting networks. The alerting network scores mimicked those found with non-verbal material, but the orienting network scores were of smaller magnitude with words than with asterisks, probably because the use of words as cues fostered a broader focus of spatial attention that hindered focusing on the exact target location.

Finally, the conflict scores were larger with words than with asterisks as cues, probably due to words summoning attention to the verbal domain and having to return it to a non-verbal domain to respond to the target arrow direction.

Regarding network interactions, we replicated the alerting network by conflict network interaction found in previous studies. The alerting network has been shown to relate to the conflict network in a rather negative way. In sustained attention tasks, activation in the right parietal and frontal cortices correlates with deactivation in the anterior cingulate cortex, an area involved in executive attention. Participants usually report a kind of "clearance of mind" under such circumstances, which might reduce their control functioning (Posner & Raichle, 1994). Thus, alerting network reduced the effectiveness of the executive network to resolve conflict, increasing RTs in incongruent with respect to congruent trials.

The most important finding of this study concerns the modulation of the orienting and conflict network interaction by negative cues in high anxious participants. Previous studies found that not all components of the orienting network are equally affected by anxiety. Studies with the dot probe task have consistently shown a threat-related bias towards that material in anxious non-clinical and clinical individuals, but the bias could reflect either faster orientation toward or delayed disengagement from threat-related stimuli (Klumpp, & Amir, 2009). The use of a neutral baseline in the dot probe task (Koster, Crombez, Verschuere, & de Houwer, 2004; Salemink, van den Hout, & Kindt, 2007), or the use of an emotional spatial cuing paradigm in which different kinds of emotional stimuli (faces, pictures, or words) are used as cues (Amir, Elias, Klumpp, & Przeworski, 2003; Broomfield & Turpin, 2005, Experiment 1; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Yiend & Mathews, 2001) have revealed that it is the disengagement component of orienting which is affected (delayed) in anxiety. In particular, differences between emotional and neutral cues are found in invalid but not in valid trials.

In some way, these results are pointing in a similar direction as those obtained by several studies about the level of trait anxiety and attentional networks (Bishop, 2009; Bishop et al., 2007; Pacheco-Unguetti et al., 2009), where the group of participants with high trait anxiety showed that the executive control network was impaired, compared with the group of low trait anxiety, irrespective of the affective valence of the stimuli. This result is incongruent with the theories about the effects of threatening stimuli or negative affective valence. Cues were stimuli with emotional significance and more complex from a semantic point of view, which may involve investment of additional resources or neural structures. That might have hindered replication of the results obtained in other studies that, for instance, used the ANT-I attentional task, a variant of the ANT task that increases the effect of alerting network by using auditory signals.

Recent studies with other tasks show that trait anxiety was associated with enhanced attentional capture by irrelevant but salient stimuli (distractors) with a negative valence (Moser, Becker, & Moran, 2012; Theeuwes, 2010).

The emotional modulation of the orienting by conflict interaction in high anxious participants suggests that these individuals might have had difficulties to adjust their attentional focus to localize the target, an operation that previous studies have attributed to the pulvinar nucleus of the thalamus (LaBerge & Buchsbaum, 1990). Conflict reduction is mainly due to participants using the cue to focus their attention on the location of the forthcoming target (the central arrow), fostering the filtering out of irrelevant flankers. That is true not only for asterisks, as in the original ANT, but also for words, as shown in the present study, although the underlying mechanisms and the efficiency in cuing target location may differ in each case (see differences in the orienting effect between asterisks and words illustrated in Figure 2). For instance, LaBerge (1983) showed that the size of the attention focus is larger for words than for letters. Thus, with asterisks as cues, participants do not have to change the size or move the attention focus from the cue position to efficiently localize the target arrow. With words, participants have to adjust the size of the attentional focus from the whole word to a more reduced area around the central letter location (cf. LaBerge, 1983). The reduction of the attention focus would facilitate target location and, importantly, would help to filter out distractor flankers. This adjustment operation, although not perfect probably due to the short cue-target interval used in this task, was done efficiently by all participants when neutral or negative words were used as cues. However, only high anxious participants failed to adjust the attentional focus when negative words were presented. In other words, negative content of cue words may have hindered high anxious individuals from disengaging the attention focus from the location occupied by the whole word. The disengagement deficit may have affected the attention focus-narrowing process, leaving attention broadly focussed on the whole word. The adjustment failure made irrelevant flankers exert their full effect on target responses, preventing any reduction in conflict scores. Other type of studies about social anxiety and facial pictures show also difficulty to disengage attention from negative stimuli (Amir et al., 2003; Buckner, Maner, &

Schmidt, 2010). Thus, inefficiency in the disengagement operation could play an important role in the maintenance of social anxiety.

These results extend the disengagement deficit associated with anxiety to orienting operations occurring within the cue stimulus location. Further research will determine whether the failure to adjust the attention focus when negative stimuli are presented can be overridden if longer cue-target intervals are used.

RESUMEN

Señalamiento emocional para evaluar el funcionamiento de las redes atencionales en ansiedad rasgo. El test de las redes atencionales (*Attention Networks Test*, ANT) ha sido muy utilizado para evaluar las tres redes atencionales propuestas por Posner y colaboradores. Aquí presentamos una versión del ANT que utiliza palabras cargadas emocionalmente como señales de orientación de la atención para evaluar el funcionamiento de las redes atencionales y sus interacciones. Estudiantes universitarios participaron en la tarea y los resultados replicaron aquellos obtenidos en estudios previos con la versión original del test. Aquellos participantes con puntuaciones extremas en la escala de ansiedad rasgo, STAI (*State Trait Anxiety Inventory*) fueron asignados al grupo de baja o alta ansiedad. El grupo de alta ansiedad mostró patrones normales de funcionamiento en las tres redes atencionales, pero las señales con carga emocional negativa modularon la interacción entre la red de orientación y la red ejecutiva. Concretamente, mostraron un déficit en el ajuste del foco atencional para abarcar justo la región espacial que contenía el estímulo objetivo, afectando a la resolución del conflicto en los ensayos incongruentes.

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APPENDIX

Negative words	*Neutral words*
ABISMO (abyss)	AGENCIA (agency)
ABUSO (abuse)	APARATO (device)
ATAQUE (attack)	ATOMO (atom)
BOMBA (bomb)	CAPILLA (chapel)
CELDA (cell)	EDICION (edition)
DISPUTA (dispute)	ENCARGO (order)
FURIA (fury)	MEDIA (average)
HORROR (horror)	MUESTRA (sample)
LESION (lesion)	OBJETO (object)
OLVIDO (forgetting)	OFICINA (office)
PELIGRO (danger)	PALMA (palm)
PENA (pity)	PATA (leg)
POBREZA (poverty)	PENSION (guesthouse)
POLVORA (gunpowder)	PLATO (plate)
PRISION (prison)	RUEDA (wheel)
SANGRE (blood)	TEXTO (text)
SOLEDAD (loneliness)	TURNO (turn)
VANIDAD (vanity)	VAPOR (steam)

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