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The effect of music-induced mood on attentional networks

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Attention network theory suggests that there are three separate neural networks that execute the discrete functions of alerting, orienting, and executive attention. Previous research on the influence of mood on attention has shown subtle and inconsistent results. The attention network theory may aid in clarifying the influence of mood on attention. The present study investigated the influence of mood on attentional networks in a normal population. Participants performed the Attention Network Test (ANT), which provides functional measures of alerting, orienting, and executive attention. Positive or negative mood was induced by listening to music with a positive or negative valence, respectively; neutral mood was induced by reading a collection of basic facts about China. The results revealed that negative mood led to a significantly higher alerting efficiency relative to other moods, while there were no significant mood effects on orienting or executive attention efficiency. According to the algorithm underlying the ANT, the higher alerting efficiency in the negative mood condition can be attributed to relatively greater benefits of cueing effects. The findings are discussed in the context of the noradrenergic system and of evolutionary significance. Specifically, the increase in the alerting function during negative mood states may be due to the modulation effect of negative mood on the noradrenergic system, and/or to the survival benefit resulting from an increase in automatic vigilance towards negative information. The current results suggest that as the influence of negative mood on attention appears to specifically consist in an enhanced alerting function, it may not be found in studies where the three attentional networks are not dissociated.

Keywords: Attention; ANT (attention network test); Mood; Alerting.

La théorie du réseau attentionnel propose l'existence de trois réseaux neuronaux séparés pour accomplir les fonctions distinctes d'alerte, d'orientation et de contrôle exécutif de l'attention. La recherche antérieure sur l'influence de l'humeur sur l'attention a donné des résultats ténus et inconsistants. La théorie du réseau attentionnel pourrait aider à comprendre l'influence de l'humeur sur l'attention. La présente étude porte sur l'influence de l'humeur sur les réseaux attentionnels dans une population normale. Les participants ont effectué *l'Attention Network Test* (ANT) qui permet une mesure fonctionnelle de l'attention au plan de l'alerte, de l'orientation et du contrôle exécutif. L'humeur positive ou négative a été induite par l'écoute de musique associée à une valence positive ou négative selon le cas. Une humeur neutre a été induite par la lecture de données de base à propos de la Chine. Les résultats révèlent que l'humeur négative s'accompagne d'une alerte significativement plus élevée comparativement à ce qui est observé avec les autres humeurs. Il n'y a pas d'effet significatif de l'humeur sur l'attention d'orientation et de contrôle exécutif. Selon l'algorithme sous-jacent à l'ANT, l'efficacité plus grande de l'alerte dans la condition de l'humeur négative peut être attribuable au bénéfice relativement plus grand des effets du signal. La discussion des résultats invoque le système noradrénergique et de leur portée en regard de l'évolution. Plus précisément, l'accroissement de la fonction d'alerte lors des états d'humeur négative pourrait être dû à la modulation de l'humeur négative sur le système noradrénergique et au bénéfice accru du point de vue de la survie résultant d'une plus grande vigilance automatique à l'égard de l'information négative ou, encore, à une seule de

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l'une ou l'autre de ces explications. Les présents résultats suggèrent que, alors que l'influence de l'humeur négative sur l'attention semble expressément produire une fonction d'alerte plus élevée, cette dernière pourrait ne pas être détectée dans les recherches où les trois réseaux attentionnels ne sont pas dissociés.

La teoría sobre redes atencionales sugiere la existencia de tres redes neuronales distintas que ejecutan las funciones discretas de alertar, orientar y la atención ejecutiva. Las investigaciones previas sobre la influencia del ánimo en la atención ha tenido resultados muy discretos e inconsistentes. La teoría sobre redes atencionales puede ayudar a aclarar la influencia que tiene el ánimo sobre la atención. El presente estudio investigó la influencia del ánimo sobre las redes atencionales en una población normal. Los sujetos completaron el Test de Redes Atencionales (TRA) [Attention Network Test], que mide las funciones de alerta, orientación, y atención ejecutiva. Se indujo un ánimo positivo o negativo por medio de música con valencia positiva o negativa, respectivamente; se indujo un ánimo neutro al leer un conjunto de datos básicos de la China. En los resultados se observó que el ánimo negativo conducía a una eficacia de alerta significativamente más alta en relación con otros estados de ánimo, mientras que no se observaron efectos del ánimo respecto de la eficacia en la orientación o la atención ejecutiva. Según el algoritmo subyacente al TRA, la mayor eficacia en la función de alerta con el ánimo negativo puede ser atribuida a los relativamente mejores beneficios de dar pistas. Se analizan los hallazgos dentro del contexto del sistema noradrenérgico y de significado evolucionista. Específicamente, el aumento en la función de alerta durante un estado de ánimo negativo puede deberse al efecto de modulación del ánimo negativo en el sistema noradrenérgico, y/o al beneficio de supervivencia, consecuencia del aumento de la vigilancia automática hacia la información negativa. Los resultados actuales sugieren que dado que la influencia del ánimo negativo sobre la atención parece estar relacionada específicamente con una función mejorada de alerta, es posible que no se pueda observar en las investigaciones donde no estén disociadas las tres redes atencionales.

Converging evidence suggests that mood states have a crucial role in modulating attentional processing. However, previous studies have provided inconsistent results on this topic (e.g., Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008, 2010; Gasper, 2004; Gasper & Clore, 2002; Rowe, Hirsh, & Anderson, 2007). Rowe et al. (2007) found that, relative to neutral mood, positive mood states broadened attentional scope, whereas negative mood had no effect (see also Fredrickson & Branigan, 2005). Conversely, Gasper and colleagues (Gasper, 2004; Gasper & Clore, 2002) reported that, relative to neutral mood, negative mood reduced attention scope, while positive mood had no effect. Additionally, Gable and Harmon-Jones (2008, 2010) showed that attention scope was narrowed by positive affect high in approach motivation, as well as broadened by negative affect low in withdrawal motivation.

Human attention is considered a multimodal system (e.g., Posner & Petersen, 1990). Therefore, the inconsistent results from studies investigating the influence of mood on attention may be due to fact that these studies pertained to different attentional systems (Dennis, Chen, & McCandliss, 2008; Moriya & Tanno, 2009; Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). Recent research suggests that human attention involves at least three anatomically distinct networks that respectively carry out the distinct functions of alerting, orienting, and executive attention (e.g., Fan, McCandliss, Sommer, Raz, & Posner, 2002; Posner & Petersen, 1990). The Attention Network Test (ANT; Fan et al., 2002) was developed to measure the efficiency of each of these three attentional networks via a simple cue and target reaction time task (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). Since 2002, more than 400 citations have confirmed that the ANT has good validity and reliability (http://scholar.google.com).

Attentional alerting involves reaching an appropriate activation level and maintaining a high sensitivity state to detect upcoming signals (Fan et al., 2002; Moriya & Tanno, 2009). The alerting system has been related to the activation of the right frontal and parietal brain areas during continuous performance and vigilance tasks, this activation being primarily linked to the cortical distribution of the brain's norepinephrine system (Coull, Nobre, & Frith, 2001; Fan et al., 2002). Alertness can be further divided into two subtypes: phasic alertness and intrinsic (tonic) alertness (Sturm & Willmes, 2001). Phasic alerting is evaluated by a warning cue that informs the individual when, but not where, a target will appear (Fan et al., 2002; Fernandez-Duque & Posner, 1997). In contrast, intrinsic alerting is usually measured by simple reaction time tasks that are not preceded by a warning cue. As the ANT task involves targets preceded by warning cues, it assesses phasic alerting.

To our knowledge, few studies have attempted to examine the relationship between mood and alertness. Compton, Wirtz, Pajoumand, Claus, and Heller (2004) reported a significant correlation between negative affect and alertness. It is worth noting that the negative affect involved was not unidimensional as it comprised anxiety, depression, anger, fatigue, and confusion.

The orienting network provides the capacity to select information from sensory input and performs three elementary operations: disengaging attention from current location, moving attention to a new location, and engaging attention at the new location (Fan et al., 2002; Moriya & Tanno, 2009). Previous findings have indicated that in Posner's cueing task a negative mood (e.g., anxiety and depression) leads to biased processing for affectively significant stimuli, and thus makes it difficult to disengage attention from threat-related stimuli (Fox, Russo, & Dutton, 2002; Moriya & Tanno, 2009). It has also been demonstrated that people in a positive mood are biased towards processing reward-related stimuli (Tamir & Robinson, 2007). However, it is unclear whether biased processing would occur for non-emotional stimuli in positive or negative induced mood states.

The final network in the attentional system, i.e., executive attention, involves resolving conflict among possible responses and top-down control of attention. The efficiency of executive attention is often assessed in tasks involving cognitive conflict such as various versions of the flanker task in which participants are instructed to respond to a centrally presented target while trying to ignore a simultaneously presented flanker stimulus to the left or right of the target. The typical findings are that reaction times and error rates are higher on incongruent trials, in which the target differs from the flanker stimuli, than on congruent trials, in which the target is identical to the flanker stimuli, suggesting a greater degree of conflict in such trials.

Previous studies indicate that mild negative mood appears to have little effect on executive control processes, whereas positive mood impairs executive functions such as planning, updating and switching (for a review, see Mitchell & Phillips, 2007). Rowe et al. (2007) have shown that positive mood reduced the efficiency of executive attention by loosening inhibitory control and broadening the scope of attention, thus increasing the probability of processing peripheral nontarget flankers, whereas these authors found no effect of negative mood on executive attention. Nevertheless, it is worth noting that not all studies have demonstrated similar effects of positive mood on executive attention relative to neutral mood (e.g., Biss, 2009; Gasper, 2004; Gasper & Clore, 2002). In addition, Pacheco-Unguetti et al. (2010) have reported that negative mood (trait anxiety) was associated with deficiencies in executive attention.

While human attention may consist of multiple subsystems, these systems work synergistically to execute various attentional functions. Therefore, the ANT task, which can measure the three functions both simultaneously and distinctly, is well suited to the study of the effect of mood on attention. In fact, several authors have used the ANT task to measure the three attentional networks under different mood states (e.g., Dennis et al., 2008; Moriya & Tanno, 2009; Pacheco-Unguetti et al., 2010). However, the emotional states involved were assessed through questionnaires, and were of the negative type exclusively. Negative emotion comprises multiple moods such as anxiety, depression, and fear (Dennis et al., 2008; Moriya & Tanno, 2009). It remains unclear whether inducing a specific mood, such as happiness or sadness, influences attentional networks. Importantly, few authors have investigated the influence of experimentally induced specific moods on the three attentional networks.

The present experiment aimed at determining the influence of inducing a specific mood on attentional networks by using a modified version of the ANT. We hypothesized that particular attentional networks would be affected by certain moods, and that all moods would not exert the same effect across all three networks. That is, the effect of mood on the efficiency of alerting, orienting, and executive attention would vary. If some subsystems of the attentional network are modulated by mood, while others are not, the nature of the relationship between mood and attention can be more fully understood. In particular, we expected that a negative mood would selectively enhance the efficiency of alerting and that a positive mood would decrease the efficiency of executive attention. Our primary consideration for making the latter prediction based on Rowe et al.'s study lies in these authors' successful induction of positive mood and in their finding that positive mood influenced executive attention. In comparison, the absence of such an influence in other studies (e.g., Biss, 2009) might be due to the failure of inducing positive mood.

METHOD

Participants

Thirty-six students (25 females, 11 males) aged between 18 and 24 ($M = 21.19$, $SD = 1.85$), who were enrolled in undergraduate programs (in social science) at Southwest University in China, participated for monetary remuneration. All participants were right-handed with normal or corrected-to-normal vision. Informed consent was obtained from all participants prior to data collection.

Apparatus and materials

Stimuli were presented on a Dell monitor controlled by a 3 GHz Pentium processor with the E-prime software package. MDR-v200 Sony headphones were used to present auditory stimuli and a keyboard was used to record participant responses. The traditional ANT was modified by replacing arrows with letters (N and H) to create the congruent (NNNNN, HHHHH) and incongruent (NNHNN, HHNHH) trials. Each letter was presented in a black upper-case Times New Roman 12-point font against a gray background. Participants viewed the stimuli from a distance of 60 cm and the visual angle between the letters was 0.09°. The entire stimulus target subtended a visual angle of 2.86° × 0.38°.

Mood induction and assessment

Recordings of classical music were used to induce positive and negative moods. This technique has been previously validated (e.g., Rowe et al., 2007). A positive mood was elicited by having participants listen to a version of Bach's Brandenburg Concerto No. 3 played by a jazz flautist. Negative mood was induced by having participants listen to Prokofiev's ''Alexander Nevsky: Russia Under the Mongolian Yoke'' played at half speed. A neutral mood was elicited by reading a collection of basic facts about China including natural conditions and social customs, population size, land mass, etc. This neutral mood induction procedure was modeled after a technique used by Rowe et al. (2007). The presentation order of the emotional materials was counterbalanced across participants. A nine-point self-rated scale measuring valence of participant mood (extremely unpleasant to extremely pleasant) was completed both before and immediately after mood induction throughout the experiment. In addition, self-reported overall arousal level was collected at these time points using a nine-point scale, anchored by the end points ''calm'' and ''excited''. To ensure the sustainability and effectiveness of the induced mood, the music involved was played softly throughout formal testing, and the participants were instructed to generate thoughts consistent with induced mood while listening to the music (e.g., the death of someone they loved while listening to the negative music or a happy event while listening to the positive music). In the neutral condition, the participants were asked to generate thoughts consistent with the material they read.

Procedure

At the beginning of each trial, a fixation cross was presented for a random duration ranging between 400 and 1600 ms, followed by the appearance of a cue for 100 ms. There were four cue conditions: no cue, center cue, double cue, and spatial cue (Figure 1a). In the no-cue condition, only the fixation cross was presented in the center of the screen for 100 ms. In the center-cue condition, an asterisk was presented in the center of the screen for 100 ms. In the last two conditions, the fixation

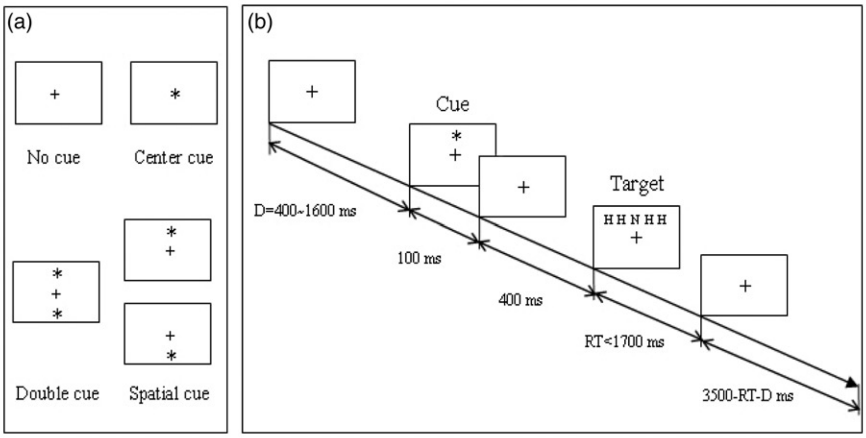

Figure 1. Experimental procedure of ANT task. (a) Cue conditions; (b) example of an incongruent trial under the spatial-cue condition. D = duration; RT = reaction time, + = fixation point, * = cue.

cross was always presented in the center of the screen. In addition, in the double-cue condition, two asterisks were presented simultaneously at two possible target positions for 100 ms; in the spatial-cue condition, an asterisk was presented at the target position for 100 ms. After cue presentation, the fixation cross was again presented for 400 ms followed by the appearance of the target at a visual angle of 0.96° above or below the cross. Target location was always uncertain except on spatial-cue trials. Participants were instructed to focus on the centrally located fixation cross throughout the task (Figure 1b).

Participants were instructed to respond as quickly and accurately as possible by pressing a key on the keyboard in correspondence to the central letter after the appearance of the target. Specifically, half of the participants were instructed to press "F" with the left index finger if the central letter was "N" and to press "J" with the right index finger if the central letter was "H"; the finger-to-key mapping was reversed in the remainder of the participants. The stimuli remained on the screen until the participants responded, but for no longer than 1700 ms. After a response was made, the stimuli disappeared immediately and a post-target fixation point was displayed for a variable duration (3500 ms minus duration of the first fixation minus RT). Each participant completed 24 full-feedback practice trials before mood induction. Formal testing consisted of 96 ANT trials (4 cue conditions × 2 target locations × 2 flanker conditions × 2 target letters × 3 repetitions) after a specific mood induction and self-rating.

Data analysis

Incorrect trials as well as trials on which reaction times (RTs) exceeded three standard deviations above or below the mean RT were excluded from the RT analyses (3% of the total). The efficiency of alerting was defined as $RT_{\text{no cue}} - RT_{\text{double cue}}$, with higher scores suggesting larger alerting effects due to the presentation of cues warning the participants of the upcoming target. The efficiency of orienting was defined as $RT_{\text{center cue}} - RT_{\text{spatial cue}}$, with higher scores suggesting larger orienting effects based on the provision of exact spatial predictive information. The efficiency of executive attention was defined as $RT_{\text{incongruent trials}} - RT_{\text{congruent trials}}$, with higher scores suggesting larger conflict interference and less efficiency. Fan et al.'s (2002) algorithm was used to calculate all three efficiency indicators.

RESULTS

A significance level of .05 was used for all statistical tests.

Mood manipulation check

The mood valence and arousal data as a function of mood are presented in Table 1. To investigate the effect of mood induction, mood valence ratings were entered into a one-way ANOVA with repeated measures on the mood factor (initial/preinduction and after neutral, positive, and negative induction). Mood valence ratings differed significantly according to the mood induction factor, $F(3, 105) = 71.57$, $\eta_p^2 = .67$. Post-hoc comparisons (Tukey's HSD) indicated that after positive mood induction, valence scores were higher than they had been prior to induction, $t(35) = 1.17$. Conversely, valence ratings were lower after negative mood induction relative to the preinduction phase, $t(35) = -2.04$. There was no significant difference between the initial valence scores and the scores recorded after neutral mood induction. The subjective arousal data were analyzed in the same fashion as the mood valence ratings. The overall level of subjective arousal of participants was significantly different across mood induction phases, $F(3, 105) = 11.96$, $\eta_p^2 = .26$. Post-hoc analysis showed that after positive mood induction, subjective arousal was significantly higher than it had been prior to induction, $t(35) = -1.46$. There were no significant differences between the initial arousal scores and the scores recorded after either the neutral or the negative mood induction.

Effect of mood on attention networks

Figure 2 illustrates the mean RTs for each attentional network under each mood condition. To assess the effect of mood on attentional

TABLE 1
Means (standard deviations) of the mood valence and arousal data as a function of mood

	Mood induction			
Measure	*Initial (baseline)*	*Neutral mood*	*Positive mood*	*Negative mood*
Mood valence	5.66 (0.78)	5.35 (0.94)	6.82 (0.86)	3.61 (1.18)
Arousal	4.41 (1.28)	4.59 (0.86)	6.06 (1.68)	4.33 (1.74)

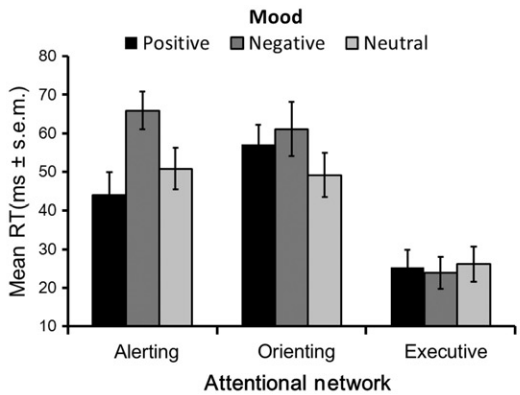

Figure 2. Mean RTs for each attentional network under each mood condition.

networks, correct RTs were submitted to an ANOVA according to a 3 (mood) × 3 (attentional network) within-subject design. The interaction between mood and attentional network was marginally significant, $F(4, 140) = 2.35$, $p = .057$, $\eta_p^2 = .06$. Simple effect analysis indicated that the alerting network was significantly affected by mood, $F(2, 70) = 6.22$, $\eta_p^2 = .15$, whereas the orienting and executive networks were not. Post-hoc (Tukey's HSD) comparisons indicated that the alerting scores under the negative mood condition were significantly greater than those under the positive and neutral mood conditions, $t(35) = 21.90$; $t(35) = 15.04$, respectively. There was no significant difference between the alerting scores recorded in the latter two conditions.

Effect of mood on attention selection

We further explored the effect of negative mood on alerting through an analysis of the effect of mood on attention selection. A three-way ANOVA with repeated measures was carried out to evaluate the effect on RTs of mood (positive, negative, neutral), cue (no cue, center cue, double cue, spatial cue) and congruency (congruent, incongruent). The results showed significant cue × congruency and cue × mood interactions, $F(2, 70) = 3.12$, $\eta_p^2 = .08$; $F(6, 210) = 2.549$, $\eta_p^2 = .07$, respectively. For the interaction between cue and congruency (see Figure 3a), the simple effect analyses revealed that, relative to no cue, $F(1, 35) = 7.40$, $\eta_p^2 = .18$, the presentation of cues—center cue, $F(1, 35) = 30.37$, $\eta_p^2 = .47$; double cue, $F(1, 35) = 47.25$, $\eta_p^2 = .57$; spatial cue, $F(1, 35) = 46.99$, $\eta_p^2 = .57$—led to a larger congruency effect. Similarly, the simple effect analysis for the interaction mood × cue (see Figure 3b) showed that the mood effect was significant for the no-cue, center-cue and

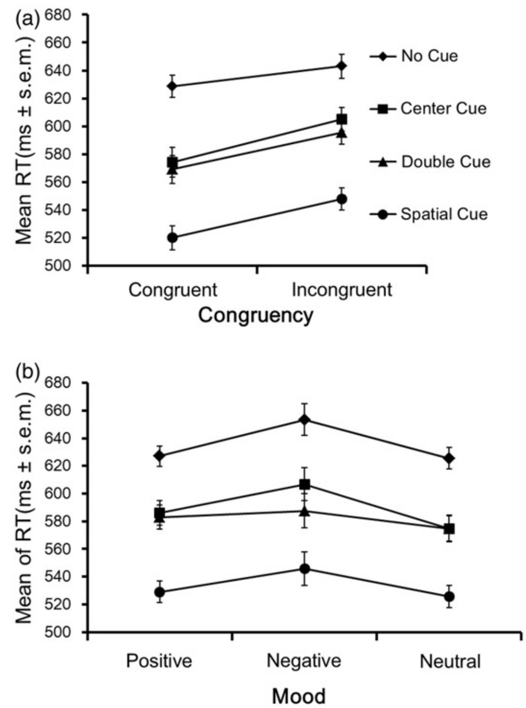

Figure 3. Mean RTs for the alerting attentional network as a function of experimental variables. (a) Mean RTs for correct trials as a function of congruency and cue. (b) Mean RTs for correct trials as a function of mood and cue.

spatial-cue conditions, $F(2, 70) = 7.42$, $\eta_p^2 = .18$; $F(2, 70) = 9.02$, $\eta_p^2 = .21$; $F(2, 70) = 2.86$, $\eta_p^2 = .08$, respectively. However, the effect of mood in the double-cue condition was not significant. Neither the mood × congruency interaction nor the mood × cue × congruency interaction was significant.

DISCUSSION

We measured RTs in a modified ANT task under positive, negative, and neutral moods. Our results followed the same patterns as those found in the original ANT task (Fan et al., 2002), providing validity for the modified letter version. As hypothesized, the results indicated that alerting efficiency was significantly greater in the negative mood condition relative to both positive and neutral moods, while there was no significant effect of mood induction on orienting or executive attention efficiency.

In accordance with ANT, the efficiency of the alerting network corresponded to the difference in RT between no-cue trials and double-cue trials. Therefore, there was a greater difference in RT between the two types of trial during the negative mood condition relative to both positive and neutral conditions. This difference may indicate either enhanced ability to use the double cue to accelerate response times or impaired ability to maintain alertness under the no-cue condition during negative mood induction. In the current study, we found a significant interaction between mood and cue conditions, in that RT during the negative mood condition was slower than during the positive and neutral mood induction under all cue conditions except the double-cue condition (see Figure 3b). That is, the ability for negative mood induction to increase RT was absent only in the double-cue condition. It is possible that the alerting effect of the double-cue condition was large enough to offset the RT delay pattern in the negative mood condition.

Our results on attention during the task may help to explain these results. In the ANT task, as the spatial cue (above or below fixation) and center cue (at the location of fixation) conditions involve a single cue, they are less alerting than the double-cue condition, which orients attention simultaneously above and below the fixation point (Johnson et al., 2008; see Figure 1). In addition, previous studies have shown that negative mood is associated with more focused attention compared to positive and neutral moods (Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007). Consequently, the increased attention during the negative mood condition may enhance the alerting efficiency in the double-cue condition. Thus, the larger alerting effect may be the result of participants in the negative mood condition gaining a greater benefit of the double cues.

Our findings are also consistent with the study conducted by Compton et al. (2004), in which alerting was significantly correlated with negative but not positive mood. Those authors suggest that the greater alerting efficiency during negative mood may be modulated by the noradrenergic system (Compton et al., 2004; Sullivan, Coplan, Kent, & Gorman, 1999). Previous studies have indicated that the noradrenergic system has been implicated in sustained attention and alerting (Coull et al., 2001; Fan et al., 2002; Fernandez-Duque & Posner, 1997). In addition, the noradrenergic system has been associated with negative affect (Sullivan et al., 1999), indicating that the induction of a negative mood may modulate activity in the noradrenergic system and thus yield larger alerting effects. Moreover, from an evolutionary perspective, negative mood is thought to signal an unsafe situation. Therefore, individuals must process information in a vigilant manner and quickly prompt specific actions to increase their chances of survival (Fredrickson, 1998; Gasper, 2004). Finally, previous studies have provided powerful evidence that humans preferentially attend to negative stimuli, exhibiting an automatic vigilance towards them (Estes & Adelman, 2008; Öhman & Mineka, 2001).

The present study found no effect of mood induction on the orienting function of attentional networks. Previous research had shown that this function was impaired among clinical patients (e.g., anxious persons) in that they displayed difficulty in disengaging attention from emotional stimuli (Fox et al., 2002; Moriya & Tanno, 2009). The difference in our results may be due to our use of normal subjects as well as a task involving non-emotional stimuli. To date, no modulatory effects of specific mood induction (such as happiness or sadness) on spatial attention have been reported in normal participants.

Our hypothesis that, relative to negative and neutral moods, positive mood would impair executive attention was not supported. Inconsistent with Rowe et al.'s result that positive affect broadened attention scope, the present findings indicated no significant difference in executive attention functioning under negative, positive, or neutral mood states. Other studies (e.g., Biss, 2009; Gasper, 2004; Gasper & Clore, 2002) have not confirmed the association of positive mood with executive attention. The discrepancy between our findings and those of Rowe et al. may lie in the distance between the flankers and the target. Rowe et al. had the flankers separated from the target according to three spacing levels, i.e., near, medium, and far. Their results suggested that at the far level positive mood resulted in high interference relative to both negative and neutral moods. Additionally, these authors found that at the far spacing level the compatibility effects diminished in the neutral mood condition. However, they did not indicate whether these effects were also present in the near and medium spacing conditions. In the present study, the distance between target and flanker was small and the compatibility effects did not vary as a function of mood.

Alternatively, the difference in target presentation location between the same two studies may explain the discrepancy. In the present case, the target was presented either above or below the central fixation point, while in Rowe et al.'s (2007) case the target was always presented in center. As the present participants were instructed to focus on the centrally located fixation point before target presentation, they had to shift their attention from central fixation to target location above or below. It is possible that they allocated some attentional resources to the cued location and some others to performing the flanker task, thus leaving few resources for the maintenance of mood information (e.g., Dennis et al., 2008). Accordingly, the influence of mood on executive attention would be attenuated, which may in turn result in the nonsignificant difference in the efficiency of attention according to mood.

There are limitations to the current study that are worth noting. The conflict effects of the present letter version of the flanker task were far weaker than the customary arrow version of the same task. It is therefore unclear whether there would be a significant difference in the executive attention network between positive, negative, and neutral moods when the standard ANT task is used. In addition, the current study only addressed how differences in mood valence influenced attentional networks. We found that following positive mood induction, participants reported a significantly higher level of arousal than following neutral or negative mood induction. Therefore, future investigations should examine the effects of arousal as well as mood valence on ANT performance.

In conclusion, the present findings indicate that negative mood induced by music exerted a significant influence on the alerting attention network measured with the ANT. The specific neural substrate of negative mood effects on alerting remains unclear. Further investigation by means of high spatial resolution brain imaging methods (e.g., functional magnetic resonance imaging, fMRI) is needed to extend these findings. The current experiment provides a potentially useful method in the exploration of how mood can influence attention performance or cognitive activities, and the data obtained may uncover a new perspective in the understanding of the relationship between mood and attention. In addition, the present study may open a new avenue for the investigation of the attention-deficit disorders that are based on emotional abnormalities.

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