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The Effect of Induced Sadness and Moderate Depression on Attention Networks

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Abstract

This study investigates how sadness and minor/moderate depression influences the three functions of attention: alerting, orienting, and executive control using the attention network test. The aim of the study is to investigate whether minor to moderate depression is more similar to sadness or clinical depression with regards to attentional processing. It was predicted that both induced sadness and minor to moderate depression will influence executive control by narrowing spatial attention and in turn this will lead to less interference from the flanker items (i.e., less effects of congruency) due to a focused attentional state. No differences were predicted for alerting or orienting functions. The results from the two experiments, the first inducing sadness (Experiment 1) and the second measuring subclinical depression (Experiment 2), show that, as expected, participants who are sad or minor to moderately depressed showed less flanker interference compared to participants who were neither sad nor depressed. This study provides strong evidence, that irrespective of its aetiology, sadness and minor/moderate depression have similar effects on spatial attention.

Human behaviour is influenced by our emotional states, which can sometimes enhance or hinder performance depending on the situational demands (Dolcos, Iordan, & Dolcos, 2011). For instance, sadness, whether short-term or long-term, is known to have significant effects across a variety of cognitive domains, including memory (Bower & Forgas, 2001; Williams, Watts, Macleod, & Mathews, 1997), cognitive control (e.g., Van Steenbergen, Band, & Hommel, 2010), judgment and decision-making (Bodenhausen, Sheppard, & Kramer, 1994; Damasio, 1999; Forgas & Moylan, 1987), as well as attention and perception (e.g., Zadra & Clore, 2011). However, some studies argue that there is limited evidence that sad mood has an effect on attention, and generally less information is known about how sadness influences attention compared to other negative emotional states (Chepenik, Cornew, & Farah, 2007).

One of the first studies looking at the effect of negative mood on attention goes back to Easterbrook (1959), who argued that negative emotions had a narrowing effect on attention. This view was subsequently expanded, such that negative and positive emotions have opposing effects on the attentional system with happiness broadening the scope of attention and sadness narrowing the scope of attention (Fredrickson & Branigan, 2005; Gasper & Clore, 2002). For example, in one study Rowe, Hirsch, and Anderson (2007) used an Eriksen flanker task and showed that happy music led to significantly more flanker interference compared to neutral or sad music. Similarly, Fenske and Eastwood (2003) found that flanker interference was increased when the target was a happy face compared to when it was a sad face. Moreover, Melcher, Obst, Mann, Paulus, and Gruber (2012) revealed that even briefly displayed affective cues, such as happy-related primes, increased Reaction Time (RT) in incongruent trials at a stimulus-based level (e.g., Stroop task) and at a space-based level (e.g., flanker task). However, this global-happy and local-sad distinction has been challenged, with some studies reporting either no effect of sadness on attention (e.g., Finucane, Whiteman &

Power, 2010; Fredrickson & Branigan, 2005, Rowe, Hirsch & Anderson, 2007) or reporting the opposite effect, that sadness broadens attention (Gable & Harmon-Jones, 2010).

One possible explanation for these inconsistent findings could be that the one-dimensional view of negative and positive emotion is too simplistic. For example, Gable and Harmon-Jones (2010) suggested that the level of spatial processing is not determined by emotional valence, but by motivational intensity. They concluded that emotions high in motivational intensity have a narrowing effect on attention in order to facilitate goals; whereas emotions low in motivational intensity have a broadening effect on attention in order to expand cognitive processes after a goal has passed. In support of their theory, they demonstrated that the two negative emotions fear and sadness had opposite effects on the scope of attention (Gable & Harmon-Jones, 2010). Therefore defining emotions in terms of ‘negative’ and ‘positive’ is not always helpful in explaining the link between emotion and attentional processes and other factors need to be taken into consideration.

The need to consider multiple factors is particularly relevant when discussing the effect of sadness on attention. This is because sadness exists in several forms including induced sadness, minor depression, moderate depression and major depression. These different forms share certain characteristics and disentangling the effects of these, and how they affect attentional processing can be complicated. In addition, the relationship between sadness and depression becomes even more complex when one considers the impact sadness and depression has on emotionally valenced stimuli. The literature shows that individuals with major depression are biased to selectively focus on negative information (see Gotlib & Joormann, 2010 for a review), which can be further exacerbated when depressed individuals are in a negative emotional state (Ingram & Ritter, 2000). Therefore, clearly there are many factors which can be taken into consideration when addressing the impact of sadness and depression on attention. In the present study, we address the impact of induced state sadness and minor-to-moderate depression on the processing of non-valenced stimuli.

Theoretically, minor-to-moderate depression can be viewed as lying on a continuum between state sadness (i.e., induced) and major depression (i.e., pre-existing), and comparatively, sadness and depression appear similar both at a behavioural and neural level (Andrews & Thomson, 2009). Depression similar to sadness is an evolved response to complex problems, whose function is to minimize disruption and sustain analysis of those problems (Andrews & Thomson, 2009). Both exist co-morbidly with other negative emotions including anger and anxiety (e.g., Belzer & Schneier, 2004; Westermann, Spies, Stahl, & Hesse, 1996). Further, empirically the patterns of brain activation for sadness and depression also overlap, again suggesting some commonality between sadness and depression (Mayberg et al., 1999). In contrast, the variance between minor to moderate and major depression appears much larger with notable differences in a number of important domains (e.g., level of severity, cognitive processing; Andrews et al., 2007; Andrews & Thomson, 2009). One example of this is that major depression is more strongly associated with cognitive ruminations, referred to as 'brooding' compared to minor depression. This means a depressed person thinks in a negative and passive way about one's problems to the extent that less attentional resources are available for other tasks (Nolen-Hoeksema, 1991; Watkins & Brown, 2002). Such damaging forms of self-evaluation is less associated with minor depression and ultimately as the attentional function of sadness is to narrow attention moderate depression may also have similar effects (Nolen-Hoeksema, 1991).

The effect of sad mood does not only occur at the function of attentional scope, but also at other functions of attention. Ultimately, the ability to monitor and control interference does not only depend on being able to focus attention and inhibit irrelevant information but also on the ability to shift attention and to maintain a level of 'response readiness' what has been also referred to as orienting and alerting (Jonides & Nee, 2005; Posner & Petersen, 1990). These three attentional functions (executive control, alerting, and orienting) have been linked to distinct brain regions (Posner & Petersen, 1990). Collectively, these three functions can be measured using a single paradigm called the Attention Network Test (ANT, Fan, McCandliss, Sommer, Raz, & Posner, 2002), which provides an independent measure of the efficiency of each attentional network (Callejas, Lupianez, & Tudela, 2004). The ANT consists of an arrow discrimination task, combined with an acoustic warning tone (alerting efficiency), a spatial cue (orienting efficiency) and surrounding flanker arrows (executive control efficiency). The tone could be either present or absent, the cue either valid (i.e., it appeared at the same location as the target arrow) or invalid, and the flankers either congruent (i.e., they pointed in the same direction as the target arrow) or incongruent. It is expected that the ANT provides a more discriminative measure of attentional functioning compared to other paradigms, but this paradigm has only been used a handful of times in the context of emotion-attention studies (Cohen, Henik & Mor, 2011; Birk, Dennis, Shin, & Urry, 2011; Dennis & Chen, 2007; Dennis, Chen, McCandliss, 2008; Finucane, Whiteman & Power, 2010; Techer, Jallais, Fort, & Corson, 2015).

The present study uses a variant of ANT, which provides information about both the individual effects of each network including their interactions (ANT-I, Attention Network Test-Interaction, Callejas et al., 2004). This task was used to investigate the effect of induced sadness and of minor/moderate depression on the three attentional functions. An important question this study aims to address is whether depression, in its very mild forms, is equivalent to a prolonged state of sadness? If that were the case then attentional effects should be very similar for induced sadness and minor/moderate depression (i.e., narrowing attention). Specifically we predicted that that induced sadness and minor/moderate depression will lead to reduced congruency effect compared to the control/no depression groups while there will be no differences in terms of both the alerting and the orienting functions.

Experiment 1

Experiment 1 investigates how induced sadness influences the three attentional networks (alerting, orienting, and executive control). Based on previous studies it is expected that sadness will influence executive control by narrowing attention (e.g., Gasper & Clore, 2002; Melcher et al., 2012), reducing the amount of interference from neighbouring distractor items.

Sadness is considered to be less associated with both alerting and orienting, as they are common characteristics of emotional states that are high in arousal (e.g., fear; Pacheco-Acosta, Callejas, & Lupianez, 2010). In order to induce a sad emotional state participants' watched an emotional video related to themes of death and injuries (i.e., car accidents). This differs from other studies using the ANT (e.g., Finucane et al., 2010), which used emotional pictures. Pictures have been shown to be less effective in terms of inducing discrete emotional states, and they are also limited in terms of inducing a prolonged intense emotional state (Rottenberg, Ray, & Gross, 2007). Thus the use of video stimuli should facilitate the emotion induction of discrete emotional categories as opposed to general negative affect, and it should also enhance the intensity of the emotional experience.

Method

Participants. Forty participants (thirteen male; mean age 24.7 years, range 18-51 years) from the University of Warwick participated in the study for £5 payment. Sample size was determined beforehand based on similar studies reporting effects in the ANT (Jiang, Scolaro, Bailey, & Chen, 2011; Pacheco-Unguetti et al., 2010; Pêcher, Quaireau, Lemercier, &

Cellier, 2011; Keehn, Lincoln, Müller, & Townsend, 2010). Participants reported normal or corrected to normal visual acuity. They were naïve to the purpose of the experiment and they gave informed consent. The study was approved by the University of Warwick Psychology Ethics Committee.

Apparatus and stimuli. Stimuli were presented on a 19”CRT (60 Hz) running at a 1024x768 pixels resolution. Participants viewed the monitor at a distance of approximately 57 cm. The experiment was controlled by an IBM-PC compatible computer using custom written software. Participants’ responses were recorded using the left and right arrow keys of the computer keyboard. Participants were wearing headphones for the duration of the experiment.

Videos and background music were used to elicit in participants either a sad or a neutral emotional state. In the sad emotion condition a collection of six film sequences were taken from advertisements on driving safety. The sequences typically consisted of scenes involving car accidents and the overall video lasted 4:05 minutes. In the neutral emotion condition the video consisted of scenes of cars driving without any accidents (3.57 min). Music was played during each video through headphones to enhance the emotional experience of the video. In the sad condition the song "My Immortal" composed by "Evanescence" was played, and in the control condition the song "VCR" composed by the band "The XX" was played.

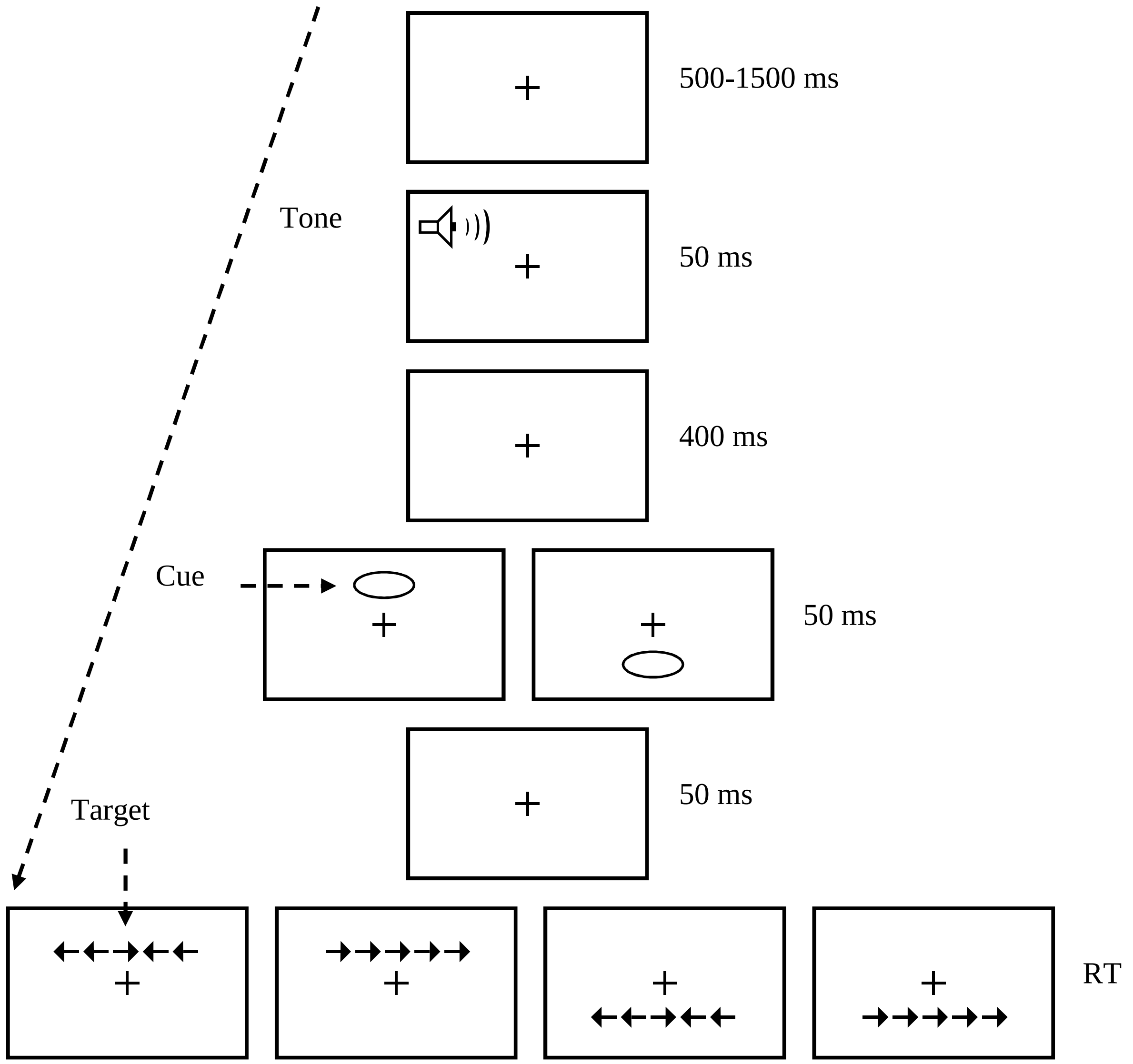

Figure 1. Sequence of events in an example trial of the ANT-I in Experiment 1. A tone (present or absent) was followed by a spatial cue (top or bottom), which in turn was followed by target arrow. The target was presented either at the cued or uncued location and surrounded by either congruent or incongruent flanker arrows. In this example participants were required to give a right arrow response. The word "Error" was presented for 1s after wrong responses, and the inter-trial interval was 1s.

In the ANT-I stimuli were drawn in grey (RGB values: 128, 128, 128) on a black background and with a line thickness of five pixels (~0.18°). The fixation cross was at the centre of the screen and had a size of 1.5°. The cue was a horizontal non-filled oval (1.6º x 0.8º) and was presented either 5.4º above or below fixation. The arrow stimuli had an overall length of 1.5º and were composed of a horizontal line (length 1.0º) and a right-angled equilateral filled triangle (0.5º x 0.7º) pointing to the left or to the right. Arrows were presented either 5.4º above or below fixation, with the target arrow at the centre (horizontally aligned with fixation), and with the adjacent flanker arrows 5.4º and 2.7º to the left and to the right of the target (see Figure 1). The alerting tone consisted of a short auditory bleep (~400Hz) played for 50ms.

Procedure. On arrival to the experiment, participants filled in a consent form and read the instructions. Then they filled in the Differential Emotions Scale (DES, Izard, Dougherty, Bloxom, & Kotsch, 1974; Philippot, 1993), which includes ten emotion categories (interest, amusement, sadness, anger, fear, anxiety, disgust, contempt, surprise, and elatedness) with three adjectives representing each category. Participants had to rate on a five-point scale from one (“not at all”) to five (“very strongly”) the extent to which these adjectives corresponded to their current emotional state. Participants were then randomly assigned to either the sad or the control condition and watched the corresponding video. After watching the video they completed another DES.

Following this, participants preformed the ANT-I (Callejas et al., 2004). The experiment consisted of one practice block with twenty trials and four experimental blocks with 64 trials in each (276 total). Between blocks were short breaks where participants listened to the first 20 s of the song that was played during the emotion induction, to act as an “emotion enhancer”. Following the completion of the ANT-I, participants rated again their emotion state with the DES.

The sequence of events in a single trial is depicted in Figure 1. Each trial, started with a central fixation cross presented for a duration of between 500 ms and 1500 ms. On half of the trials, the fixation cross was followed by an alerting tone (in the other half of the trials no tone was played). After another 400 ms the cue appeared for 50 ms, which shortly after (50 ms) was followed by the target arrow. The target arrow appeared in half the trials at the same location as the cue (valid cue) and in the other half at the other location (invalid cue). The target was surrounded by flanker arrows that were pointing either in the same direction as the target (50% congruent flanker) or in the opposite direction (50% incongruent flanker). The target stayed on until the participant responded. The participant's task was to indicate the direction of the target by pressing the corresponding left or right arrow key on the keyboard. Error feedback consisted of the word "Error" presented at the centre of the screen for 1s. The inter-trial interval was 1s. Participants were asked to respond as quickly and accurately as possible making less than 5% errors overall.

Design. A 2x2x2x2 mixed design was used with Alerting (tone, no tone), Orienting (valid, invalid) and Congruency (congruent, incongruent) as within-subject factors and with Emotion Condition (sad, control) as a between-subject factor. Combinations of within-subject factors were presented in random order, and participants were assigned alternatingly to either the sad or the control condition.

Analysis. The data was analysed using SPSS version 22 (IBM Corp., Armonk, NY). RT indexes for each attention network were calculated using the mean RTs for each combination of the 2x2x2x2 design, excluding errors and outliers (RTs below 200 ms or above 2000 ms). The alerting index was calculated by subtracting the mean RT of the four conditions with a tone from the mean RT of the four conditions without a tone. The orienting index was calculated by subtracting the mean RT of the conditions with a valid cue from those with an invalid cue. The executive control index was calculated by subtracting the mean RT of the conditions with congruent flankers from those with incongruent flankers. The effect of

Emotion Condition on the attentional networks was tested with a 2x2x2x2 mixed design ANOVA, with the within-subject factors Alerting (tone, no tone), Orienting (valid, invalid) and Congruency (congruent, incongruent), and the between-subject factor Emotion Condition (sad, control).

Results

Differential Emotions Scale (DES). Table 1 shows the subjective ratings averaged separately across participants in each group for each emotion category at time 1, time 2, and time 3. In order to further analyse these ratings, ten separate mixed design ANOVAs with the within-subject factor time (T1, T2, or T3) and the between-subject factor group (control or sad) were run separately for each emotion category (using Bonferroni correction to adjust α). In order to summarize the results, we have grouped together emotion categories that showed a similar pattern. The positive emotions (amusement, interest, elatedness) decreased in both groups, over time (time main effect, all ps < .001), and this was exacerbated for amusement and elatedness in the sad group (interaction effect, both ps < .005). Participants reported stronger negative feelings over time for contempt, disgust, and fear (time main effect, all ps < .005). Finally, participants reported significantly stronger sadness and disgust only after the sad video and not after the neutral video (interaction effect, all ps < .005). This effect was stronger for sadness (increase by 1.2) than for disgust (increase by 0.95) or fear (increase by 1.0).

Table 1. The mean subjective ratings for each emotion category and group in Experiment 1.

	Control Group (n = 20)			Sad Group (n = 20)		
Emotion	Time1	Time2	Time3	Time1	Time2	Time3

Amused	3.15	2.90	1.95	3.50	2.30	2.20
Angry	1.50	1.65	1.75	1.45	2.00	1.55
Anxious	1.50	1.65	1.50	1.95	2.50	2.45
Contempt	1.15	1.10	1.35	1.10	1.70	1.60
Disgust	1.25	1.15	1.30	1.10	2.05	1.65
Fearful	1.25	1.50	1.35	1.35	2.35	1.65
Interested	3.50	3.50	2.35	3.65	3.50	2.65
Sad	1.55	1.35	1.45	1.65	2.85	2.50
Surprised	1.25	1.40	1.25	1.40	1.40	1.30
Elated	2.65	2.45	1.75	2.70	1.75	1.90

Figure 2 shows that participants reported not much sadness (1.6) at the beginning of the experiment (T1) and this was evident for both groups. However, immediately after emotion induction (T2) the sad group showed a sharp increase in the sadness rating whereas the control group showed no increase (1.2 vs. -0.2, respectively), and this increase was maintained to the end of the experiment (T3, 0.9 vs. -0.1, respectively). In comparison, some of the other negative emotions (anxiety or anger) showed a different pattern or a similar, yet weaker pattern (fear, disgust, or contempt). This is in line with the literature, showing that it is difficult – if not impossible – to induce sadness without other negative emotions, such as anger, anxiety or fear (Izard, 1972; Schaefer, Nils, Sanchez & Philippot, 2010; Schwartz and Weinberger, 1980; Rottenberg et al., 2007). However, we believe that the current emotion induction did not simply induce negative emotions, but it primarily induced sadness, with some co-variation of other negative emotions.

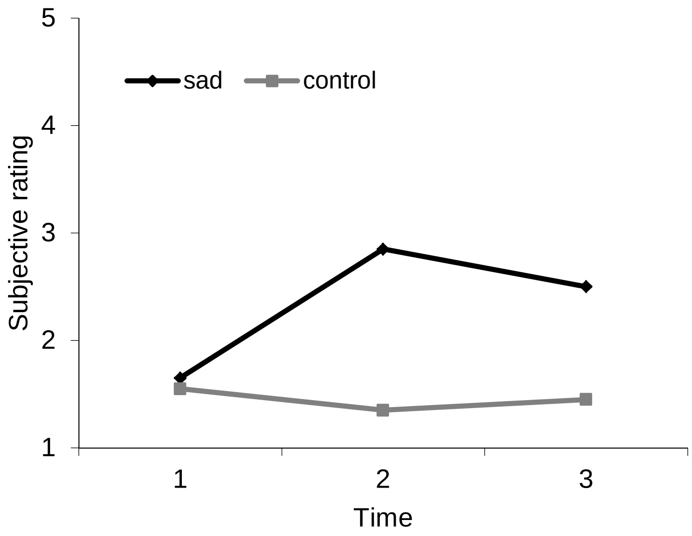

Figure 2: Averaged DES sadness ratings for participant in the sad condition and in the control condition at time 1 (prior to emotion induction), time 2 (immediately after emotion induction), and time 3 (at the end of the experiment) in Experiment 1.

RT analysis. Mean RTs were calculated for each participant and within-subject factor combination, excluding 1.5% errors and 1.3% outliers. Overall mean RTs across participants for each combination of the factorial design are given in Table 2. The corresponding mixed-design ANOVA using the individual mean RTs revealed several significant effects. In terms of within-subject factors (i.e., not including Emotion Condition), all main effects and all 2-way interactions were significant (all $p < .001$), as well as the 3-way interaction, $F(1,38) = 10.12$, $p = .003$, $\eta^2 = .21$. More importantly, in terms of effects involving Emotion Condition, there was a significant interaction between Emotion Condition and Orienting, $F(1,38) = 9.58$, $p = .004$, $\eta^2 = .20$, and between Emotion Condition and Congruency, $F(1,38) = 5.13$, $p = .029$, $\eta^2 = .12$. As can be seen from Figure 3, which shows the RT indexes for each attentional network, the participants in the sad condition showed overall less orienting effects and less congruency effects than those in the control condition. The latter effect was because incongruent RTs were on average 47 ms faster in the sad group than in the control group (622 vs. 669 ms, respectively). Finally, the 3-way interaction between Orienting, Congruency, and Emotion Condition, F(1,38) = 13.56, *p* = .001, η^2 = .26, also reached significance, due to a somewhat larger congruency effect with invalid cues in the control condition.

Table 2. Mean RTs in milliseconds (S.D.) for each factor combination in Experiment 1.

	Invalid		Valid	
	Congruent	Incongruent	Congruent	Incongruent
Control condition				
No tone	570 (80.6)	669 (89.9)	512 (71.0)	591 (81.8)
Tone	544 (72.7)	669 (95.8)	484 (71.7)	561 (87.1)
Sad condition				
No tone	555 (63.9)	625 (68.1)	501 (57.4)	573 (69.4)
Tone	529 (47.1)	619 (63.0)	466 (59.7)	546 (74.6)

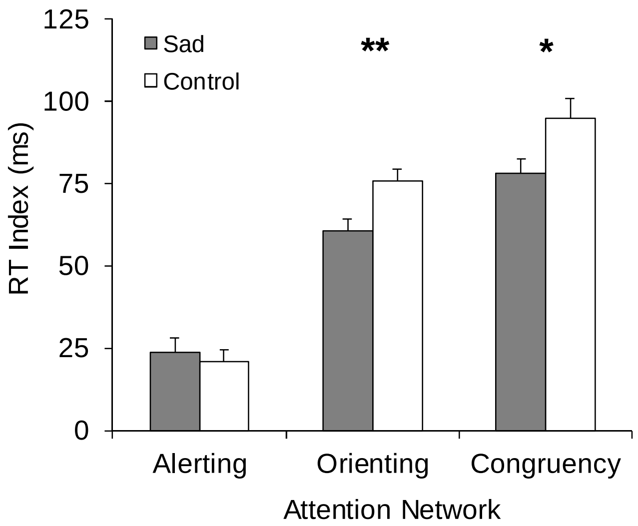

Figure 3. Reaction time index for the sad and control condition as a function of attention network in Experiment 1.

Errors. Table 3 shows the mean percentage errors for each factor combination. Overall participants made only a few errors (1.5%). The overall pattern of errors is similar to the overall pattern of RTs, however the equivalent mixed-design ANOVA revealed no significant effects involving Emotion Condition (all $p > .35$).

Table 3. Mean percentage errors for each factor combination in Experiment 1.

	Invalid		Valid	
	Congruent	Incongruent	Congruent	Incongruent
Control condition				
No tone	0.0	3.9	0.3	1.6
Tone	0.0	5.2	0.0	1.0
Sad condition				
No tone	0.1	3.2	1.8	0.0
Tone	0.0	4.2	0.0	0.7

Discussion

The results of Experiment 1 partially support our predictions showing that sadness reduces the amount of interference from flanker stimuli in comparison to a neutral emotional state. However, sad participants also had a reduced orienting response, which means that they were better in ignoring the non-informative spatial cue. These findings differ from other studies using the ANT in several ways. For example, Finucane et al. (2010) reported that alerting, orienting and executive control did not significantly differ for a sad or happy group relative to a neutral group. We can only speculate whether this lack of significant results is due to the mood induction procedure: In their study participants viewed (sad, happy or neutral) images taken from the International Affective Picture System (IAPS; Lang, Bradley,

& Cuthbert, 1997). It has been shown that emotional pictures are less effective than videos for inducing an emotional state (Rottenberg et al., 2007). Another study by Jiang et al. (2011) found that negative mood, induced by music, led to an increased effect in the alerting network. However, in that study it is not clear to what extent the negative mood might have elicited a fear-related component, which has been shown to heighten the alerting response (see Pacheco-Unguetti et al., 2010).

It could be argued that the reduced flanker interference shown by participants in the sad condition was due to the effect of fear and anxiety narrowing spatial attention (Easterbrook, 1959). However, we do not believe this to be the case as evidence shows that participants with induced fear or with trait anxiety show stronger not smaller congruency effects in relation to the attentional network test than non-anxious participants (Pacheco-Unguetti et al., 2010). Therefore if our findings were driven by fear or anxiety rather than sadness, then we should have found the same pattern as Pacheco-Unguetti et al. (2010). The fact we found the opposite pattern suggests that another emotion must play a role in driving the attentional effects, and as shown from the emotion ratings, sadness increased significantly for the sad group compared to the control group.

A limitation of Experiment 1 is that inducing sadness also led to the co-occurrence of other emotion states, such as fear. As mentioned above, disentangling the effects of sadness and other negative emotions in experimental settings is complex; there seems to be a high level of co-occurrence, especially between sadness and fear (Izard, 1972; Schaefer, Nils, Sanchez, & Philippot, 2010; Schwartz & Weinberger, 1980; Rottenberg et al., 2007). As we have argued above, there is some empirical evidence suggesting that fear would have the opposite (i.e., an increased congruency) effect to what was found here with sadness. However, this does not allow us to completely rule out an involvement of fear; it is still possible that a combination of fear and sadness is responsible for the current findings.

Ultimately, when using any emotion induction procedure, there will always be the issue that certain emotions cannot be induced in isolation, without triggering related emotional states. In order to determine the effectiveness of emotion induction procedures, it is therefore important to test for a range of emotions, not just the one desired emotional state. This way the co-occurrence of emotions can be analysed and reported, which is beneficial both in terms of interpreting the findings accurately, and also in terms of highlighting the ways in which emotional states interact.

Experiment 2

Experiment 2 is concerned with how minor to moderate depression influences alerting, orienting, and executive functions. Of particular interest is whether, pre-existing depression has the same effect on the attention networks as induced sadness. A similar study by Pacheco-Unguetti et al. (2010) showed that induced anxiety and trait anxiety could have very different effects in each attention network. However, in this experiment it is predicted that minor to moderate depression will have similar effects on attention as induced sadness, that is, moderately depressed participants will show a reduced effect in the executive network.

Methods

Participants. A new sample of forty participants (18 male; 22 female, mean age 20.6 years, SD=1.2) from the University of Warwick participated for £5 payment. They all reported normal or corrected to normal vision and were naïve to the purpose of the experiment.

Stimuli. In addition to the ANT-I and the DES, which were both identical to that used in Experiment 1, an 18-item self-report measure of depressive symptomatology was used (Goldberg, 1993). Participants had to respond to eighteen questions such as “I do everything slowly" and "I feel restless and cannot relax" on a six-point scale from 0 representing "not at all" to 5 representing "to a great extent". Participants were told to think about the questions carefully before answering and to answer as honestly as possible. All responses were coded to preserve the participants' anonymity. This inventory provided a measure for pre-existing depression, where a score of 0-9 indicated that depression was unlikely, 10-19 possibly minor depression, 20-35 minor depression, 36-53 moderate depression, and 54 or higher severe depression (Goldberg, 1993).

Procedure. The procedure was identical to Experiment 1 except that no emotion manipulation was carried out and instead the depression inventory was administered prior to completing the ANT-I. The number of experimental trials was 160 and one block of 20 practice trials was competed prior to this.

Design. The design was similar to Experiment 1 with the within-subject factors Alerting, Orienting and Congruency, and with the between-subject factor Depression Group. The assignment of participants to Depression Group was based on the score of the depression inventory (see below).

Results

Depression Scale. Depression scores ranged from 3 to 69 (mean 17.3 ±12.9), with nine participants in the category "depression unlikely" (0-9), twenty participants in "possibly minor depression" (10-19), eight participants in "minor depression" (20-35), two participants in "moderate depression" (36-53), and with one participant in the category "severe depression" (54 or higher). The participant in the severe depression category was not included in the subsequent analysis, and participants in the moderate and in the minor depression category were collapsed into one group for statistical purposes.[1] Hence the remaining 39 participants were divided into three depression groups: depression unlikely (n=9), possibly minor depression (n=20), and minor to moderate depression (n=10).

RTs. Mean RTs were calculated for each participant and within-subject factor combination, excluding errors and outliers where RTs were below 200 ms or above 2000 ms (2.3%). Mean RTs across participants of each emotion group are given in Table 4. RT indexes for alerting, orienting, and congruency are given in Figure 4.

[1] Note that subsequent statistical results did not depend on whether the one participant in the severe depression category or the two participants in the moderate depression category were included or excluded from the analysis.

Table 4. Mean RTs in milliseconds (S.D.) for each factor combination in Experiment 2.

	Invalid		Valid	
	Congruent	Incongruent	Congruent	Incongruent
Depression unlikely (N=9)				
No tone	600 (64.5)	710 (108.5)	576 (61.6)	670 (107.9)
Tone	592 (70.6)	711 (95.3)	546 (72.0)	640 (98.2)
Possibly minor depression (n=20)				
No tone	616 (56.3)	735 (61.3)	576 (61.7)	673 (65.3)
Tone	593 (49.6)	702 (50.3)	547 (42.4)	636 (42.4)
Minor to moderate depression (N=10)				
No tone	595 (51.0)	661 (68.8)	566 (60.6)	614 (55.3)
Tone	566 (44.3)	659 (35.0)	519 (28.0)	590 (34.4)

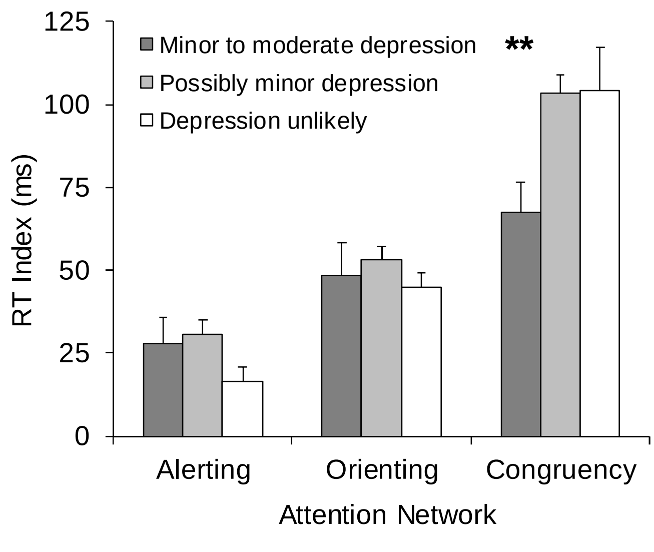

Figure 4. Reaction time index for the three depression groups as a function of attention network in Experiment 2.

Individual mean RTs were submitted to a mixed-design ANOVA with the within-subject factors Alerting (tone, no tone), Orienting (valid, invalid) and Congruency (congruent, incongruent), and with the between-subject factor Depression Group (unlikely, possibly minor, minor to moderate). Of the effects involving only within-subject factors, all main effects were significant (all $p < .001$), the Alerting x Orienting interaction, $F(1,36) = 9.11$, $p = .005$, $\eta^2 = .20$, and the Orienting x Congruency interaction, $F(1,36) = 15.82$, $p < .001$, $\eta^2 = .31$. More interesting where the effects involving Depression Group, where the Congruency x Depression Group interaction was significant, $F(1,36) = 5.23$, $p = .010$, $\eta^2 = .23$. As can be seen from Figure 4, the minor-to-moderate depression group showed overall a smaller congruency effect than both, the possibly-minor and the unlikely depression group (69 vs. 103 and 104 ms, respectively). Further split-up ANOVAs confirmed this interpretation. Furthermore there was a significant 3-way interaction between Alerting, Congruency, and Depression Group, $F(1,36) = 4.39$, $p = .020$, $\eta^2 = .20$. As can be seen from Table 4, the congruency effect of the minor-to-moderate depression group was even more reduced when the tone was absent than when it was present (57 vs. 82 ms, respectively).

Table 5. Mean percentage errors for each factor combination in Experiment 2.

	Invalid		Valid	
	Congruent	Incongruent	Congruent	Incongruent
Depression unlikely (N=9)				
No tone	0.6	8.3	1.1	3.3
Tone	0.0	12.2	0.0	5.6
Possibly minor depression (n=20)				
No tone	0.0	8.8	0.0	4.5
Tone	0.0	10.5	0.3	2.5
Minor to moderate depression (N=10)				
No tone	0.0	6.5	0.0	0.5
Tone	0.0	6.3	1.3	3.5

Errors. Overall participants made 3.6% errors. Mean percentage errors for each factor combination are shown in Table 5. The pattern of errors mirrors that of RTs, although the equivalent mixed-design ANOVA revealed no significant effects involving Depression Group (all $p > .18$).

Discussion

Experiment 2 showed that participants in the minor to moderate depression group had a reduced congruency effect in comparison to participants with no or possibly minor depression. This indicates that they were less influenced by the surrounding flanker stimuli, supporting the prediction that, similar to induced sadness, low levels of depression (i.e., minor or moderate) enhances cognitive control possibly through the narrowing of spatial attention.

The congruency effect of the minor to moderate depression group was even more reduced when the tone was absent than when it was present. The reduction of the congruency effect when the tone is absent compared to when it is present is a common finding in other ANT studies as well (e.g., Callejas et al., 2004). Posner (1994) explained the two-way interaction between alerting and executive control with an inhibitory relationship between the two networks (i.e., executive function is shut down when alerting is highly activated). This prevents the system from engaging in higher level processing, which helps to respond faster to the present stimulus.

General Discussion

A large part of everyday goal-directed behaviour involves being able to ignore irrelevant information (Kanske, 2012; Pêcher et al., 2011). The current study suggests that sad individuals are better able to do this compared to individuals who are in a neutral emotional state. As shown in Experiment 1, being sad reduced the congruency effect compared to the control group. This finding is in line with previous studies showing that sadness narrows attention and promotes an analytic processing style (e.g., Easterbrook, 1959; Gasper & Clore, 2002) both of which are indicators of being able to ignore distracting information.

However, Gable and Harmon-Jones (2010) have also shown that in some circumstances sadness can broaden attention. This is not the case in the present study as reduced interference is indicative of a narrow attentional state. One factor that might explain this discrepancy could be that there were substantial differences in the emotional stimuli used. The current study used an emotional induction procedure, which typically elicits more intense and prolonged emotional states. Gable and Harmon-Jones (2010) on the other hand used pictures that have been shown to induce emotional states, which are less intense and short lasting, evoking feelings on a trial-by-trial basis (Carvalho, Leite, Galdo-Álvarez, & Gonçalves, 2012). Furthermore, it could be argued that because participants completed an emotional rating scale (DES) prior to completing the ANT-I this may have contributed towards their emotional state during the attentional task. Indeed, it is apparent that emotional states can be influenced by a wide range of environmental factors, with even factors such as the weather and the time of day influencing people’s emotional state (Egloff, Tausch, Kohlmann, & Krohne, 1995; Forgas, Goldenberg, & Unkelbach, 2009). However, irrespective of environmental factors, the effectiveness of our sadness emotion induction procedure was still evident. Participants’ emotional ratings were in line with the emotion induction procedure they experienced, that is, participants in the sad condition reported feeling significantly sadder following the sadness emotion induction procedure compared to participants in the control group.

The results of Experiment 2 show that minor or moderately depressed individuals are better able to filter out distracting information and to focus on the target than individuals where depression is unlikely. This finding is similar to De Fockert and Cooper (2014) who used a global-local shape task and found that non-clinical participants with an above average depression score showed a reduced global processing bias.

Our findings contrast with the clinical literature on depression, which show a series of deficits in relation to executive control (for see Rogers et al., 2004 for a review). They confirm the view that major depression has unique features that differentiate it from its subclinical counterparts (Fechner-Bates, Coyne, & Schwenk, 1994). For example, clinically depressed individuals typically report problems with sleeping, eating, and a general decline in previously enjoyed activities (American Psychiatric Association [APA], 2013) and thus it might be a non-specific lack of motivation, which can account for why clinical populations perform poorly on executive function tasks (Rogers et al., 2004). In addition, the cognitive ruminations associated with clinical depression are likely to impair performance by distracting attention. The present study would not only argue that sad or moderately depressed individuals are unaffected by such impairments, but that they show an improved ability to select the relevant information.

An important part of this study was not only to examine executive control but also establish the effect a sad mood has on alerting and orienting functions. In relation to alerting, as expected, there was no effect of alerting on sadness or moderate depression. This is in line with the previous literature, which typically shows no significant alerting effects in relation to sadness (e.g., Finucane, et al., 2010) or depression (e.g., Murphy & Alexopoulos, 2006).

Generally speaking, effects related to alertness are more closely associated with fear and anxiety (e.g., Pacheco-Unguetti et al., 2010). However, one finding that was unexpected was the reduced orienting response that occurred with sad participants but not with minor to moderately depressed participants. A possible reason for this result could be that the narrowed attentional focus of sad participants also had the effect of reducing the strength of the spatial cue, which might have appeared outside the attentional focus. Indeed this interaction between congruency and orienting has also been found in previous studies (e.g., Callejes et al., 2004). Further, this interaction might be apparent for induced sadness but not pre-existing depression because of the situational variation. For instance, in the context of anxiety, state anxiety has been more closely associated with ‘bottom-up’ processes (i.e., alerting and orienting), whereas trait anxiety is associated with ‘top-down’ processes (i.e., executive control; Eysenck, Derakshan, Santos, & Calvo, 2007; Pacheco-Unguetti et al. 2010). Therefore, a similar state-trait dissociation effect may be occurring for sadness, with induced sadness influencing orienting because it is a ‘bottom-up’ process and minor/moderate depression only influencing executive control because it is a ‘top-down’ process.

From an evolutionary perspective, depressed affect is expected to promote a high level of attentional ‘focusedness’ in order to conserve resources following a situation where there has been harm or loss (Melcher et al., 2012; Andrews et al., 2007). Therefore, depressed affect can be seen as having evolved to deal with challenging problems that require a focused attentional state and low distractibility (Watson & Andrews, 2002). Thus, considering the purpose of depressed affect, it would follow that it facilitates executive control by narrowing attention, regardless of whether it is induced or pre-existing.

The present study shows that minor/moderate depression is overall more similar to sadness in relation to attentional executive control. Whether a narrowing of attention is beneficial to the attentional system ultimately is context dependent – indeed there might be some instances where being distracted by information is helpful. It is also important to note that although induced sadness and minor/moderate depression is similar in the context of spatial attention it might not be in other domains. In fact in relation to other areas of functioning, minor/moderate depression is more similar to major depression. For example, minor/moderate depression can lead to deficits in social functioning in the same way as clinical depression (e.g., Wells, Burnam, Rogers, Hays, & Camp, 1992). Therefore, whether the effect of minor-moderate depression is more similar to sadness and or clinical depression depends on the context (e.g., cognitive, social functioning).

Future research could examine the attentional effects of sadness and depression on emotional stimuli, comparing induced sadness to low risk and moderate depression groups. This would compliment the work carried out here, which used non-emotional stimuli. Theoretically, it would be of interest to determine whether induced sadness and minor-to-moderate depression have similar or different attentional effects in an emotional context. A recent study showed that depressed individuals tend to focus on negative stimuli whereas non-depressed individuals focus on positive stimuli (Newman & Sears, 2015), indicating that there might be high levels of variation.

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