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BRIEF REPORT

Anxious mood narrows attention in feature space

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Spatial attention can operate like a spotlight whose scope can vary depending on task demands. Emotional states contribute to the spatial extent of attentional selection, with the spotlight focused more narrowly during anxious moods and more broadly during happy moods. In addition to visual space, attention can also operate over features, and we show here that mood states may also influence attentional scope in *feature* space. After anxious or happy mood inductions, participants focused their attention to identify a central target while ignoring flanking items. Flankers were sometimes coloured differently than targets, so focusing attention on target colour should lead to relatively less interference. Compared to happy and neutral moods, when anxious, participants showed reduced interference when colour isolated targets from flankers, but showed more interference when flankers and targets were the same colour. This pattern reveals that the anxious mood caused these individuals to attend to the irrelevant feature in both cases, regardless of its benefit or detriment. In contrast, participants showed no effect of colour on interference when happy, suggesting that positive mood did not influence attention in feature space. These mood effects on feature-based attention provide a theoretical bridge between previous findings concerning spatial and conceptual attention.

Keywords: Emotion; Selective attention; Anxiety; Happiness; Visual attention; Mood induction.

At any moment, we can process information at different scopes. In the case of spatial attention, the area of the world covered by the "spotlight" of attention can vary, depending on our goals (Eriksen & St. James, 1986). If given enough information about where goal-relevant information will appear, people can narrow their attentional spotlight so that they show minimal interference from competing information (Yantis & Johnston, 1990). However, individuals can also spread their

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attention across a broader region of space, but they may experience greater interference from competing information (Eriksen & St. James, 1986). The second example of the varying scope of processing occurs in "conceptual space." Items that are conceptually close share a semantic neighbourhood whereby activation of one item is likely to spread to the others (e.g., "bank" and "money"). In contrast, remotely associated items (e.g., "bank" and "river") are more conceptually distant so activation of one item is less likely to spread to others (Mednick, 1962).

Such processing scope effects are often studied by different research communities in isolation from each other. This gap likely occurs because the underlying systems are perceived as far apart—"low-level" spatial attention versus "high-level" conceptual space. Here we present an intermediate example, a demonstration of variable processing scope in *featural* space (Cave, 1999). Employing manipulations typically used to manipulate spatial and conceptual scope, we show that it is possible to manipulate the scope of the non-spatial features that a person attends to (here we use colour, but other visual features such as shape or texture might be influenced similarly). These results help bridge the gap between multiple literatures by highlighting a common characteristic across different processing systems.

We manipulated processing scope by inducing different moods, which has been shown to influence both spatial and conceptual attention scope. People in anxious moods exhibit a constricted visuospatial attention focus (Derryberry & Tucker, 1994; Eysenck, 1992) and process fewer peripheral cues in their environment (Wachtel, 1968), especially when peripheral information is irrelevant to a primary task (Eysenck, 1992). In contrast, people in happy moods process visual information at a global level more efficiently than in anxious moods (Derryberry & Tucker, 1994; Johnson, Waugh, & Fredrickson, 2010). However, increased processing fluency in positive moods does not mean that people are simply better at all attentional tasks. For example, participants in a positive mood showed impaired performance on a task requiring focal visual attention (Rowe, Hirsh & Anderson, 2007) suggesting that positive mood led to a broadening of spatial attention that was detrimental to performance.

People show similar mood-related biases in conceptual attention. Individuals in anxious states show evidence for a restricted focus of conceptual attention, performing worse on remote associates problem-solving tasks (Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009). They also have more difficulty verifying inferences that require further elaboration vs. inferences that do not (Richards, French, Keogh, & Carter, 2000). In contrast, people in positive moods more frequently utilise global cognitive schemas (Gasper & Clore, 2002), show enhanced access to remote semantic associations (Bolte, Goschke, & Kuhl, 2003) and perform better on creative problem-solving tasks (Subramaniam et al., 2009).

In addition to selection based on spatial location, people can select specific features such as colour or motion across visual displays (Sàenz, Buracas, & Boynton, 2003). When responding to a target, participants are also more distracted by items sharing a common feature, such as motion (Driver & Baylis, 1989) or colour (Baylis & Driver, 1992), even if these items are farther away. Thus, a narrower or broader featural scope would encompass fewer or more features, respectively. In our experiment, we tested the feature of colour, such that a broader featural scope would encompass more colours and a narrower focus would include fewer colours.

One laboratory task to measure spatial attentional scope is the flanker task, in which people indicate the identity of a central object while ignoring competing objects to each side. When the flanking objects differ from the central target and are mapped to a different response, people are less accurate and respond more slowly, showing flanker interference (Eriksen & Eriksen, 1974). Previous research indicated that people show more interference on this flanker task when in a happy mood, suggesting that happiness engenders a broader or leakier focus of spatial attention (Rowe et al., 2007).

We propose that the scope of featural attention can vary just as the scope of spatial and conceptual attention varies. Given that anxiety narrows spatial attention scope, we hypothesised that participants in an anxious mood would be more featurally selective. Specifically, participants will be faster to focus on the centre letter and resolve response conflict if the centre letter has a unique colour. In contrast, we hypothesised that participants would be less featurally selective in a positive state of amusement.

The "colour flanker" task in this study had participants make the same decision as in previous flanker tasks (e.g., Rowe et al., 2007), but participants were explicitly informed that the letters' colours had no relation to target identity. The task contrasted "mixed-colour" blocks, in which the flankers differed from the target letter by the irrelevant feature of colour, with "solid-colour" flanker blocks in which colour was still irrelevant, but was shared by all items (see Figure S1). In the mixed-colour condition, the target and each of the four flankers were one of five different colours so that each letter was a distinct colour.

In addition, the colour of the centre letter stayed the same throughout the mixed-colour blocks so that participants could focus on the target letter by attending to a constant feature. If participants in a positive mood exhibit reduced featural selectivity, then they should show high flanker interference effects in both the mixed-colour and solid-colour conditions (i.e., they make no distinction between cases in which a feature of the flankers (colour) exhibits multiple feature values or exhibits a single value). In contrast, if participants show increased feature selectivity in an anxious mood then they should show reduced flanker interference effects on the mixed-colour condition in which attending to an irrelevant stimulus feature helps them focus on the centre item in the flanker task. Participants in an anxious mood may also show *increased* flanker interference in the solid-colour condition compared to the mixed-colour condition, because enhanced selection of the target colour would also lead to enhanced selection of the same-colour distractors.

EXPERIMENT 1

Methods

Thirty-four Northwestern University undergraduates completed eight blocks of a flanker task (Eriksen & Eriksen, 1974; Rowe et al., 2007) containing 80 trials each. Between each of the flanker blocks, participants viewed film clips selected to induce them into either a happy or anxious mood.

In the flanker task, participants indicated whether the centre letter was an "H" or an "N" via a key press. On congruent trials, the centre letter was flanked by two identical letters on each side (e.g., HHHHH), and on incongruent trials, it was flanked by two letters on each side mapped to the opposite response (e.g., NNHNN). Screen distance (60 cm) was maintained with a chinrest. Response time (RT) data from error trials and from trials exceeding 1.5 seconds were discarded (<3% of trials). The colours of the five items (target + four flankers) in the mixed-colour condition were chosen to be maximally perceptually distinct (see Table S1).

Solid and mixed-colour blocks were interleaved (ABABABAB) and counterbalanced across participants, with no effect on the results. In each solid-colour block, the letter colour was randomly chosen and remained the same throughout the block. In the mixed-colour blocks, each of the five letters was a different colour, and the randomly chosen colour of the centre letter remained the same throughout the block. On each mixed-colour trial, the colours of the four flanker letters were chosen randomly from the remaining colours without replacement. Participants were explicitly instructed that letter colour was irrelevant to their task.

Mood induction and assessment

To induce an anxious mood, participants viewed three film clips from the horror movie *The Shining* and one film clip from *The Silence of the Lambs*. To induce a happy mood, participants viewed four film clips from the American version of *Whose Line Is It Anyway?*, an improvisational comedy television series. Each approximately three-minute clip was presented full screen with headphones, on the same monitor as the flanker task. The horror and comedy film clips were presented in sequences with flanker blocks interleaved (e.g., horror clip, flanker, horror clip, flanker, etc.). Mood sequence order was counterbalanced between participants and did not influence results.

To examine mood over the course of the experiment, participants completed 17 ratings with a computerised visual analogue scale for each of three emotion words describing their current mood state (happy, anxious, energised). For each emotion word, participants provided an initial rating, ratings after each of the eight film clips and ratings after each of the eight flanker blocks. The ratings collected immediately following each film clip were averaged to produce composite scores measuring participants' moods after each type of film. In addition, the ratings immediately after each flanker block were averaged to produce composite scores measuring the participants' residual mood states after completing a flanker block.

The visual analogue scale was used to avoid anchoring effects, which can occur when discrete scale values are used for repeated mood measurements (Ahearn, 1997). The scale subtended 25.4° of horizontal visual angle, and the ratings data are reported as percentages of the total scale. Using the mouse, participants moved a vertical marker line along the scale ranging from "*not at all*" on the left to "*very*" on the right, and they clicked the mouse to indicate their response.

Results

Overall, participants showed a highly reliable flanker RT interference effect (incongruent RT − congruent RT) because they were reliably slower to respond to incongruent flanker trials than congruent flanker trials, M(incongruent RT) = 539 ± 7 ms), M(congruent RT) = 489 ± 7 ms); $t(33) = 18.74$, $p < .001$, Cohen's $d = 1.28$. This interference effect occurred in all conditions and was always based on longer incongruent RTs, so to simplify further explanations, subsequent analyses and results focused on the flanker interference effects rather than on raw incongruent and congruent RTs (see Table S2). All statistical effects were unchanged when interference effects were corrected for baseline RT differences [i.e., (incongruent − congruent)/congruent].

Flanker interference effects for each participant were subsequently analysed with a separate 2 × 2 (Colour-condition by Mood) within-subjects analysis of variance (ANOVA). The influence of colour condition on the flanker interference effect varied across participants' mood states, creating a reliable two-way interaction, $F(1, 33) = 5.04$, $p = .032$, MSE = 273.9, $\eta_p^2 = .132$ (Figure 1). While in an anxious mood, participants showed a reliably lower interference effect in the mixed-

Figure 1. *Flanker interference effects (incongruent RT − congruent RT) by mood and colour condition.*

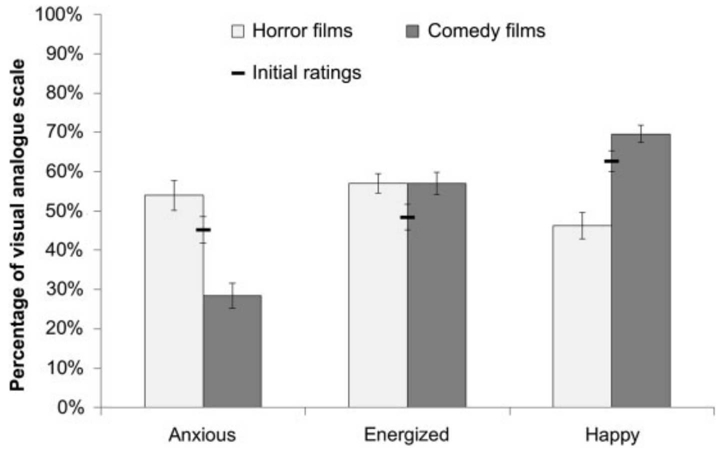

Figure 2. *Participants' moods immediately after the film clips relative to their initial ratings. Note: To give the reader a sense for how participants responded, raw data values are presented, even though some analyses focused on rating-specific Z-scores (available online).*

colour condition than in the solid-colour condition, $t(33) = 3.14$, $p = .004$, $d = 0.57$. In contrast, when these same participants were in a happy mood, they did not exhibit reliable differences in the interference effect between the mixed- and solid-colour conditions, $t(33) = 0.26$, $p = .798$, $d = 0.04$. Overall, there was no effect of mood by itself, $F(1, 33) = 0.042$, $p = .839$, potentially because interference effects in the mixed- and solid-colour conditions were virtually identical in the happy mood and they cancelled each other out in the anxious mood (see Figure 1).

In addition to the mood by colour-condition interaction, participants showed reliably lower interference effects, across moods, in the mixed-colour condition than in the solid-colour condition, $F(1, 33) = 5.52$, $p = .025$, MSE = 183.1, $\eta_p^2 = .143$. A uniquely coloured target letter appears to have facilitated selection, but only in an anxious mood, where we predicted stronger feature selection. Note that this effect may also reflect worse performance in the solid-colour condition for observers when they were anxious, where selecting a single colour would be detrimental because selecting the feature of colour entails selecting the distractor letters as well. Both of these patterns are consistent with the prediction that anxiety narrows selection in feature space.

Accuracy of flanker data

Participants were reliably more accurate on congruent flanker trials than on incongruent flanker trials, M(congruent) = 98.6 ± 0.3%), M(incongruent) = 94.0 ± 0.7%); $t(33) = 8.73$, $p < .001$, $d = 1.25$. A highly reliable interference effect (congruent accuracy − incongruent accuracy) was obtained in each condition. These accuracy interference effects were analysed with a similar 2 × 2 within-subjects ANOVA as the RT interference effects. There were no reliable main effects or interactions, likely because overall accuracy (96.3 ± 0.4%) was near ceiling. There was no evidence of speed-accuracy trade-offs.

Mood manipulation check

Participants' mood ratings suggested that both the horror and comedy film clips effectively induced the desired mood state (see Figure 2). Immediately after viewing the horror film clips, participants reliably rated themselves as more anxious than after viewing the comedy film clips, $t(33) = 5.40$, $p < .001$, $d = 1.25$. In contrast, participants reliably rated themselves as more happy after viewing the comedy film clips than after viewing the horror film clips, $t(33) = 5.77$, $p < .001$, $d = 1.42$. In addition, participants showed no arousal difference after viewing the horror film clips than after viewing the comedy film clips, $t(33) = 0.04$, $p = .97$, $d = 0.004$.

Participants' residual mood ratings after the intervening flanker task block suggested that the mood changes engendered by the film clips remained even after participants completed the flanker block. Specifically, after completing the flanker blocks, participants still rated their anxiety reliably higher throughout the horror clip sequence than throughout the comedy sequence [Comedy: $M = 36.2 \pm 3.1\%$; Horror: $M = 46.6 \pm 3.4\%$], $t(33) = 3.49$, $p = .001$, $d = 0.54$, and participants rated their happiness reliably higher throughout the comedy sequence than throughout the horror sequence [Comedy: $M = 59.5 \pm 2.3\%$; Horror: $M = 52.5 \pm 2.8\%$], $t(33) = 2.70$, $p = .011$, $d = 0.46$. Additionally, participants showed no reliable difference in residual arousal ratings between the two sequences [Comedy: $M = 49.7 \pm 2.9\%$; Horror: $M = 50.8 \pm 2.8\%$], $t(33) = 0.65$, $p = .52$, $d = 0.07$.

To compare the ratings of different emotional words (e.g., anxious vs. happy) within a clip sequence (e.g., horror), the ratings were converted to rating-specific Z-scores for each participant [e.g., (happy rating − mean happy rating)/happy rating SD]. This conversion ensured that all of the mood ratings would be on the same scale and also accounted for individual differences (i.e., individual means and SDs) in using the rating scales. To better show participants' actual responses, Figure 2 depicts raw data (all Z-scores reported in Table S3). During the horror sequence, anxious Z-scores following each clip were significantly higher than happy Z-scores, $t(33) = 8.86$, $p < .001$, $d = 2.50$, and energised Z-scores, $t(33) = 3.46$, $p = .001$, $d = 0.64$. During the comedy sequence, happy Z-scores were significantly higher than anxious Z-scores, $t(33) = 12.25$, $p < .001$, $d = 3.46$, and energised Z-scores, $t(33) = 6.86$, $p < .001$, $d = 1.19$. During the horror sequence, residual anxious Z-scores after the flanker blocks were significantly higher than residual happy Z-scores, $t(33) = 6.25$, $p < .001$, $d = 1.68$, and residual energised Z-scores, $t(33) = 4.34$, $p < .001$, $d = 1.00$. During the comedy sequence, residual happy Z-scores after the flanker blocks were significantly higher than residual anxious Z-scores, $t(33) = 3.42$, $p = .002$, $d = 0.95$, and residual energised Z-scores, $t(33) = 5.10$, $p < .001$, $d = 0.95$. Overall, the mood ratings suggest that the horror and comedy film clips effectively changed participants' moods in the predicted ways, and these mood changes were maintained until the end of the following flanker block.

Discussion

One limitation of Experiment 1 is the lack of a neutral mood condition, making it more difficult to determine if the anxious mood decreased interference in the mixed-colour condition, and/or increased interference in the solid-colour condition, and how the results from the happy condition relate to the anxious condition. As a result, data from an independent group of participants who completed solid-colour and mixed-colour flanker blocks without a mood induction were compared to the data from Experiment 1.

EXPERIMENT 2

Methods

Thirty-three Northwestern undergraduates participated in Experiment 2, but none had completed Experiment 1. Participants completed similar mixed-colour and solid-colour flanker blocks and mood rating scales as in Experiment 1, but did not view any mood clips. However, instead of 16 flanker blocks of 80 trials each, participants completed 12 total blocks of 64 trials each. Participants completed additional solid-colour blocks that were interleaved with black letter blocks rather than mixed-colour blocks. These two contexts (solid/mixed, solid/black) were grouped together into two halves and were counterbalanced. Data from the solid/black blocks are not comparable to the data presented in Experiment 1, so for simplicity, they will not be discussed further. Participants completed the same anxious, happy and energised mood ratings as in Experiment 1, but only rated their mood at baseline, before and after a 30-second break halfway through the experiment, and after the last flanker block.

Results

Flanker trials

Like Experiment 1, analyses for Experiment 2 also focused on flanker interference effects (for raw RTs, see Table S4). Participants showed 49 ± 4 ms and 53 ± 5 ms interference effects in both the solid- and mixed-colour conditions, respectively. However, interference effects did not differ between the solid and mixed conditions, $t(32) = 0.61$, $p = .55$, $d = 0.15$. To better compare the two experiments, baseline RT differences were accounted for by expressing all interference effects as a percentage difference from the congruent trial RTs (i.e., [incongruent RT − congruent RT]/congruent RT).

Next, two ANOVAs compared these percentage differences between moods, with Colour (solid vs. mixed) and Experiment (1 vs. 2) as factors. For the ANOVA comparing anxious to neutral moods, no main effects for Experiment, $F(1, 65) = 0.10$, $p = .75$, MSE = .003, $\eta^2_p = .002$, or Colour, $F(1, 65) = 1.07$, $p = .31$, MSE = .002, $\eta^2_p = .016$, were found, but these factors showed a significant interaction, $F(1, 65) = 4.86$, $p = .031$, MSE = .002, $\eta^2_p = .070$. Post-hoc t tests revealed that the anxious participants in Experiment 1 showed a trend towards greater flanker interference in the solid-colour condition than the participants in a neutral mood in Experiment 2, $t(65) = 1.76$, $p = .083$, $d = 0.43$; but participants in Experiments 1 and 2 did not differ significantly in the mixed-colour condition, $t(65) = 1.16$, $p = .25$, $d = 0.28$. For the ANOVA comparing happy to neutral moods, no significant main effects or interactions were found (all Fs < 1, all ps > .4).

Mood ratings

When comparing anxious, energised and happy Z-scored ratings, participants in Experiment 2 showed no significant differences between ratings before, $F(2, 64) = 2.45$, $p = .094$, MSE = .617, $\eta^2_p = .061$, or after the flanker blocks, $F(2, 64) = 1.50$, $p = .231$, MSE = .547, $\eta^2_p = .045$, suggesting they were in a neutral mood (raw mood ratings and Z-scores in Table S5).

Discussion

Taken together, the data from Experiments 1 and 2 suggest that the positive mood induction had little effect on attentional scope in both the mixed- and solid-colour conditions. In contrast, these data provide some evidence that the anxious mood induction increased flanker interference in the solid-colour condition relative to a neutral mood but do not indicate decreased flanker interference in the mixed-colour condition relative to the neutral mood condition.

Although these data provide some support for our contention that anxious moods increased featural selection, the neutral mood data were obtained with different participants, so comparisons to the other mood conditions should be interpreted with caution. Future studies investigating the link between featural selection and anxious and happy mood states could include a neutral mood induction condition in the same group of people to provide a better measure of the directionality of these effects.

GENERAL DISCUSSION

Our results indicate that mood influences the processing of non-valenced featural information. Specifically, an anxious state aids participants in selecting a single target feature to focus attention more effectively, even though participants were explicitly told that this feature was irrelevant to their response. This selective focus on the irrelevant feature of colour also occurs in the solid-colour condition and causes participants to show an increased flanker interference effect, suggesting that participants are more likely to also select the flanking letters that share the target feature when they are in an anxious mood. Overall, an anxious mood appears to cause participants to "zoom in" within feature space. In contrast, a happy mood does not aid participants in selecting the target letter using colour. Instead, participants' attentional bias in a happy mood is to attend non-selectively to all of the items' colours, relevant or not, which does not facilitate isolation of the target from the competing information.

On the surface, these results do not match those of Rowe et al. (2007) who found that happy mood broadened attention in a condition similar to our solid-colour condition. However, numerous differences existed between that study and our study, including the negative mood used (sad vs. anxious), the mood induction method (music vs. films) and the design of the flanker task (variable vs. fixed spacing of flankers). Nevertheless, we did find that a negative mood state narrowed attention, but to stimulus features rather than to spatial location.

One additional caveat is that the anxious and happy states induced by viewing horror and comedy clips in the current study may also have differed in terms of their motivational intensity, rather than simply in emotional valence. Based on past research, the anxiety induced by the horror film clips was likely low in approach motivation and high in avoidance motivation, whereas the amusement brought on by the comedy clips likely engendered a low approach and low avoidance, post-goal state (Harmon-Jones, Gable, & Price, 2012). On the other hand, after each funny film clip, participants seemed highly motivated to "get through" the next set of boring flanker trials so that they could watch the next funny film in the series. Thus, the true level of participants' motivational intensity and its influence on the results remain unknown. Future studies using the feature flanker paradigm could measure and manipulate participants' motivational intensity to assess the role that this factor may play in featural selection.

Our results are consistent with the hypothesis that negative affect acts as a cue that one should switch from the dominant focus (Huntsinger, 2012). Our participants were not primed to have either global or local focus of attention, so presumably they entered the study with the default broadened focus (Eriksen & St. James, 1986). The fact that the anxious mood induction led to a narrowed focus in featural space is consistent with the previous findings and extends them into the domain of features, rather than just spatial locations. In addition, the lack of effects in featural space in the happy mood condition is also consistent with the theory that mood acts as a signal to maintain the dominant (broad) focus of attention.

CONCLUSION

In sum, an anxious mood influences attention to stimulus features, even emotionally neutral ones that are irrelevant to the task and to one's emotional state. This modulation of feature attention provides a bridge between previously reported effects on the scope of spatial attention (Derryberry & Tucker, 1994; Johnson et al., 2010) and the scope of conceptual attention (Richards et al., 2000; Subramaniam et al., 2009). An anxious mood state appears to exert a general narrowing influence on the spatial and *featural* scope of external visual attention, as well as the scope of internal semantic attention. Happy moods, in contrast, do not appear to exert strong effects on people's attention to features.

This link between the scope of external visual attention and internal semantic attention is consistent with prior findings. The breadth or narrowness of visual attention scope can influence the breadth or narrowness of the scope of conceptual attention (Wegbreit, Suzuki, Grabowecky, Kounios, & Beeman, 2012), and the brain circuits involved in perceptual and conceptual selection show a surprising amount of overlap (Nee & Jonides, 2009). Our results indicate that anxious mood states also influence attention to stimulus features, even if they are not emotionally valenced features themselves. This result in turn suggests that a state of anxiety exerts a narrowing influence on internal and external attention in a very general way, markedly influencing the way people view both the external world and the contents of their own minds. These results add to our basic knowledge of the way in which anxious and happy mood states shape our experience of the world.

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Supplemental data

Supplementary Tables and Figure are available via the "Supplementary" tab on the article's online page (http://dx.doi.org/10.1080/02699931.2014.922933).

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