

# Does emotion of relevant and irrelevant stimuli affect allocation of attention?

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## Abstract

Attention is a limited resource, so certain stimuli are given attentional priority, such as stimuli of positive and negative valence and socially relevant stimuli such as faces. This study aimed to examine if emotion of relevant stimuli and irrelevant stimuli influences the allocation of attention using the inattention blindness paradigm (Mack & Rock, 1998). We predicted that the emotion of both stimuli would affect detection rates of the irrelevant stimulus, task accuracy and response times. We predicted greater attentional capture of negative critical stimuli, and a similar effect for emotional faces. We predicted that higher anxiety and depression levels would be associated with detection bias towards negative stimuli. Seventy-eight participants carried out a task in which they had to determine the emotional expression of happy, angry or neutral faces. In the final trial, an additional image of either positive or negative valence was also presented. Results show that detection was higher for positive critical images, suggesting a positive detection bias for critical images. Additionally, emotional faces had higher response times than neutral emotional expressions in the primary task, suggesting that emotional faces capture attentional resources due to their positive or negative value. No influence of emotional congruency or depression and anxiety levels was seen. An attentional bias for positive stimuli suggests that positive emotions might facilitate processing of an unattended stimuli.

## Declaration

The dissertation is original work by the student unless referenced to the contrary, no portion of the work referred to in the dissertation has been submitted in support of an application for another degree to this or any other university or other institute of learning.

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## Introduction

Attention is a finite resource, so certain stimuli are given prioritised attention and tend to be detected more often than others (Becker & Pashler, 2007). However, people tend to think that they would perceive all stimuli presented in their visual field and suffer from illusion of attention (Chabris & Simons, 2010). While driving on a highway, a driver might be focused on their original task and fail to notice a motorcycle or unexpected object appearing in their visual field, leading to accidents caused by inattention (McLay, Anderson, Sidaway & Wilder, 1997; Most & Astur, 2007). This error of perception that results in a lack of attention to an unexpected object has been denoted inattention blindness (Chabris & Simons, 2010).

Allocation of attention to unexpected stimuli is, according to the Perceptual Load Theory (Rees, Frith & Lavie, 1997) influenced by complexity and cognitive resources needed for the relevant task. Attention is not paid to task-irrelevant distractors when attentional resources are fully consumed by task-relevant material (Neumann, Mohamed & Schweinberger, 2011). Inattention can be manipulated through varying perceptual load of the primary task. Cartwright-Finch and Lavie (2006) saw altering by altering the difficulty of a relevant task, they could manipulate perception of an irrelevant stimulus. Across their first three experiments, detection rates of the irrelevant stimulus were 75% in the low perceptual load condition and 33% the high load condition. Inattention blindness depends on the extent to which the relevant task captures attentional capacity.

Mack (2003) suggests that perception is a limited capacity process, meaning that a task involving high perceptual load might not leave resources available for the perception of other stimuli. Schwartz et al. (2005) extend this to suggest that distractors may even be actively suppressed. This suppression may depend on endogenous factors, such as attentional load of current task, or exogenous factors, such as sensory competition among simultaneous stimuli.

Schwartz et al. (2005) manipulated attentional load of a visual monitoring task (relevant task) and saw that functional magnetic resonance imaging (fMRI) responses to task-irrelevant peripheral checkerboards in the visual cortex decreased when attentional load increased. Therefore, attentional resources available influence the extent to which an irrelevant stimulus is perceived.

Inattention blindness occurs when an observer fails to detect the unexpected presentation of stimuli in their visual field (Devue, Laloyaux, Feyers, Theeuwes & Bredart, 2009). The paradigm to test inattention blindness was developed by Mack and Rock (1998) with a task that required participants to judge which arm of a cross was longer. On their fourth trial, in addition to the length-judgement task, a shape was presented parafoveally. Participants were asked if they had seen anything else. Their results indicate that when a neutral stimulus such as a shape was presented in this way, 85% of participants failed to see it. This suggests that when attention is focused on a task, we can fail to detect irrelevant items even when they are presented to the centre of our visual field.

To examine the effect of change blindness in a more naturalistic setting, Simon and Chabris (1999) conducted an experiment where they were to count passes in a basketball game from players wearing black or white, and recorded if they were able to notice a person in a black gorilla suit walking past. Despite being highly salient, 58% of participants failed to detect this. They did observe, however, that the likelihood of detection was increased to 83% when participants were told to count passes made by players wearing black rather than white, suggesting that likelihood of noticing an unexpected object depends on the similarity to other objects currently relevant to the task. This suggests that similarity between a relevant and irrelevant stimulus will increase detection.

However, these experiments have been done using irrelevant stimuli that are not socially relevant and therefore might have a lesser rate of detection as they are ignored in normal settings to reduce perceptual load of the environment. Due to the importance of faces as social stimuli (Neumann et al., 2011), they may have higher attentional capture than other stimuli when in a condition of inattention. Devue et al. (2009) suggest that faces and names capture more attention when presented below the threshold of consciousness, in an effect similar to the Cocktail party effect. This effect suggests that if own name is presented in the unattended ear, participants can successfully report its occurrence, suggesting that important information cannot be filtered out (Shapiro, Caldwell & Sorensen, 1997). Vuilleumier, Armony, Driver and Dolan (2001) suggested that stimuli with emotional significance such as faces may be presented outside focus of attention but still be detected. This is because faces can capture attention when in competition with other non-face objects (Langton, Law, Burton & Schweinberger, 2007). Devue et al. (2009) show that presenting faces outside of the focus of attention can lead to their detection when they compete with other stimuli for attentional resources.

A possible alternative reason that faces capture attention might be due to their complexity. Mack and Rock (1998) suggested that complex stimuli such as names and faces are likely to overcome the inhibition of attention. Devue et al. (2009), in experiments with faces or objects as the irrelevant stimulus in an inattentional blindness task, found that faces were detected by 58% of participants, while objects were detected by 4%. When comparing upright to inverted faces, upright faces were detected by 50% of participants while inverted faces by 21%, suggesting that increased detection of faces is not solely due to their complexity. Therefore, faces would be more resistant to inattentional blindness than most stimuli.

Evidence suggests that there might be a distinct response to different facial expressions due to the social meaning that these expressions convey. Highly emotional faces might be given

more attentional priority compared to other stimuli or more neutral faces. Calvo and Estevez (2005) found in subliminal presentation of faces, schematic emotional faces were detected when presented for a 25 milliseconds (ms), while neutral faces were presented had a higher identification threshold, suggesting more efficient attentional processing for emotional faces. Fearful facial expressions would generally suggest the presence of a threat stimulus. Presenting fearful faces results in activation of the amygdala even in the absence of attention, suggesting that threat stimuli might be processed automatically in the absence of awareness (Anderson, Christoff, Panitz, DeRosa & Gabrieli, 2003). The effect of emotional expression is reduced when attention is diverted, therefore there might be a reduced effect of face emotion if there is another irrelevant stimulus presented. Angry faces might be given priority of attention due to their relevance as both social stimuli and threat stimuli.

Adaptive behaviour needs to deal with opposing demands, balancing between the selection of goal relevant stimuli for processing by mechanisms of attention and detection of significant events that may occur unpredictably outside the focus of attention. Threatening stimuli might trigger these adaptive mechanisms, prioritizing the processing of threat stimuli, as evolutionarily relevant and detrimental to survival (Belopolsky, Devue & Theewes, 2011; Fox, Russo, Bowles & Dutton, 2001). In a visual search task using schematic threatening, friendly and neutral faces, faster and more accurate detection of threatening stimuli was seen compared to friendly targets (Öhman, Lundqvist & Esteves, 2001). Emotional stimuli of negative valence might be determined as a threat and therefore be preferentially processed, seen through higher response times for probe threat words when primed by an identical parafoveal word (Calvo, Castillo & Fuentes, 2006). Threatening stimuli are associated with higher detection rates (Most, Scholl, Clifford & Simons, 2005), thus irrelevant stimulus of negative valence could be associated with increased resistance to inattention blindness



Additionally, an effect of congruence could affect attention to irrelevant stimuli. Calvo et al. (2006) saw that parallel processing of threat-related words occurred even when these were outside of focus of attention, enhancing processing in emotionally congruent unpleasant context. Congruence in terms of affective stimuli that were presented subliminally facilitated responses to affectively congruent relevant stimuli (Hermans, Spruyt, DeHouwer & Eelen, 2003). A similar effect of affective congruence could be expected between inattentional presentation of negative stimulus and negative emotion of the relevant task. Given this prioritization of the processing of threat stimuli, we will aim to test whether valence of stimuli influences allocation of attention. Valence of both task relevant and irrelevant items will be tested to examine if the valence of either, and their relationship, influences inattentional blindness.

Levels of anxiety correlate with increased sensitivity to threat stimuli and anxiety disorders are characterized by enhanced detection of potentially threatening cues (Rapee & Heimberg, 1997). Joorman and Gotlib (2007) suggest that anxious participants might be biased towards detecting anger, as they perceived faces morphed to be in an angry-neutral continuum as angry sooner than healthy participants. In an experiment by Lee and Telch (2008), individuals with either high or low trait social anxiety, were induced to high or low state social anxiety conditions. Frowning faces had a greater signal value when presented to high trait social anxiety individuals in induced high social anxiety condition potentially due to hypervigilant processing. Participants with high anxiety were twice as likely to identify the frowning face relative to those with low social anxiety, while low social anxiety individuals were more likely to detect a smiling face. Therefore, a difference between perception of potentially threatening stimuli, including negative valence threat images or angry faces might be seen in participants with higher anxiety levels. Thus, levels of anxiety will be measured in this experiment.

Additionally, levels of depression can bias towards increased detection of negative stimuli. Kanske and Kotz (2012) suggest that individuals with high trait depression were more distracted by irrelevant negative stimuli and faster to detect negative stimuli than participants with low trait depression. Joorman and Gotlib (2007) saw attentional biases towards processing of emotional faces (sad and happy) relative to neutral faces in individuals who were currently and formerly depressed compared to healthy controls. Healthy controls showed an attentional bias for happy faces, while depressed and formerly depressed participants showed a bias for sad faces. Gotlib, Krasnoperova, Yue and Joormann (2004) saw that depressed participants oriented their attention towards sad faces after they were presented for one second. Additionally, in a task where they had to determine gender of a face while ignoring the emotion of the face, depressed participants had impaired response times compared to healthy controls. This suggests that depressed participants might be more affected by irrelevant negative stimulus than healthy individuals. Therefore, levels of depression were therefore also measured to evaluate their effect on inattention blindness of stimulus with positive or negative valence used in our task.

Based on previous evidence, the current study aimed to investigate if the emotional valence of relevant and irrelevant stimuli affects allocation of attention. This was assessed using the inattention blindness paradigm (Mack & Rock, 1998) to evaluate the effect of emotional valence of faces, the relevant stimuli, and positive or negative irrelevant (“critical”) images presented unexpectedly on the final trial. The effect of different emotional valence (happy, neutral, angry) on attentional allocation towards task-relevant stimuli will be measured with respect to accuracy and response times in the primary task.

To test the effect of valence of relevant and irrelevant stimuli, detection of the critical stimulus on the final critical trial will be analysed with respect to emotional valence of each stimulus. We predicted that allocation of attention is influenced by emotion, with the

percentage of participants who detected the critical stimulus being affected by valence of critical stimulus and face emotion. We predicted a greater capture of attention by negative, relative to positive, critical stimuli due to threat value. Therefore, we hypothesised a greater detection of negative compared to positive critical images. We predicted that neutral faces would have higher response times and less accuracy than emotional faces. Additionally, we predicted an effect of congruence between positive and negative face task and critical image valence. We predicted negative critical images would be more likely to be detected when presented with an angry face, and similar effects for positive congruent stimuli. Evidence suggests that higher depression and anxiety levels bias processing of negative emotional stimuli, so state-anxiety and depression values will be examined to evaluate their influence in response time, accuracy and detection of critical image.

## Method

### *Participants*

Seventy-eight participants (21 male) were recruited using opportunity sampling through the University of Manchester SEPS scheme. Participants had a fluency in English, normal or corrected-to-normal vision and were over 18 years old. Additionally, participants did not have a history of neurological or mental health issues.

All participants gave written consent to participate in the experiment, which had ethical approval from the University of Manchester Neuroscience and Experimental Psychology Division Research Ethics Review Panel (project ID 2791). Participants were given 2 SONA credits for their participation.

### *Materials*

#### Stimulus

Faces were used as stimuli for the primary task (Figure 1). Six male and six female faces were chosen from the NimStim database (Tottenham et al., 2009). Faces depicted a happy, angry or neutral facial expression. One female and one male face were presented for each emotional expression in the primary task, and these images were 100 by 129 pixels in size.



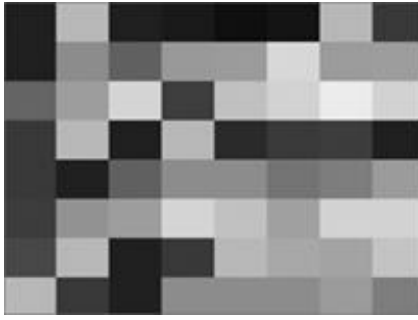
*Figure 1:* Faces used. a) Male faces: happy, neutral and angry. b) Female faces: happy, neutral, and angry.

The critical images (Figure 2) were presented in the final trial of the task and were taken from the IAPS database (Lang, Bradley, & Cuthbert, 2008). These images were rated by Lang et al. (2008) on a nine-point scale for arousal, valence and dominance. To experimentally manipulate valence, images chosen were of positive or negative valence of approximately equivalent rating magnitude. The images used were similar in levels of arousal and dominance, and 224 by 159 pixels in size. One of these images was presented with the face on the final experimental trial, bottom-left or bottom-right corners of the screen, the centre of the image at coordinates 341, 753.



*Figure 2:* Critical images used. a) Positive valence images. b) Negative valence images used.

A mask was used before and after each trial and consisted of an 8x8 checkerboard of greyscale squares of 142 by 112 pixels each (Figure 3). Squares of different tonalities were randomly organised each time the mask was presented.



*Figure 3: Example of mask used*

### Questionnaires

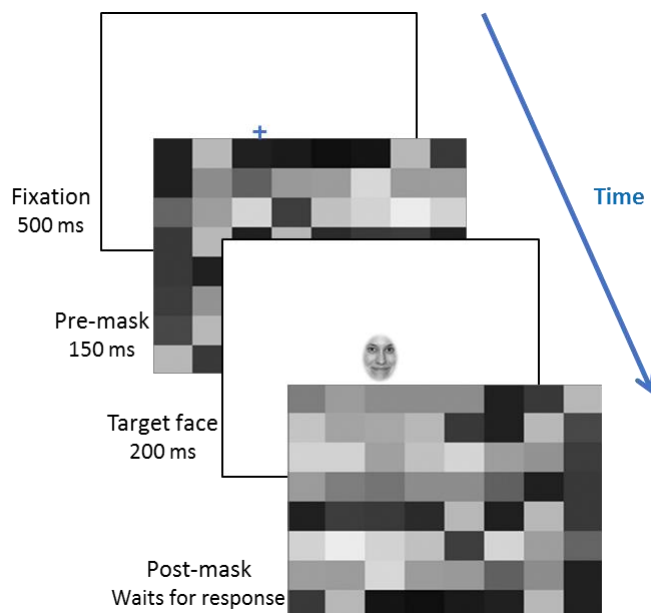
Beck's Depression Inventory (Beck, Steer, & Brown, 1996), a widely accepted self-report questionnaire, was used to measure trait levels of depression. This questionnaire included 21 items, to measure attitudes and symptoms of depression over the past two weeks. Participants indicated their answers on a 4-point Likert scale. For example, item 15 related to the symptom of depression of fatigue and loss of energy (American Psychiatric Association, 2013), with 0 being "I have as much energy as ever" and 3 being "I don't have enough energy to do anything". Scores ranged from 0 to 63, with scores over 10 indicating a mood disorder and higher scores indicating symptoms of depression.

The State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to measure levels of anxiety. This widely accepted questionnaire is used for clinical and non-clinical populations and consists of 20 items that participants had to rate on a Likert scale with respect to how they presently feeling, with 1 being "not at all" and 4 being "very much so". Statements were symptoms of anxiety such as "I am worried". Nine items were reverse-scored as higher scores meant lower levels of anxiety, such as "I feel calm". Higher scores on this questionnaire were related to higher anxiety.

## Procedure

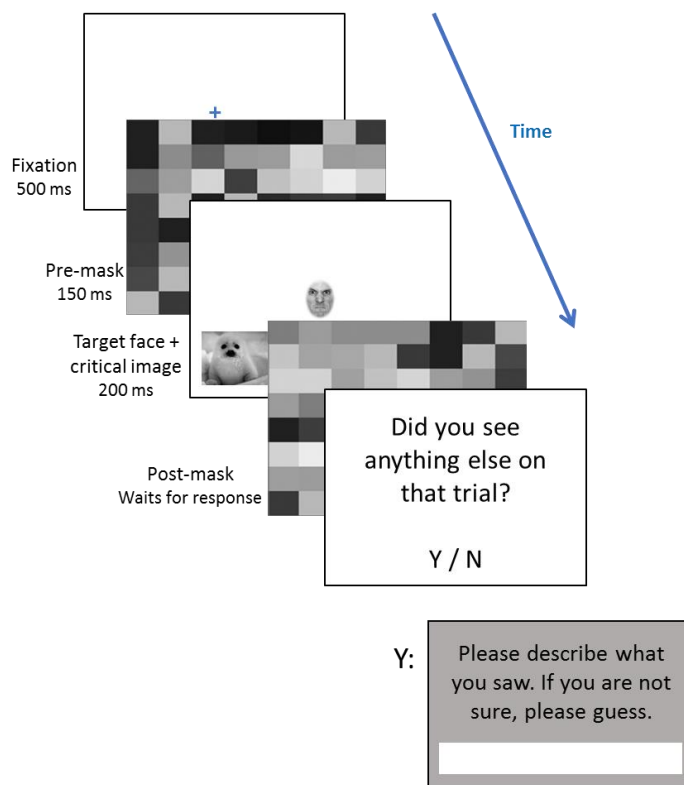
The experiment was carried out in a well-lit individual cubicle, and participants were given oral and written instructions before the task. They were also administered a mood check to monitor mood throughout the course of the experiment.

The task was programmed and administered using e-Prime (Schneider, Eschman & Zuccolotto, 2002) and presented on a computer monitor approximately 60 cm away from the participant. The primary task consisted of six non-critical trials and one critical trial. For the non-critical trials (Figure 4), participants were presented with fixation, a cross of 87 by 87 pixels in the centre of the screen for 500ms. A pre-mask was then presented for 150ms. Then participants were presented with a face for 200ms. Face emotion and gender were randomised. A post-mask was presented until the participants made a response via button-press. Participants were instructed to press the up arrow if they saw a happy face, left if they saw an angry face, and down arrow if they saw a neutral face.



*Figure 4:* Experimental procedure for non-critical trial. Each trial began with a fixation period (500ms), then a pre-mask (150ms). A face was displayed for 200ms, and then a post-mask was presented until a response was made. This was done for the first six trials.

For the seventh, critical trial (Figure 5) procedure was identical to the non-critical trials, except a critical stimulus was presented at the same time as the face. After participants made their response indicating the emotion of the face, they were asked if they noticed anything else on that trial, where they had to respond using the Y or N buttons on the keyboard. If they pressed N, the experimental task finished. If they pressed Y, they were prompted with a textbox with instructions to describe what they saw.



*Figure 5:* Experimental procedure for critical trial. A fixation cross was presented for 500ms, followed by a pre-mask (150ms). Participants saw the critical trial, including a face and the critical stimuli for 200ms. A post-mask was presented until a response was recorded. Participants were then asked if they had seen anything else in this trial and were prompted to describe what they saw.



After completing the experimental trial, participants completed the questionnaires and were administered the second mood check to ensure they had not been unduly affected by the task. Participants were then debriefed and dismissed.

### *Design and Statistical Analysis*

Critical image valence (positive, negative) was manipulated between subjects. Face emotion in the primary task (happy, angry, neutral) was manipulated within-subjects. Trial type (critical, non-critical) was a within-subjects independent variable. Accuracy of responses, reaction time and detection of the critical stimulus were measured as dependent variables. Additionally, anxiety and depression were measured as covariates.

Accuracy and response time data for non-critical trials were subjected to separate analyses of variance (ANOVA), with face emotion, in levels angry, happy and neutral as the independent variable. Accuracy, detection and response time data were subjected to separate analyses of covariance (ANCOVA). The variables for this analysis were face emotion in levels angry and happy, and critical image valence, in levels positive and negative. Additional variables of depression and anxiety levels were measured as covariates to determine if they affected the significance of dependent variables.

## Results

### *Accuracy across non-critical trials*

To assess performance on the face emotion judgement task, proportion of correct responses in the non-critical trials was examined. Average accuracy in non-critical trials of the face detection task was higher for happy faces ( $M = 0.92$ ,  $SD = 0.08$ ) than angry faces ( $M = 0.89$ ,  $SD = 0.03$ ) or neutral faces ( $M = 0.85$ ,  $SD = 0.03$ ).

A repeated-measures ANOVA was used with the dependent variable of accuracy (proportion correct) and the independent variable of face emotion (happy, neutral, angry). There was no significant effect,  $F(1,154) = 2.05$ ,  $p = .132$ , partial  $\eta^2 = .026$ .

### *Accuracy of critical vs non-critical trails*

To determine whether the addition of the critical image affected performance on the face emotion judgement task, accuracy on critical versus non-critical trials was assessed as a function of face emotion and critical image valence.

*Table 1:* The mean ( $M$ ), standard deviation ( $SD$ ) and 95% confidence intervals (95% CI) of accuracy (proportion correct) of responses across conditions.

|                    |              | Critical Image Valence |       |          |       |
|--------------------|--------------|------------------------|-------|----------|-------|
|                    |              | Positive               |       | Negative |       |
|                    | Face emotion | Happy                  | Angry | Happy    | Angry |
| Non-critical trial | $M$          | 0.94                   | 0.91  | 0.83     | 0.86  |
|                    | $SD$         | 0.03                   | 0.04  | 0.05     | 0.04  |
| Critical trial     | $M$          | 1.00                   | 1.00  | 0.94     | 0.90  |
|                    | $SD$         | 0.00                   | 0.00  | 0.06     | 0.07  |

A two-way mixed ANCOVA was used to evaluate the effect of condition (happy/positive, happy/negative, angry/positive, angry/negative) as a between-subjects independent variable and trial type (critical, non-critical) as the within-subjects independent variable, on accuracy of responses. Effects of depression and anxiety levels on accuracy were also examined. There was no main effect of trial type,  $F(1,72) = 0.30$ ,  $p = .586$ , partial  $\eta^2 = .004$ . There was no main effect of condition,  $F(3,72) = 1.81$ ,  $p = .153$ , partial  $\eta^2 = .070$ . Interaction between trial type and condition was not significant,  $F(3,72) = 0.51$ ,  $p = .675$ , partial  $\eta^2 = .021$ . Depression and anxiety scores did not significantly interact with either independent variable (all  $p$  values  $> .05$ ).

#### *Response time across non-critical trials*

To assess whether the face emotional influenced speed of response, reaction times on correct non-critical trials were analysed.

Response times were submitted to a repeated-measures ANOVA with the independent variable of face emotion (happy, neutral, angry). A significant effect of face emotion was seen  $F(2,92) = 3.81$ ,  $p = .026$ , partial  $\eta^2 = .076$ .

To clarify this effect, three paired samples t-test were carried out, using a Bonferroni correction of 0.017 for significance. Neutral faces ( $M = 1899.06$ ,  $SD = 1572.34$ ) had a significantly higher response time than happy faces ( $M = 1314.16$ ,  $SD = 1282.75$ ), ( $t(46) = 2.93$ ,  $p = .005$ ) but not angry faces ( $M = 1425.39$ ,  $SD = 1134.90$ ), ( $t(46) = 1.82$ ,  $p = .075$ ). No significant difference in reaction times was seen when comparing angry and happy faces,  $t(46) = 0.53$ ,  $p = .601$ .

### Response time across critical vs non-critical trials

To determine whether addition of the critical image affected performance, response times for critical versus non-critical trials were analysed.

Table 2: The mean (*M*), standard deviation (*SD*) and 95% confidence intervals (95% CI) of response time (milliseconds) of responses across conditions.

|                    |           | Critical Image Valence |         |          |         |
|--------------------|-----------|------------------------|---------|----------|---------|
|                    |           | Positive               |         | Negative |         |
| Face emotion       |           | Happy                  | Angry   | Happy    | Angry   |
| Non-critical trial | <i>M</i>  | 1783.96                | 1428.18 | 1574.79  | 1225.20 |
|                    | <i>SD</i> | 1410.65                | 736.77  | 654.98   | 459.59  |
| Critical trial     | <i>M</i>  | 675.61                 | 890.18  | 962.50   | 623.70  |
|                    | <i>SD</i> | 223.74                 | 383.50  | 473.44   | 178.07  |

Response times on correct trials were submitted to a two-way mixed ANOVA. The within-subjects independent variable was trial type (critical, non-critical) and the between-subjects independent variable was condition (happy/positive, happy/negative, angry/positive, angry/negative).

The main effect of trial type was significant,  $F(1,43) = 23.91, p < .001$ , partial  $\eta^2 = .357$ . Non-critical trials ( $M = 1546.21, SD = 1004.00$ ) had a significantly higher response time than critical trials ( $M = 763.62, SD = 329.82$ ). The main effect of condition was not significant  $F(3,43) = 0.74, p = .535$ , partial  $\eta^2 = .049$ . The interaction between trial type and condition was not significant,  $F(3,43) = 1.13, p = .347$ , partial  $\eta^2 = .073$ .

### *Detection of critical image*

To assess inattention blindness (failure to detect the critical image), the detection rate of the critical image was analysed. Of the 78 participants tested, 11 (14.1%) reported seeing an additional image in the critical trial across all conditions and 67 (85.9%) did not.

*Table 3.* The mean (*M*), standard deviation (*SD*) and 95% confidence intervals (95% CI) of the percentage of participants who detected the critical image across conditions.

| Face emotion | Critical image valence |       |          |       |
|--------------|------------------------|-------|----------|-------|
|              | Positive               |       | Negative |       |
|              | Happy                  | Angry | Happy    | Angry |
| <i>M</i>     | 17.39                  | 37.50 | 5.88     | 0     |
| <i>SD</i>    | 8.00                   | 13.0  | 6.00     | 0     |

A between-subjects ANCOVA was carried out to using critical image valence and face emotion as independent variables, and the covariates of depression and anxiety scores on detection of critical image. There was a significant main effect of critical image,  $F(1,72) = 10.40, p = .002$ , partial  $\eta^2 = .126$ . Detection rates were higher with the positive ( $M = 25.64, SD = 44.23$ ) compared with negative critical image (mean = 2.56,  $SD = 16.01$ ). No significant effect was seen for face emotion ( $F(1,72) = 0.55, p = .461$ , partial  $\eta^2 = .008$ ). No significant interaction was seen between critical image and face ( $F(1,72) = 0.27, p = .120$ , partial  $\eta^2 = .330$ ). Depression and anxiety scores did not significantly interact with any of the variables (all  $p$  values  $> .05$ ).

## Discussion

This experiment aimed to investigate the effect of emotional valence of relevant and irrelevant stimuli on allocation of attention. Using the inattention blindness paradigm, the effect of emotional valence of faces and critical images was examined. Allocation of attention, seen through detection of critical stimulus was influenced by emotion. However, the effect was only seen by emotional valence of critical stimulus, not face emotion. Greater attentional capture was not seen for negative critical stimuli, as the positive critical image was recognised more frequently than the critical image with negative valence. Neutral faces had higher response time than emotional faces, but no difference of face emotion was seen on accuracy.

Neutral faces had a slower response time than happy faces, but not angry faces. No difference was seen between angry and happy faces. Emotional congruence of the relevant and irrelevant task did not have a positive processing effect, as a negative stimulus did not facilitate processing of a negative critical image, and no effect of congruence was observed. Additionally, we expected that anxiety and depression levels would generate a negative bias towards relevant and irrelevant negative valence stimuli. However, no effects of anxiety and depression were observed.

No effect of congruence was seen between emotional value of a task-relevant stimuli and of an unexpected image. This is inconsistent with prior research that suggests that emotional congruence with a previously presented stimulus can help detection for an irrelevant stimulus of the same emotional valence compared to emotionally-incongruent (Calvo & Nummenmaa, 2007). However, evidence shows that there is an effect of emotional congruency of mood and detection of unexpected stimulus of the same valence (Becker & Leininger, 2011). Therefore, prior mood of participants might have been congruent with positive critical

images and therefore generated an effect of congruence between mood and detection of a positive critical image.

An influence of emotional value had an effect in allocation of attention, measured through the detection of critical stimuli. This was affected by the emotional valence of relevant but not task-irrelevant stimuli. This is contradictory with previous evidence, as angry faces have been seen to have higher attentional capture than happy faces due to their potential to signal threat. However, angry faces in our computational task were not directly threatening to the participant, and participants were familiar with these faces due to previous trials.

There was an influence of emotional value on attention, as the valence of critical image influenced if it was detected. However, contrary to prior research which indicates that negative critical images might be more detected because of their value as threatening stimuli (Anderson et al., 2003), positive critical images were detected more frequently than negative critical images, both when angry and happy faces were presented as task-relevant stimuli.

This pattern of results could be due to a positive bias of detection in our sample, which consisted of healthy participants from a student sample. Gotlib, McLachlan, Katz (1988) proposed that there was a positive bias across a variety of tasks and situations, leading to preferential processing of positive stimuli. Joorman and Gotlib (2007) showed that healthy participants had a positive bias against detection of negative faces. This effect was seen in a dot-probe task, a task used to test selective attention. Mack, Pappas, Silverman and Gay (2002), saw that own name and cartoon happy faces capture attention due to their importance. However, the cartoon happy face was seen to be detected more frequently than objects and a scrambled face, not faces of other emotions. Mack and Rock (1998), in an inattentive blindness task, saw that a smiling face icon was detected and identified more frequently than a

frowning face. A similar bias could therefore be interpreted with respect to the detection of positive critical images.

Furthermore, Stothart, Wright, Simons and Boot (2017) suggested that participants are not more likely to notice unexpected objects that were indirectly associated with negative consequences. Therefore, a positive bias of detection of positive stimulus and lack of connection of both relevant and irrelevant stimulus as a threat might have led participants to detect the positive image. Mood of the participants while completing the task might have also positively biased detection of the critical image. As participants were part of a sample of students with no history of mood disorders, their mood during the task was potentially positive.

An alternative explanation is based on content of the critical images. Positive critical images were composed of a baby seal and a smiling baby while negative critical images consisted of a shark and a snake. A difference between detection of positive and negative image could be due to the presentation of a human in one of the conditions. Pappas, Fishel, Moss, Hicks and Leech (2015) suggested that featural similarity to the stimulus led to identification of a stimulus presented in a condition of inattention. Therefore, the similarity between faces being presented and the baby image could have accounted for increased detection rates of these images.

Additionally, the positive identification of critical images could be accounted for by an effect of familiarity, increasing detection of positive stimuli and decreasing detection of negative stimuli. Participants are unlikely to have encountered snakes or sharks like those seen in the negative critical image, but more likely to have encountered objects similar to the positive stimuli of the baby seal and baby. Familiar stimuli like babies might have been more likely to capture attention due to emotional associations due to previous experiences with children (Buttle & Raymond, 2003). Lack of personal familiarity with snakes and sharks might have led



to perception of these as no real threat. In future experiments, the effect of modern and evolutionary threat stimuli as critical images in an inattentional blindness paradigm could be examined. Flykt, Esteves and Öhman (2007) saw that there was similar skin conductance responses (SCR) to evolutionary threat stimuli, such as the ones presented in the present experiment, and culturally relevant fear stimuli such as guns. This suggests that modern threat stimuli which could be more familiar to participants could be examined. This might show similar effects as previous research that suggests that there is an attentional bias towards threat stimuli.

Moreover, emotional faces were detected faster than neutral or non-emotional ones. Previous research has shown that it takes longer to determine that a face is neutral. This effect could be due to enhanced perception of emotional faces due to their social value. Emotional stimuli are given prioritized attention compared to neutral stimuli. Neural evidence has shown different patterns of activation for fearful faces compared to happy ones, but a stronger effect was seen for emotional faces compared to neutral faces (Whalen et al., 1998). This evidence could suggest that attention is prioritised to detect emotional faces faster due to the positive or negative social value that this could convey. Due to the prominence of faces that need to be ignored when navigating the rich perceptual world, neutral faces would be more likely to not be allocated attention. Additionally, determining that a face is neutral has been seen to be cognitively harder than to determine its emotion (Fox et al., 2000). The importance to determine an angry face is due to threat detection (Anderson et al., 2003), and the happy faces could be detected quicker due to their importance when determining approachability and potential of social connection (Joorman & Gotlib, 2007). Additionally, the previously explained positive bias for critical stimulus could have also been seen with respect to happy faces, as healthy participants were seen to recognise happy faces quicker when they were

presented as an irrelevant stimulus (Joorman & Gotlib, 2007), and a similar effect was observed when happy faces were presented as the relevant stimuli.

No influence of depression and anxiety levels was seen on detection levels, response times or accuracy of the relevant task. A negative bias was expected for anxiety (Pérez-Dueñas, Acosta & Lupiáñez, 2009), as a heightened detection of negative stimuli was expected due to hypervigilance. A similar effect was expected for depression levels, as individuals with depression are faster to detect and more distracted by negative stimuli (Kanske & Kotz, 2012). Our results did not support this hypothesis. However, it must be noted that a sub-clinical population was examined, as one of the exclusion criteria for the study was presence of a mental health issue, only 16 of 78 participants (20%) had a score above 40 in the State-Trait Anxiety Questionnaire, score that would indicate clinically-significant symptoms of anxiety (Addolorato et al., 1999). Only nine (12%) of 78 participants showed significant levels of clinical depression. Prior literature on emotional effects on attention has yet to examine the effect of clinical levels in depression and anxiety on bias for negative stimuli using the inattentional blindness paradigm. Therefore, further investigation on the effect of clinical levels of both depression and anxiety using social stimuli and irrelevant stimuli of positive and negative valence should be conducted. This effect could be explored with individuals with phobias, generalised anxiety disorder and social anxiety, using critical images that are relevant to the anxiety disorder of an individual and social stimuli as the primary task.

Additionally, rates of detection in this investigation (14%) were lower than the average rates of detection for previous studies using the inattentional blindness paradigm, for example 58% in Simon and Chabris (1999). This could be attributed to the high perceptual load required by facial expression tasks. Cartwright-Finch and Lavie (2006) suggest that inattentional blindness can be manipulated by manipulating perceptual load, as a cognitively demanding task would leave few resources to process stimuli that was not expected. Evidence has found

that these tasks require larger amount of attention (Palermo & Rhodas, 2007; Pessoa, McKenna, Gutierrez & Underleider, 2002). Previous experiments use less cognitively demanding tasks such as determining which arm of a cross was longer (Mack & Rock, 1998), which may account for the difference in detection rates. Additionally, the critical images in this experiment were presented in the periphery of the visual field as they could not be presented at fixation due to the size of both the emotional face and the critical image. Previous evidence suggests that peripheral emotional stimuli are not attended to when carrying out a highly demanding main task (Holmes, Vuilleumier & Eimer, 2003). Therefore, further research could use similar stimuli but a primary task with lower cognitive demands, such as determining gender of faces instead of emotion. Higher detection levels of the critical image would be expected, and observation of which stimuli captures attention could be observed more closely.

In conclusion, the present study suggests that emotional valence affects allocation of attention, using the inattention blindness paradigm. It suggests that emotional congruency between task-relevant and irrelevant simultaneously presented stimuli does not affect the detection of irrelevant stimuli of emotional value. Healthy participants might have a positive detection bias for processing of unattended stimuli. Alternative explanations have also been discussed. Additionally, this experiment suggests that emotional social information, such as positive or negative facial expressions, is given attentional priority compared to neutral faces. Attentional capture of positive images in healthy participants was seen for both relevant and irrelevant stimuli.

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