Sleep-related attentional bias for tired faces in insomnia: Evidence from a dot-probe paradigm

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Sleep-related attentional bias for tired faces in insomnia: evidence from a dot-probe paradigm

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Abstract

People with insomnia often display an attentional bias for sleep-specific stimuli. However, prior studies have mostly utilized sleep-related words and images, and research is yet to examine whether people with insomnia display an attentional bias for sleep-specific (i.e. tired appearing) facial stimuli. This study aimed to examine whether individuals with insomnia present an attentional bias for sleep-specific faces depicting tiredness compared to normal-sleepers. Additionally, we aimed to determine whether the presence of an attentional bias was characterized by vigilance or disengagement. Forty-one individuals who meet the DSM-5 criteria for Insomnia Disorder and 41 normal-sleepers completed a dot-probe task comprising of neutral and sleep-specific tired faces. The results demonstrated that vigilance and disengagement scores differed significantly between the insomnia and normal-sleeper groups. Specifically, individuals with insomnia displayed difficulty in both orienting to and disengaging attention from tired faces compared to normal-sleepers. Using tired facial stimuli, the current study provides novel evidence that insomnia is characterized by a sleep-related attentional bias. These outcomes support cognitive models of insomnia by suggesting that individuals with insomnia monitor tiredness in their social environment.

Abbreviations

DSM-5 - Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition.
HADS - Hospital Anxiety and Depression Scale
SSS - Stanford Sleepiness Scale
MS - Milliseconds

Introduction

Insomnia is a prevalent sleep disorder affecting up to 10% of adults at disorder level (Espie, Kyle, Hames, Cyhlarova, & Benzeval, 2012; Morin, LeBlanc, Daley, Gregoire, & Merette, 2006). Characterized by difficulty with sleep initiation, maintenance and/or early morning awakening, and accompanied by significant impairment to daytime functioning, insomnia often leads to impaired quality of life (Kyle, Espie, & Morgan, 2010). Several theoretical cognitive models have been put forward to explain the mechanisms underlying the development and maintenance of insomnia (e.g. Espie 2002; Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; Harvey 2002). Emphasized in these models is the notion that insomnia is in part maintained by an attentional bias for sleep-related 'threat' cues which may be internal (i.e. bodily sensations) or external (i.e. environmental noises) (Espie et al., 2006; Harvey, 2002). Such 'threats' may be the product of sleep-specific anxiety, which is maintained by a combination of heightened arousal, distress, negative thoughts concerning sleep and belief that sleep difficulties during the night contribute to impaired functioning during the day. Due to this anxious state, attentional resources are preferentially allocated to the processing of sleep-related threat cues. Once detected, such cues may be interpreted in an insomnia-consistent manner, serving to further increase arousal, distress, and negative thoughts concerning sleep and daytime function: a vicious thought cycle that is partly maintained by the sleep-related attentional bias.

Several studies have examined the presence of a sleep-related attentional bias in insomnia using experimental tasks including the dot-probe, the flicker and the emotional Stroop (Barclay and Ellis, 2013; Beattie, Bindemann, Kyle, & Biello, 2017; Jansson-Fröjmark, Bermas, & Kjellen, 2013; Lundh, Froding, Gyllenhammar, Broman, & Hetta, 1997; MacMahon, Broomfield, & Espie, 2006; Marchetti, Biello, Broomfield, Macmahon, & Espie, 2006; Spiegelhalder, Espie, Nissen, & Riemann, 2008; Spiegelhalder et al., 2016; Woods, Marchetti, Biello, & Espie, 2009; Woods, Scheepers, Ross, Espie, & Biello, 2013; see Harris et al., 2015 for a review). Whilst many of these studies suggest that poor sleepers and individuals with insomnia display an attentional bias for sleep-related stimuli (Barclay and Ellis, 2013; Beattie et al., 2017; Jansson-Fröjmark et al., 2013; MacMahon et al., 2006; Marchetti et al., 2006; Spiegelhalder et al., 2008; Woods et al., 2009), the evidence base suggesting the presence of such a bias in insomnia remains mixed (Lundh et al., 1997; Spiegelhalder et al., 2016; Woods et al., 2013). A possibility for this may stem from methodological differences regarding the specific task or population.

The aforementioned studies largely used sleep-related words and images of objects. Such stimuli could be considered to be distal or abstracted from the insomnia experience, and research is yet to examine whether people with insomnia display an attentional bias for sleep-specific faces. Sleep-specific faces may be more proximal stimuli than words or images of objects, and thus more closely related to the insomnia experience, given the salience of tiredness (and its outward expression) in the interpersonal environment. Indeed, salient and often threatening faces are widely used to examine the presence of an attentional bias in many psychopathologies including anxiety and depression. For example, individuals with anxiety often show an attentional bias for threatening faces which display the expression of anger (Bradley, Mogg, White, Groom, & De Bono, 1999; Fox, Russo, & Dutton, 2010); whereas individuals with depression often show a bias for disorder-consistent faces depicting sadness (Bourke, Douglas, & Porter, 2010). With that in mind, recent research from our group demonstrated that people with insomnia were quicker to direct their initial attention to, and maintain overall attention towards, areas of the face associated with tiredness whilst viewing their own and other people's neutral faces (Akram, Ellis, Myachykov, & Barclay, 2017). Given that neutral facial stimuli were used in this study, the results suggest that areas of the face that are typically associated with threat are being monitored to detect such threat even when threat is absent. Moreover, this outcome also suggests insomnia may be characterised by a propensity to monitor faces for cues focused around the eye and mouth regions which are known to be associated with tiredness. The next logical step is to determine the presence of preferential attention towards faces that depict tiredness (threat) compared to neutral faces.

Using a dot-probe paradigm, the overall aim of the present study was to examine whether individuals with insomnia exhibit an attentional bias for sleep-specific faces depicting tiredness compared to normal-sleepers. Further, the nature of this potential bias, specifically vigilance (i.e. speeding of attention towards salient stimuli) or disengagement (i.e. difficulty in shifting attention away from salient stimuli) was also investigated. Given that experimental research to date has yielded mixed evidence concerning the presence and nature of sleep-related attentional bias in insomnia, the present study is the first to attempt to address this question using more proximal and salient stimuli. As such, we consider this to be an exploratory investigation, with no a-priori hypotheses.

Method

Participants

Participants were recruited from the general population using posters around Sheffield Hallam University, and social media. Participants completed a diagnostic screening questionnaire to determine eligibility to take part and group allocation – insomnia or normal-sleeper groups (see 'Measures and materials' for details). The sample consisted of 41 individuals with insomnia (mean age = 27.97 years, SD = 9.52 years; 65% female), and 41 normal-sleepers (mean age = 25.28 years, SD = 8.31 years; 67% female). The average duration of insomnia within the insomnia group was 32.23 months (SD = 45.58 months), ranging from 3 to 252 months. All participants had normal or corrected-to-normal vision.

Measures and materials

Screening questionnaire for eligibility and group allocation

A screening questionnaire determined eligibility and insomnia status. Individuals who reported symptoms of a sleep/wake disorder other than insomnia, an existing psychiatric illness, a central nervous system disorder, use of medication that may affect sleep, prior head injury or current shift-work were ineligible to participate. Participants with insomnia met DSM-5 criteria for insomnia disorder (American Psychiatric Association, 2013). Specifically, individuals with insomnia reported dissatisfaction with sleep characterized by either a difficulty initiating or maintaining sleep or early morning awakenings. Insomnia had to be present for three or more nights per week, for at least three months, and cause significant daytime impairment. Finally, these conditions had to be met despite adequate opportunity to sleep. It was a requirement that normal-sleepers reported no problems with sleep and no history of any sleep-disorder. Of note, the SLEEP-50 questionnaire (Spoolmaker, Verbeek, Van Den Bout, & Klip, 2005) was used to ensure the absence of a sleep/wake disorder other than insomnia.

Control measures

A number of measures were included to account for several factors that could influence attentional behaviour. Specifically, symptoms of anxiety and depression and self-reported sleepiness. Symptoms of anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS; Zigmond and Snaith, 1983), consisting of 14 items (seven for both anxiety and depression) scored between 0-3, with a maximum score of 21 on both subscales. Higher scores on each subscale represent greater anxiety and depression. Both subscales demonstrated good internal consistency (Cronbach's α=.84 for anxiety, and .76 for depression). The Stanford Sleepiness Scale (SSS; Hoddes *et al.,* 1973) was administered to assess participants' subjective state sleepiness. The measure consists of a 7 item likert scale ranging from 1 (feeling active, vital, alert, or wide awake) to 7 (no longer fighting sleep, sleep onset soon, having dreamlike thoughts). Higher scores are indicative of greater state sleepiness.

Facial stimuli for dot-probe task

A subset of 12 tired-neutral face-pairs (50% female) previously developed by our group were used for the present study (Akram, Sharman, & Newman, 2017). Specifically, with approval from the authors, facial photographs displaying a neutral expression were taken from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Ohman, 1998). Subsequently, the hair and neckline was cropped from each neutral image, leaving a series of oval shaped neutral facial images. To create the corresponding tired faces, each neutral face was subject to standardized manipulations of: increased pretarsal skin show; upper eyelid depression; dark circles under eyes; and drooped corners of the mouth (see Akram et al., 2017 for details). These specific manipulations have previously been associated with an increased perception of tiredness (Akram et al., 2016; Knoll et al., 2008; Sundelin et al., 2013). This resulted in a series of face pairs comprised of a threating (i.e. tired appearing) and neutral facial expression made by the same person (see Figure 1).

INSERT FIGURE 1 HERE

<u>*Procedure*</u>

All participants provided written informed consent prior to participation. Ethical approval was granted by the Sheffield Hallam University Research Ethics committee. The experiment was conducted in a quiet laboratory room in the department. Each participant was seated in front of a computer screen and task instructions were presented in writing on screen and explained orally. The participants then completed eight practice trials, followed by 192 experimental trials separated by a short break. To ensure that results were not confounded by order effects, face pairs were presented in a random order. Each practice and experimental trial first consisted of a fixation cross, which appeared in the centre of the screen for 500ms. This was followed by presentation of a face pair horizontally aligned, appearing for 500ms. After a gap of 100ms, a dot-probe (large dot) subsequently appeared either on the right or left position. This remained on the screen until a response key was pressed on the keyboard or the trial timed-out (3000ms). Participants were specifically required to press the corresponding key, which indicated the position of the probe (key Z for left position; M for right position), as quickly and as accurately as possible. Following each response, accuracy feedback was presented where either 'correct' or 'incorrect' was displayed in the centre of the screen for 500ms. After an interval of 1000ms, the next trial began (see Figure 2). Participants completed 192 trials in total. Half of the trials contained a tired-neutral pair, with each of the 12 pairs displayed 8 times with an equal probability that the probe would replace the tired or neutral picture. The remaining trials consisted of neutral-neutral pairs with each of the 12 neutral faces being displayed side by side 8 times. The relative positions (left or right) of each pair of pictures were counterbalanced. After completing the dot-probe task, participants completed the HADS and SSS. Following this, participants were debriefed on the purpose of the study.

INSERT FIGURE 2 HERE

<u>*Statistical Analyses*</u>

Examination of accuracy and preparation of data

The mean accuracy (i.e. correctly identifying the probe location) was 98.79%, and only correct trials were used in the final analysis (Salemink, Van Den Hout, & Kindy, 2007). Accuracy did not differ significantly between groups ($t(80)=2.89, P=.47$). In addition, reaction times below 200ms, those which timed out after 3000ms, and those that were three standard deviations above each participant's individual mean were eliminated (1.5% of trials).

Calculation of vigilance and disengagement

To examine the relationship between insomnia and attentional bias, indices of vigilance and disengagement were calculated. The vigilance index was calculated by subtracting the mean reaction time for threatening stimuli from the mean reaction time for neutral stimuli: Vigilance index = dN,N – dT, N. Here, dN, N represents dots replacing neutral faces in the presence of the corresponding neutral face (i.e. neutral: neutral-neutral trials); and dT, N for dots replacing tired faces in the presence of the corresponding neutral face (i.e. congruent: tired-neutral trial). A positive score on the vigilance index indicates faster response to dots appearing after tired as compared to neutral faces (Salemink et al., 2007), i. e. greater vigilance for 'threatening' stimuli. To calculate disengagement from tiredness, the mean reaction time for neutral trials were subtracted from the mean reaction time for trials where the dots replaced neutral stimuli in the presence of tired stimuli: Disengagement index = dN, T – dN, N. Here, dN, T represents dots replacing neutral faces in the presence of the corresponding tired face (i.e. incongruent: tired-neutral trials). A positive score on the disengagement index indicates slower responses to dots replacing neutral faces in the presence of the corresponding tired face (Salemink, et al., 2007), i.e. that attention was not directed to the neutral face but directed elsewhere (possibly the tired face) when the tired face was present. In sum, greater positive scores for both indices, vigilance and disengagement, are indicative of an attentional bias.

Analyses

Pearson's bivariate correlations examined associations between measures of anxiety, depression and sleepiness with indices of attentional bias (vigilance, disengagement). This was conducted for all participants, and individually for the insomnia and normal-sleeper groups to assess whether these factors influenced attention and determine the necessity of controlling for these factors in further analyses. In the case that any associations were significant, these variables were included as covariates in further analysis. Following the method used by Jansson-Fröjmark et al., (2013), a 2 (group: insomnia vs. normal sleepers) x 2 (bias index: vigilance vs disengagement) multivariate analysis of variance (MANOVA) was conducted, with the two bias indices as the dependent variables.

Results

The mean reaction times for each trial type (congruent, incongruent, neutral) and scores for the HADS and SSS for each group are presented in Table 1. Correlational analyses indicated no significant associations between measures of anxiety, depression and sleepiness with vigilance or disengagement scores for the whole sample (all p's>.05), suggesting that these factors did not influence attention. However, for individuals with insomnia, anxiety was significantly associated with disengagement (r= -.34, P=.03). As such, this was controlled for in the multivariate analysis. There were no other significant correlations between variables for each group (all p's>.05).

INSERT TABLE 1 HERE

Attentional bias: Vigilance and Disengagement

The descriptive statistics for the two bias indices for each group are presented in Table 2. The Wilk's Lambda multivariate test of overall differences amongst groups was significant (F(1,78)=8.43,P=.005). Univariate between-subjects tests demonstrated that vigilance (F(1,78)=8.44,P=.005) and disengagement (F(1,78)=10.93,P=.001) scores differed significantly between the insomnia and normal-sleepers groups. Compared to normal-sleepers (-2.14±10.66), individuals with insomnia were slower to orient their attention to tired faces, as demonstrated by a lower score on the vigilance index (-26.18±66.73). Moreover, compared to normal-sleepers (0.78±12.97), individuals with insomnia were also slower to shift attention away from tired faces as indicated by a higher score on the disengagement index (27.53±71.65).

INSERT TABLE 2 HERE

Discussion

The present study aimed to examine whether individuals with insomnia present an attentional bias (in the form of vigilance and/or disengagement) for sleep-specific faces depicting tiredness compared to normal-sleepers. Two key findings are drawn from the current study. First, individuals with insomnia and normal-sleepers differed significantly in terms of vigilance to sleep-specific cues. However, individuals with insomnia displayed decreased rather than increased vigilance towards sleep-specific cues. Second, the current data shows that insomnia appears to be characterized by difficulty in disengaging attention away from faces depicting sleep-specific cues (i.e. tired appearing) when compared to normal-sleepers. This outcome is in line with previous research using the dot-probe and Posner paradigms, which demonstrated that individuals with insomnia experience difficulty in shifting attention away from sleep-specific pictorial stimuli (Jansson-Fröjmark et al., 2013; Woods et al., 2009).

It may be theorized that individuals with insomnia exhibit prolonged attentional engagement for sleep-specific facial threat, which consequently impedes their motor response (to the key press), resulting in slower vigilance on this particular test. This finding is in line with recent work by Beattie et al. (2017) using a free-viewing eye-tracking task who demonstrated that individuals presenting with insomnia symptoms are not more vigilant for sleep-specific images, but retain longer attention towards such images once fixated. A replication of the current study in conjunction with eye-tracking would allow us to confirm the hypothesis that once fixated, the corresponding motor response is impeded by the salience of the sleep-specific faces depicting tiredness. Alternatively, considering recent evidence that those with insomnia experience difficulty in engaging with target words irrespective of valance (Woods et al., 2013), the overall response delay noted in the current study amongst those with insomnia may be reflective of a general performance deficit often reported by this population (Espie et al., 2012). That said, it is relevant to note that those with insomnia were marginally faster when responding to neutral-neutral trials, with a ‘performance deficit’ apparent only in the presence of sleep-specific stimuli.

Cognitive theories postulate that insomnia is partly maintained by selective attention and monitoring for cues that indicate the presence of a poor night’s sleep (Espie et al., 2006; Harvey, 2002). With that in mind, subjective reports evidence that individuals with insomnia selectively attend to their bodily sensations on waking and throughout the day for signs of impairment, including fatigue and tiredness (i.e. sore head, heavy eyes) as a result of a poor night’s sleep (Akram, 2017; Semler & Harvey, 2004; Wicklow & Espie, 2000). Indeed, greater emphasis placed upon these self-cues upon awakening and during the day to confirm the nature of their sleep disturbance would certainly serve to fuel worry, arousal and distress as described in cognitive models of insomnia (Espie et al., 2006; Harvey, 2002). Evidence highlights a significant role of the eye-region in projecting tiredness cues using facial manipulations or experimentally induced sleep deprivation to external perceivers (Akram et al., 2016; Knoll et al., 2008; Sundelin et al., 2013), and prior research has demonstrated that individuals with insomnia show preferential attention towards the eyes whilst observing neutral faces, of both themselves and others (Akram et al., 2017a). The current results expand on previous research using neutral faces (Akram et al., 2017a), by evidencing that individuals with insomnia display prolonged attention for more proximal sleep-specific facial cues. However, as this study used facial stimuli comprised of other people, we cannot draw the conclusion that people with insomnia monitor their own faces for such cues. That said, individuals with insomnia commonly interpret negative attributes pertaining to physical self-perception (i.e. facial cues of tiredness, facial complexion cutaneous features: Akram et al., 2016; Akram, 2017; Gupta, Gupta, & Knapp, 2014; Oyetakin-White, 2105), and by determining an attentional bias for facial tiredness cues, novel treatment outcomes may be presented. Indeed, prior research proposes feedback relating to a self-misperception of facial tiredness in insomnia can serve to improve subsequent self-perceptions of tiredness (Akram et al., 2016). Theoretically, this may remove one source of maintenance of the disorder (i.e. the propensity to attended to and negatively interpret physical cues consistent with a poor night’s sleep). Accordingly, further work is now required to explore whether the current outcomes extend to the self.

While there are many studies which have used emotional faces to assess various aspects of cognition (i.e. attention, interpretation) in numerous mental health conditions (e.g. anxiety, depression, bipolar disorder, anorexia nervosa: Bradley et al., 1999; Bourke et al., 2010; Fox et al., 2010; Pollatos, 2008; Surguladaze et al., 2010), there are some crucial issues to consider. Firstly, facial cues (e.g. of aggression) are likely to be interpreted as signalling a threat in both healthy people, and those with mental health conditions. Additionally, faces exhibiting a neutral expression may be interpreted as threatening based on structural features of the face rather than the emotional content (Oosterhof & Todorov, 2008). However, whether individuals with insomnia, or normal sleepers, actually consider sleep-specific faces depicting tiredness as ‘threatening’ comes into question. Future studies need to determine whether facial cues of tiredness are actually considered to be ‘threatening’, and whether this ‘threat’ drives the attentional biases evidenced here; or whether these attentional biases are stimulated by the salience of sleep, and tendency to monitor the external environment for cues associated with sleep, in individuals with insomnia. This latter explanation would be consistent with the idea that the attentional bias in insomnia represents a 'craving' for sleep rather than interpreting sleep-specific cues as 'threats'.

Several limitations of the current study should be noted. Whilst the current study used facial stimuli depicting tiredness that were based on established tiredness cues (Akram et al., 2016a; Knoll et al., 2008; Sundelin et al., 2013), they were not naturally occurring. With that in mind, facial stimuli based on photographs of individuals displaying experimentally induced tiredness through sleep deprivation may be more suitable. Second, whilst the dot-probe task is a commonly used measure of attentional allocation, the reaction-time nature of this task is limited to an indirect measure of attention, assessing only indices of covert attention allocation (Marks, Roberts, Stoops, Pike, Filmore, & Rush, 2014). As such, it would be worthwhile for future research to assess the presence of a sleep-related attentional bias for threatening faces depicting tiredness using a more overt measure of attentional allocation such as eye-tracking.

Taken together, the present study tentatively suggests that individuals with insomnia present an attentional bias in the form of increased difficulty disengaging from facial cues depicting tiredness. Salient, and often threatening faces are commonly used in conjunction with reaction time tasks to examine the presence of an attentional bias in many mental health issues. As such, the current outcomes advance the insomnia-attentional bias literature, bringing research in this area in line with other psychological conditions. More importantly, the current outcomes provide support for cognitive models of insomnia, suggesting that this population engage in an attentional bias for sleep specific faces. That said, as individuals with insomnia demonstrated lower vigilance for tired faces compared with normal sleepers, the current findings should be interpreted cautiously. Further research is required to clarify whether the current findings are indeed characteristic of a sleep-related attentional bias such that attention to sleep-specific stimuli is maintained, impairing responses, or the result of a performance deficit.

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Table 1

Means and standard deviations (M±SD) for normal-sleepers and insomnia groups reaction times on the dot-probe task, and measures of anxiety, depression and sleepiness.

	Normal Sleepers	Insomnia
Reaction time (msec):		
Congruent	392 ± 57	409 ± 56
Incongruent	390 ± 59	412 ± 67
Neutral	389 ± 57	381 ± 73
Anxiety*	5.20 ± 3.25	8.48 ± 4.23
Depression*	2.10 ± 2.08	4.95 ± 3.37
Sleepiness	2.23 ± 1.23	2.83 ± 1.00

Note: Congruent are where dots replace threat faces, incongruent where they replace neutral faces in a threat-neutral pair and neutral are responses for Neutral-neutral trials; Anxiety and depression scores range from 0-21 respectively, whereas sleepiness ranges between 1-7. Higher scores on each measure indicate greater symptomology.

*Sig at P>.01

Table 2
Means and standard deviations (M±SD) for normal-sleepers and insomnia groups scores on the vigilance index and disengagement index.

	Normal Sleepers	Insomnia
Vigilance Index*	-2.41 ± 10.66	-27.63 ± 66.55
Disengagement Index*	0.78 ± 12.79	30.89 ± 73.93

Note: Vigilance indicated by difference between neutral and congruent trials; Disengagement indicated by difference between neutral and incongruent trials.
* Sig at P>.01.

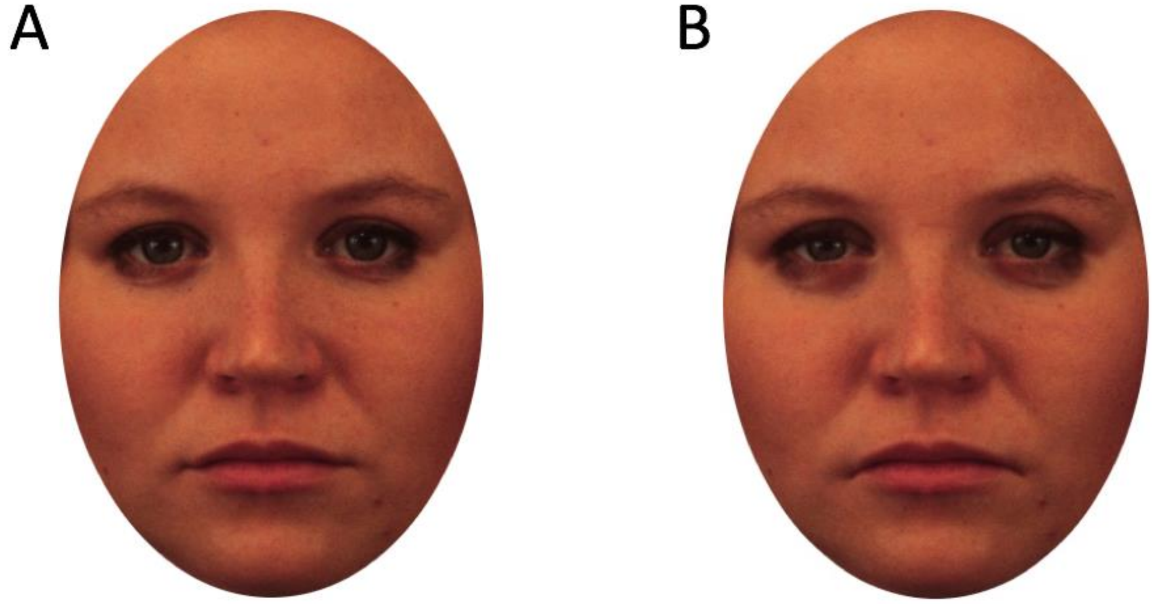

Figure 1. **(A)** Example of neutral face. **(B)** Example of corresponding tired face based on standardised manipulations of the neutral face, created using Plastic Surgery Simulator software. Specifically, manipulations of: increased pretarsal skin show; upper eyelid depression; dark circles under eyes; and drooped corners of the mouth were used (see Akram et al., 2017b for more detail).

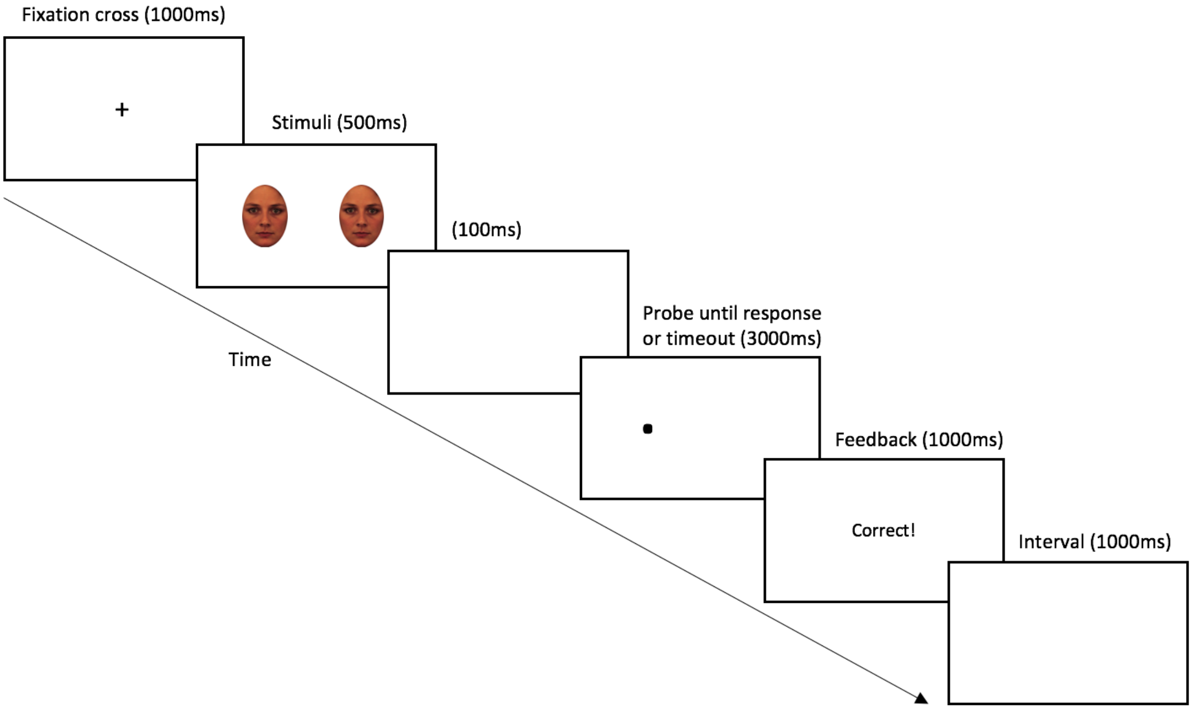

Figure 2: Example order of individual trial sequence for the dot probe task. Fixation cross first presented for 1000msec, followed by facial stimuli side-by-side for 500ms. After 100ms interval, probe appears until response or timeout. Correct response feedback presented if the corresponding probe location key was pressed, incorrect presented if the wrong key was pressed. Next trial begins after 1000ms blank screen interval.