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Preferential Attention Towards the Eye-Region Amongst Individuals with Insomnia.

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Abstract

People with insomnia often perceive their own facial appearance as more tired compared to the appearance of others. Evidence also highlights the eye-region in projecting tiredness cues to perceivers, and tiredness judgments often rely on preferential attention towards this region. Using a novel eye-tracking paradigm this study examined: i) whether individuals with insomnia display preferential attention towards the eye-region, relative to nose and mouth regions, whilst observing faces compared to normal-sleepers; and ii) whether an attentional bias towards the eye-region amongst individuals with insomnia is self-specific or general in nature. Twenty individuals with DSM-5 Insomnia Disorder and 20 normal-sleepers viewed 48 neutral facial photographs (24 of themselves, 24 of other people) for periods of 4000msec. Eye movements were recorded using eye-tracking, and first fixation onset, first fixation duration, and total gaze duration were examined for three interest-regions (eyes, nose, mouth). Significant *groupXinterest-region* interactions indicated that, regardless of the face presented, participants with insomnia were quicker to attend to, and spent more time observing the eye-region, relative to the nose and mouth-regions compared to normal sleepers. However, no *groupXfaceXinterest-region* interactions were established. Thus, whilst individuals with insomnia displayed preferential attention towards the eye-region in general, this effect was not accentuated during self-perception. Insomnia appears to be characterized by a general, rather than self-specific, attentional bias towards the eye-region. These findings contribute to our understanding of face-perception in insomnia, and provide tentative support for cognitive models of insomnia demonstrating that individuals with insomnia monitor faces in general, with a specific focus around the eye-region, for cues associated with tiredness.

Keywords

Attentional-Bias, Cognitive-Processes, Facial-Cues, Sleep, Tiredness, Self-Perception

Introduction

Cognitive models of insomnia highlight the role of attentional biases towards sleep-related cues as a factor in the maintenance of the disorder (Espie *et al.*, 2006; Harvey, 2002). It is postulated that sleep-specific anxiety is generated, and 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. Further, attentional resources allocated to the processing of sleep-related threat cues relating to ones internal (i.e. bodily sensations) and external (i.e. outside noises) environment are consequently increased as a result of this anxious state (Espie *et al.*, 2006; Harvey, 2002). Upon the detection of a threat cue, an individual with insomnia may interpret it in a disorder-consistent manner. Indeed, attentional resources drawn to ones' immediate environment to assess for sleep-related threat, may increase the probability of noticing and subsequently interpreting ambiguous or meaningless cues as threat. Thus, attentional and interpretive biases are likely to be more prevalent amongst individuals with insomnia due to enhanced disorder-specific information processing.

Several studies have investigated attentional biases to sleep-related cues in insomnia using experimental tasks including the dot-probe, the flicker, and the emotional Stroop (Barclay and Ellis, 2013; Jansson-Frömark, *et al.*, 2013; Lundh *et al.*, 1997; MacMahon *et al.*, 2006; Marchetti *et al.*, 2006; Spiegelhalder *et al.*, 2008). The majority of these studies confirm that poor-sleepers and individuals with insomnia display attentional biases towards sleep-related words and images compared to normal-sleepers (Barclay and Ellis, 2013; Jansson-Frömark, *et al.*, 2013; MacMahon, *et al.*, 2006; Marchetti, *et al.*, 2006; Spiegelhalder *et al.*, 2008; and see Harris *et al.*, 2015 for a review). Moreover, research using the insomnia ambiguity paradigm demonstrated that poor-sleepers interpret ambiguous sentences in a manner consistent with their specific difficulties (Ellis *et al.*, 2010; Ree *et al.*, 2006).

Individuals with insomnia commonly report daytime impairments including the experience of psychological distress, daytime dysfunction, and tiredness (Balter and Uhlenhuth, 1991; Carey, *et al.*, 2005; Fortier-Brochu *et al.*, 2012; Kyle *et al.*, 2010; Lichstein *et al.*, 1997; Moul *et al.*, 2002). Subjective reports evidence that individuals with insomnia selectively attend to 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 (Semler and Harvey, 2004; Wicklow and Espie, 2000). Given the frequent self-report of tiredness amongst individuals with insomnia (Balter and Uhlenhuth, 1991; Lichstein *et al.*, 1997),

research should examine disorder-consistent biases of attention with a specific focus on tiredness using objective methods. This will provide further and more explicit evidence that individuals with insomnia selectively attend to cues associated with this specific daytime impairment.

Specific aspects of the face function to characterise perceptions of tiredness (Akram *et al.*, 2016a; Knoll *et al.*, 2008; Sundelin *et al.*, 2013). A tired appearance is generally characterised by a depression of the upper eyelid and an increased pretarsal show (height of skin exposed between the upper-eyelid and eyebrow: see Knoll *et al.*, 2008 for details). Hanging eyelids, wrinkles and lines around the eyes, and dark patches under the eyes also project tiredness cues to perceivers (Sundelin *et al.*, 2013). Moreover, when asked to make judgments of tiredness, individuals tend to focus predominantly on the eye-region compared to the rest of the face (Nguyen *et al.*, 2009). Therefore, eye-region cues appear to promote the perception of tiredness. Whilst research has investigated perceptions of sleep-related facial cues of tiredness (i.e., hanging eyelids) using external observers (Knoll *et al.*, 2008; Sundelin *et al.*, 2013), little research has examined how individuals with insomnia perceive these cues. To that end, using a novel visual task whereby participants indicated when a morphing image of their face, varying in degrees of tiredness and alertness, represented their current level of tiredness, Akram and colleagues (2016a) demonstrated that individuals with insomnia displayed an interpretive bias in that they misperceived their own face as appearing more tired than they physically were. A follow-up study determined that this bias did not extend to the perception of other peoples' faces (Akram *et al.*, 2016b). Thus, individuals with insomnia only interpret their own facial attributes of tiredness in a manner consistent with the physical presence of a sleep-deficit. However, an attentional bias specifically towards regions of the face associated with tiredness (i.e. the eye-region) has yet to be confirmed.

To date, attentional biases for sleep-related stimuli amongst individuals with insomnia have largely been determined by means of reaction time experiments (Barclay and Ellis, 2013; Jansson-Frömark *et al.*, 2013; MacMahon, *et al.*, 2006; Marchetti *et al.*, 2006; Spiegelhalter *et al.*, 2008). Whilst instrumental in confirming the presence of an attentional bias for sleep-related stimuli in insomnia, reaction time tasks are indices of covert attention allocation, and are thus a somewhat indirect measure of attentional bias (Marks *et al.*, 2014). Hermans and colleagues (1999) first highlighted the significance of gaze behavior in providing a continuous index of attention allocation. Using this methodology, the amount of time

observing disorder-consistent stimuli serves as a measure of attentional bias (Eizenman *et al.*, 2003; Hermans, Vansteenwegen and Eelen, 1999). As individuals generally direct their eye-gaze towards stimuli that attract attention (Jonides, 1981), examining where individuals direct and fixate their gaze, using eye-tracking, provides a more objective and direct assessment of visual attention (Godijn and Theeuwes, 2003). Indeed, eye-tracking allows for visual attention allocation to be continuously recorded throughout stimuli presentation, rather than approximating gaze behavior prior to a response (Marks *et al.*, 2014). Thus, eye-tracking affords an expansion beyond snapshots provided by reaction time measures of attention, inherently providing a more ecological observation of visual and selective attention (Armstrong and Olatunji, 2012). With that in mind, examining eye-movement behavior (i.e. first fixation onset, first fixation duration, total gaze duration) towards disorder-consistent stimuli has proven to be a reliable measure of selective attention in disorders of mood (i.e. depression) and addiction (i.e. alcohol) (Duque and Vázquez, 2015; Eizenman *et al.*, 2003; Kellough *et al.*, 2008; Miller and Fillmore, 2010). To that end, Cleland Woods and colleagues (2013) utilized eye-tracking methods to establish a timeline of visual attention allocation to sleep-related and neutral words amongst individuals with insomnia relative to normal-sleepers. Whilst there was no evidence of an attentional bias to sleep-related words, amongst those with insomnia, the use of eye-tracking enables us to move the sleep-related attentional bias literature forward.

The present study used eye-tracking to examine whether individuals with insomnia, relative to normal-sleepers, differentially observe their own and other peoples' faces with preferential attention towards facial regions known to be associated with tiredness (i.e. eye-region). For the current purpose, neutral rather than manipulated (e.g. sleep-related) facial stimuli were used. This was deemed the most appropriate and ecologically valid stimulus given that everyday social situations entail observations of naturally appearing faces. Thus, the use of such stimuli acts as a useful first step in understanding how individuals with insomnia naturally observe their own and other peoples' faces.

This study specifically aimed to determine: i) whether individuals with insomnia display preferential attention towards the eye-region, relative to nose and mouth regions, whilst observing faces in general (i.e. self or other) compared to normal-sleepers; and ii) whether an established bias of attention towards the eye-region amongst individuals with insomnia is self-specific or general in nature. We hypothesized that compared to normal-sleepers,

individuals with insomnia would be quicker to direct their initial gaze towards, and display longer first fixation and total gaze durations on the eye-region relative to nose and mouth regions whilst observing faces in general. Further, considering insomnia appears to be characterised by a self-specific *interpretive* bias (Akram *et al.*, 2016a, 2016b), we also hypothesized that compared to normal-sleepers, individuals with insomnia would be quicker to direct initial gaze towards, and display a longer first fixation and total gaze durations on the eye-region whilst observing their own faces compared to those of other people (i.e. a self-specific *attentional* bias towards the eye-region).

Materials and methods

Participants

Participants were recruited from the general population using posters around Northumbria University, emails to students, and social media. Participants completed a diagnostic screening questionnaire to determine eligibility to take part and group allocation - insomnia or normal-sleeper (see 'Measures & Materials' section for details). The final sample consisted of 20 individuals with insomnia (mean age =21.30 years, SD=3.91 years; 85% female), and 20 normal-sleepers (mean age =24.05 years, SD=7.08 years; 75% female). The average duration of insomnia within the insomnia group was 0.97 years (SD=0.74), ranging from 0.3 to 3 years. 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 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. The 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.

Control measures

A number of measures were included to account for several factors that could influence gaze behaviour. Specifically, symptoms of anxiety and depression, self-reported sleepiness, and the amount of time participants had been awake prior to assessment were recorded.

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 $\alpha=.86$ for anxiety, and $.78$ for depression).

The Stanford Sleepiness Scale (SSS: Hoddes *et al.*, 1973) was administered to assess participants' state feeling of 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.

To control for the amount of time participants had been awake prior to the study, participants stated at what time they had woken. The researcher noted the time at which participants were tested. Wake time was deducted from test time to calculate 'time since awakening' (hours:minutes).

Materials

A digital camera was used to take headshot photographs of each participant, required for stimuli creation, against a white background in a laboratory room. Eye movements were recorded using an EyeLink-1000 (SR Research Ltd) eye-tracker (1000Hz sampling-rate). Stimuli, 640x640px in size, were presented centrally on a 17" monitor (75Hz refresh-rate). Monocular recording was conducted, whereby the movements from the dominant eye were registered. Eye-dominance was determined using the Miles test (see Miles, 1929 for more detail). A height adjustable chin-rest and forehead support was used to ensure that participants' heads remained still whilst eye movements were recorded.

To examine differences in how individuals with insomnia and normal-sleepers observe their own and other peoples' faces, facial photographs of each participant (for presentation of the

'self') and two other individuals (for presentation of 'others'): one male, and one female (mean age =22years, SD=1.41 years), were taken for use as stimuli. These 'other' individuals reported the absence of any sleep-disorder. A headshot photograph of each participant and the two 'other' individuals was taken. They were asked to display a neutral expression, move hair away from the face and wear no make up. In total, 48 neutral facial photographs were presented to participants during the experimental task. Twenty-four of the individual participant (self-presentation), and the remaining 24 photographs of two other people, twelve male, and twelve female (other-presentation).

Procedure

All participants provided written informed consent prior to participation. Ethical approval was granted by the Faculty of Health and Life Sciences Ethics committee at Northumbria University. Participants were tested between 9:00am and 12:00pm on each day, over two consecutive days. On the first day of testing, facial photographs of each participant were taken. The photographs were subsequently programmed into an individualised computerised experiment by a researcher for each participant between testing days.

Participants returned at the same time the following day to complete the computerised experimental task. Firstly, participants completed the HADS, SSS, and reported what time they had woken up that morning. After completing the eye-dominance test, participants placed their chin and forehead onto the support in front of them, approximately 60cm from the computer screen. This was adjusted to a comfortable height, and the eye tracker was appropriately positioned and focused to capture the participant's dominant eye. A nine-point calibration task was then completed to confirm $< 1^\circ$ visual angle of recorded eye movements. Participants attended to the screen, and were required to fixate upon a dot that appeared on the centre of the screen. Subsequently, a series of fixation dots successively appeared, and participants were required to direct their gaze and fixate upon each dot until the task was over. A nine-point validation task was subsequently performed to verify calibration.

Upon successful calibration, the experimental task began. Forty-eight trials were completed. For each, participants were presented with each facial photograph for 4000msec and were asked to explore, examine and remember the presented face for a subsequent recognition task. Prior to each trial, a fixation cross was displayed at the bottom left corner of the screen

to ensure standardization of starting gaze location. Order of presentation was randomised. After each trial, participants completed a short recognition task lasting approximately 5000msec to mask the nature of the experiment. After completing the task, participants were thanked and debriefed. Of note, the outcome of the recognition task was not of relevance to the current study, whereas the critical measure was the duration that participants attended towards different facial regions when presented with each face for 4000msec.

Statistical analyses

Interest-regions

To examine how participants observed the presented facial photographs, three interest-regions were pre-determined and analysed for first fixation onset, first fixation duration, and total gaze duration in msec: the eyes; nose; and mouth. See Figure 1 for an example of interest-regions used for analyses. The eye-region accounted for pretarsal skin show and wrinkles/lines around the eye-region including the skin above the nose (i.e. glabella) and lower forehead, and crows-feet as these features have previously been associated with tiredness (Forte *et al.*, 2015; Knoll *et al.*, 2008; Sundelin *et al.*, 2013).

For each interest-region: first fixation onset was defined as the amount of time elapsed (in msec) before the first fixation landed within the interest-region; first fixation duration was defined as the time (in msec) between the start of the first fixation which landed within the interest-region until this fixation oriented elsewhere; and total gaze duration was defined as the total summation of the fixations' duration (in msec) that landed within the interest-region. These were extracted for analysis using the 'Dataviewer' (SR Research Ltd) computer software. SPSS was used to perform formal statistical analyses of the differences in mean gaze-durations between and within participant groups.

Insert **Figure-1**

Analyses

Pearson's bivariate correlations examined associations between measures of anxiety, depression, and sleepiness, with parameters of eye-movement (first fixation onset, first fixation duration, total gaze duration), whilst viewing one's own and others' faces. This was

conducted for all participants, and individually for the insomnia and normal-sleeper groups to assess whether these factors influenced gaze-duration 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 analyses. Of note, results for other male and female faces were collapsed into a single 'other' group for analysis.

A series of 2 (group: insomnia vs. normal-sleepers) x 2 (face: self vs. other) x 3 (interest-region: eyes vs. nose vs. mouth) mixed measures ANOVA analyses were employed, with first fixation onset, first fixation duration, and total gaze-duration as dependent variables. This was conducted to assess the main effects of group, face, and interest-region. The group x face, group x interest-region, face x interest-region, and group x face x interest-region interactions were also assessed. Tests for pairwise comparisons were also conducted. As participants were tested at different times within a three-hour window (9:00am-12:00pm) time since awakening was included as a covariate to ensure that test-time variation did not affect gaze behaviour. Significance was considered at the $p < .05$ level.

Results

Mean scores for first fixation onset, first fixation duration, total gaze duration, HADS, SSS, and time since awakening for each group are presented in Table 1.

Insert Table-1

First Fixation Onset

Overall, correlational analyses indicated a significant association between sleepiness and first fixation onset to other peoples' mouths ($r = -.36$, $p = .045$). Moreover, for individuals with insomnia, sleepiness was significantly associated with first fixation onset to other peoples' eyes ($r = .47$, $p = .04$); and symptoms of anxiety were significantly associated with first fixation onset to other peoples' noses ($r = .49$, $p = .04$) and mouths ($r = .56$, $p = .02$). Accordingly, the variables demonstrating associations with the dependent variable were controlled for in the mixed measures analyses. There were no other significant correlations between variables for each group (all p 's $> .05$).

A significant group x interest-region interaction ($F[2,78] = 3.67$, $p = .03$) demonstrated that, irrespective of the presented face (self vs. other), participants with insomnia were quicker to

direct their gaze to the eye region, relative to the nose and mouth regions compared to normal-sleepers (see Table 2 for means). However, the lack of a three-way interaction (group x face x interest-region) ($F[2,78]=.34, p=.72$) confirms that, whilst individuals with insomnia were quicker to observe the eye-region when viewing faces in general compared to normal-sleepers, this effect was not more pronounced whilst observing their own face.

No significant effects of group ($F[1,26]=.75, p=.39$), face ($F[1,26]=.29, p=.60$), or interest-region ($F[1,52]=1.32, p=.28$), or group x face ($F[1,52]=1.34, p=.26$) and face- x interest-region ($F[1,52]=2.61, p=.08$) interactions were found.

Insert Table-2

First Fixation Duration

Overall, correlational analyses indicated a significant association between symptoms of anxiety and the duration of first fixations on participants own noses ($r=.33, p=.04$). Moreover, for normal-sleepers, sleepiness was significantly associated with the duration of first fixations on their own mouths ($r=-.50, p=.048$), and other peoples' eyes ($r=-.48, p=.048$) and noses ($r=-.55, p=.01$). As such, these variables were controlled for in the mixed measures analyses. There were no other significant correlations between variables for each group (all $p's > .05$).

The results demonstrated no significant effects of group ($F[1,27]=.29, p=.60$), face ($F[1,27]=1.97, p=.17$), or interest-region ($F[1,54]=2.16, p=.13$), or group x interest-region ($F[2,81]=.44, p=.65$), group x face ($F[1,54]=2.98, p=.10$), face x interest-region ($F[2,54]=.05, p=.95$), or group x face x interest-region ($F[2,81]=.19, p=.82$) interactions concerning first fixation duration.

Total Gaze Duration

Overall, correlational analyses indicated no significant associations between anxiety, depression, and sleepiness with total gaze duration towards each of the interest-regions (all $p > .05$), suggesting that these factors did not influence gaze behavior. However, for normal-sleepers, symptoms of anxiety were significantly associated with total gaze duration towards their own ($r=.61, p=.01$) and other peoples' noses ($r=.55, p=.01$). Additionally, for normal-sleepers symptoms of depression were significantly associated with total gaze duration

towards other peoples' mouths ($r=-.50$, $p=.03$). Accordingly, the variables demonstrating associations with the dependent variable were controlled for in the mixed measures analyses. There were no other significant correlations between variables for each group (all $p's>.05$).

The results revealed a significant main effect of interest-region, ($F[1,38]= 1.53, p=.001$) on total gaze duration. Pairwise comparisons confirmed that regardless of the face presented, all participants observed the eye-region ($M=1764.12$, $SD=704.37$ msec) for longer than the nose ($M=329.38$, $SD=330.38$ msec) and mouth ($M=152.21$, $SD=147.58$ msec) regions. Additionally, participants observed the nose-region for longer than the mouth-region (all $p=.01$). However, no main effects of group ($F[1,35]=1.80, p=.19$) or face ($F[1,35]=.01, p=.99$) were found.

A significant group x interest-region interaction ($F[2,105]=6.29$, $p=.003$) indicated that, irrespective of the presented face (self vs. other), participants with insomnia spent more time observing the eye-region, relative to the nose and mouth regions compared to normal-sleepers (see Table 3 for means). Despite the significant group x interest-region interaction, no group x face x interest-region interaction was confirmed ($F[2,105]=1.69$, $p=.19$). Thus, whilst individuals with insomnia spent more time observing the eye-region whilst viewing faces in general compared to normal-sleepers, this effect was not more profound whilst observing their own face. These results suggest that individuals with insomnia display a general, rather than self-specific, attentional bias towards the eye-region compared to normal-sleepers. No group x face ($F[1,70]=0.03, p=.87$) or face x interest-region ($F[2,105]=0.33, p=.72$) interactions were found.

Insert Table-3

Discussion

The present study examined: i) whether individuals with insomnia display preferential attention towards the eye-region, relative to nose and mouth regions, whilst observing faces compared to normal-sleepers; and ii) whether an attentional bias towards the eye-region amongst individuals with insomnia was self-specific or general in nature.

First, the current findings demonstrated that individuals with insomnia were quicker to direct their initial attention towards, and spend more time observing, the eye-region relative to other facial regions (i.e. nose, mouth), whilst viewing faces in general compared to normal-sleepers. As evidence highlights a significant role of the eye-region in projecting tiredness cues to perceivers (Akram *et al.*, 2016a; Knoll *et al.*, 2008; Sundelin *et al.*, 2013), the current results provide suggestive evidence that individuals with insomnia exhibit a propensity to monitor faces, with a specific focus around the eye-region, potentially for cues associated with tiredness (i.e. hanging eyelids, wrinkles and lines around the eyes). Indeed, considering that cognitive processes often suggested to facilitate the maintenance of insomnia include selective attention, monitoring, and interpretive biases for cues that indicate the presence of a poor night's sleep (Espie *et al.*, 2006; Harvey, 2002), it is perhaps not surprising that individuals with insomnia were more attentive to areas of the face that portray tiredness.

Second, contrary to expectation, this attentional bias amongst those with insomnia was not accentuated during self-perception (i.e. whilst observing ones' own face). Individuals with insomnia were quicker to direct their initial attention to and maintain overall attention towards the eye-region whilst viewing both their own and other peoples' faces. Thus, insomnia appears to be characterized by a more general rather than self-specific attentional bias towards the eye-region. This was unexpected considering previous work by our group determined that individuals with insomnia display an *interpretive* bias of the face that is self-specific in nature (i.e. facial attributes of tiredness are interpreted in a manner consistent with the presence of a sleep-deficit for photographs of the self only, Akram *et al.*, 2016a, 2016b). The current study extended the previously identified self-specific *interpretive* bias of the face amongst individuals with insomnia, by examining the specificity of the *attentional* bias. Despite existing evidence of a differential self/other interpretive bias concerning facial attributes of tiredness, our data confirms individuals with insomnia display an equivalent level of attention towards both their own and other peoples' facial features relating to tiredness. As such, it may be posited that individuals with insomnia attend to other peoples' facial attributes of tiredness to evaluate these features and draw comparisons to their own. Indeed, the face is used in social perception to portray one's internal state to others (Allison *et al.*, 2000). Thus, in this case, it is likely that individuals with insomnia not only monitor and subsequently perceive their own facial appearance in terms of an increased sleep-deficit (i.e. as appearing more physically tired as a result of poor sleep), but also monitor the faces of

other people and use this information to inform their judgments. Given the dysfunctional nature of these self/other comparisons (e.g. 'I look exhausted compared to everybody else'), worry, arousal and distress could certainly be perpetuated as described in cognitive models of insomnia (Espie *et al.*, 2006; Harvey, 2002).

Interestingly, whilst individuals with insomnia were quicker to direct their initial gaze towards the eye-region of faces in general, relative to normal-sleepers, suggesting an attentional bias towards cues pertaining to tiredness, no group difference concerning first fixation duration on the eye-region was established. Thus, it appears that individuals with insomnia show a faster response towards a salient area of the face, however they do not maintain or disengage differently to normal sleepers once initial attention is placed.

Several limitations to the present study should be noted. Whilst the current data suggests that individuals with insomnia display a propensity to monitor faces for cues associated with tiredness, only neutral facial stimuli were presented. As no facial manipulations associated with an increased perception of tiredness as used in previous research were employed (i.e. upper-eyelid depression: see Akram *et al.*, 2016a for details), the current results focusing on the eye-region generally are limited to suggestive evidence. That said, we also consider this a strength of the current study, informing us that using neutral facial stimuli acts as a useful first step in understanding how individuals with insomnia naturally observe their own and other peoples' facial regions compared to normal-sleepers. Future research should expand upon the current observations, which may act as a baseline, by encompassing facial manipulations of tiredness to further examine self/other attentional biases concerning the face. Indeed, considering the current bias towards areas of the face associated with tiredness amongst individuals with insomnia, we demonstrate that this effect may inherently be more profound using manipulated sleep-related (i.e. tired appearing) facial stimuli (as used by Akram *et al.*, 2016a). Further, considering evidence of cross-cultural differences in how emotional states portrayed by the face are perceived (see Russell, 1994 for a review), such differences may have affected participant's observations in the current study. That said, given physical tiredness can result in the relaxing of muscles which would inherently alter one's facial expression similarly across cultures (Enoka and Stuart, 1992), in the current context tiredness is likely to be cross-culturally perceived as an external representation of an internal physiological and physical, rather than emotional, state. Additionally, the current sample consisted primarily of female participants in the insomnia

group. As such, the present findings may not be fully generalizable to males. That said, women are more likely than men to be diagnosed with insomnia (Zang and Wing, 2006). For standardization, participants were required to remove any make-up prior to their photograph being taken. For some female participants, particularly with insomnia, removal of make-up may have negatively influenced gaze behaviour whilst viewing themselves in a manner that they would not ordinarily. Therefore, replication of the current study amongst a larger and more balanced sample, with the addition of tired stimuli, would be beneficial.

It is also relevant to comment on the relatively young age of our sample (compared to other research on insomnia). This was intentional for two reasons. Firstly, we considered it necessary to account for age related changes to sleep continuity (i.e. sleep disturbances attributable to the onset of menopause). Secondly, previous work by our group which examined the notion of a self-specific interpretive bias of the face was restricted to a sample of younger adults with insomnia (see Akram et al., 2016a, 2016b), to account for age-related changes to sleep continuity and increased sensitivity to early signs of skin aging. To maintain consistency between our studies the mean age of the current sample was also limited to younger adults. Future research should also consider using a more representative sample inclusive of older adults.

To summarize, the present study demonstrates that individuals with insomnia display preferential attention towards the eye-region whilst viewing faces compared to normal-sleepers, suggesting that insomnia is characterized by a general, rather than self-specific, bias of attention towards the eye-region. These findings contribute to our understanding of face perception in insomnia and provide tentative support for cognitive models of insomnia (Espie *et al.*, 2006; Harvey, 2002), demonstrating that individuals with insomnia monitor faces in general, with a specific focus around the eye-region, for cues associated with tiredness.

Taken together with our previous findings (Akram *et al.*, 2016a, 2016b) we conclude that insomnia is characterized by a general *attentional* bias towards the eye-region to evaluate cues of tiredness in themselves and others; the information of which is then used to draw comparisons with one's own state, culminating in a self-specific *interpretive* bias.

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Figure 1. Example of the pre-determined interest regions used for analyses. *Note:* Eyes = Red; Nose = Blue; Mouth = Yellow

Table 1. Scores for first fixation onset, first fixation duration, total gaze duration, anxiety, depression, sleepiness, and time since awakening (means \pm standard deviation)

	Normal-sleepers	Insomnia
First Fixation Onset (msec)		
Self Eyes	874 \pm 559	530 \pm 318
Self Nose	1337 \pm 657	1807 \pm 880
Self Mouth	1430 \pm 545	1964 \pm 599
Other Eyes	858 \pm 728	435 \pm 203
Other Nose	1045 \pm 636	1480 \pm 1178
Other Mouth	1796 \pm 772	2172 \pm 627
First Fixation Duration (msec)		
Self Eyes	320 \pm 109	392 \pm 271
Self Nose	325 \pm 131	400 \pm 178
Self Mouth	326 \pm 105	405 \pm 314
Other Eyes	357 \pm 187	442 \pm 344
Other Nose	398 \pm 344	437 \pm 532
Other Mouth	281 \pm 86	308 \pm 110
Total Gaze Duration (msec)		
Self Eyes	1376 \pm 697	1813 \pm 600
Self Nose	434 \pm 369	275 \pm 24
Self Mouth	235 \pm 224	188 \pm 133
Other Eyes	1638 \pm 895	2229 \pm 547
Other Nose	430 \pm 438	179 \pm 218
Other Mouth	116 \pm 170	69 \pm 72
Anxiety	7.00 \pm 3.37	9.45 \pm 3.25
Depression	2.85 \pm 2.13	4.15 \pm 2.58
Sleepiness	2.15 \pm 0.75	2.50 \pm 0.69
Time Since Awakening (hours:minutes)	2:13 \pm 0:44	1:49 \pm 0:37

Note: Anxiety, Depression: Hospital Anxiety & Depression Subscales; Sleepiness: Stanford Sleepiness Scale.

Table 2. Scores for first fixation onset (msec) to each interest region, regardless of face presented (means \pm standard deviation)

	Normal-sleepers	Insomnia
Interest Region		
Eyes	866 \pm 615	482 \pm 247
Nose	1167 \pm 556	1650 \pm 803
Mouth	1589 \pm 603	2052 \pm 536

Table 2. Scores for total gaze duration (msec) for each interest region, regardless of face presented (means \pm standard deviation)

	Normal-sleepers	Insomnia
Interest Region		
Eyes	1507 \pm 767	2021 \pm 540
Nose	432 \pm 393	227 \pm 219
Mouth	176 \pm 187	129 \pm 93