Running Head: Culture, gaze, and emotion in face WM

A cross-cultural investigation into the influence of eye gaze on working memory for happy and angry faces.

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Declaration of interest statement

The authors, Samantha Gregory, Stephen Langton, Sakiko Yoshikawa and Margaret Jackson, declare that they have no conflict of interest.

Abstract

Previous long-term memory (LTM) research found that angry faces were more poorly recognised when encoded with averted vs. direct gaze, while memory for happy faces was unaffected by gaze. Contrastingly, working memory (WM) accuracy for angry faces was unaffected by gaze, but WM was enhanced for happy faces with averted vs. direct gaze. Because the LTM study was conducted in an Eastern culture (Japan) with Japanese faces, while the WM study was conducted in a Western culture (UK) with Caucasian faces, here we investigated WM further to examine whether gaze effects diverge due to cultural variation between the faces and participants. When Western participants viewed Japanese faces (Experiment 1), the happy-averted gaze advantage in WM was replicated. In contrast, Japanese participants viewing Caucasian faces (Experiment 2a) showed poorer WM for angry faces with averted vs. direct gaze, and no influence of gaze on WM for happy faces. When Japanese participants viewed Japanese faces (Experiment 2b), gaze did not modulate WM. Therefore, the way in which expression and gaze interact to influence face WM does not appear to rely on the specific memory system engaged, but instead may be attributed to cultural differences in display rules between Eastern and Western cultures.

Key words: Emotion; faces; gaze; working memory; cross-cultural

When engaging with people, we use information conveyed via the face to gain information about their identity and mental state. This information can then be used to decode their current intentions and, crucially, whether or not these intentions are relevant to us (see Parkinson, 2005 for review). Information about intentions can be interpreted from both eye gaze and facial expression. However, while people tend to look where they intend to act (Land & Tatler, 2009), eye gaze can have a number of additional motivational and emotional connotations. For example, depending upon context, direct gaze can signal attentiveness (Freeth, Foulsham, & Kingstone, 2013), or dominance (Strongman & Champness, 1968), while averted gaze can signal nervousness (Larsen & Shackelford, 1996), deception (Aavik et al., 2006), or boredom (Kleinke, 1986). Intent information can be further understood through facial expressions, where for example these can reflect positive intentions when someone is smiling or negative intentions when someone is angry.

A reasonably well-established body of research shows that eye gaze direction can influence how facial expressions of emotion are decoded and processed. The vast majority of these studies have examined perception of emotion as a function of gaze, in terms of how readily emotions can be categorised or how intense the emotions are perceived to be for direct versus averted gaze faces (e.g., Adams & Kleck, 2003, 2005; Bindemann, Burton, & Langton, 2008). Furthermore, some cultural differences in the influence of gaze on emotion perception have been reported (e.g. Adams, Franklin, et al., 2010; Akechi et al., 2013), outlined below. In contrast, there is very limited research on the combined influence of emotional expression and eye gaze on memory for faces, and currently no cross-cultural investigation of these effects. The current study is the first to directly examine cross-cultural influences on how eye gaze and emotional expression interact to modulate working memory (WM) for faces. Our findings indicate Eastern versus Western cultural differences in how direct and averted gaze signals modulate WM for angry and happy faces.

Before addressing known emotion and gaze effects in memory, first we review ways in which the signals of eye gaze and facial expression are shown to interact in perception. Research has shown that people are faster to identify approach emotions (happy, angry) in a face with direct eye gaze, whereas withdraw/avoid emotions (fear, sad) are identified faster with averted eye gaze (Adams & Kleck, 2003, 2005; Bindemann et al., 2008). Experiments looking at emotional intensity of expressions found that congruent emotion-gaze conditions (direct for approach, averted for withdraw) resulted in higher participant ratings of emotional intensity (N'Diaye, Sander, & Vuilleumier, 2009; Sander, Grandjean, Kaiser, Wehrle, & Scherer, 2007). Willis, Palermo, and Burke, (2011) in addition found that angry faces with direct gaze were rated as less approachable and less trustworthy than angry faces with averted gaze, but happy faces were rated as more approachable and trustworthy when they displayed direct vs. averted gaze. This body of research implies that perceived social intent is interpreted via a combination of both emotional expression and gaze direction. Notably, as far as we can tell these experiments were conducted in Western cultures using Caucasian or Caucasian-like faces. However, further experiments in Japan investigating the response of the amygdala to happy and angry faces with averted or direct gaze found increased activity for expressions shown with direct gaze (Sato, Kochiyama, Uono, & Yoshikawa, 2010; Sato, Yoshikawa, Kochiyama, & Matsumura, 2004). There are also additional effects of culture on gaze and emotion perception.

Cultural differences in eye contact perception have been found between Eastern and Western cultures. It is commonly reported that in Eastern cultures, and specifically in Japan, it is disrespectful to maintain eye contact during conversation, whereas this is not the case in Western cultures where it may be disrespectful to continuously look away (e.g. McCarthy, Lee, Itakura, & Muir, 2006; Uono & Hietanen, 2015). Furthermore, eye gaze is shown to modulate emotion perception in culture-specific ways. Akechi et al., (2013) found that Japanese people interpreted a neutral facial expression as looking angrier with direct gaze than with averted gaze. Contrastingly, for Western (specifically Finnish) participants the level of anger reported was not affected by gaze direction, despite both Western and the Japanese participants rating the direct gaze condition as more arousing than the averted gaze condition. They also found that Japanese participants rated the direct gaze faces as more unapproachable and unpleasant than western (Finnish) participants. Therefore, it appears that Japanese individuals and Western individuals not only differ in eye gaze display, they also differ in eye gaze interpretation.

Beyond perception, other research shows that gaze influences long-term memory for neutral faces, and emotion and gaze interact to influence both long-term and working memory face recognition. In LTM, neutral faces with direct gaze are remembered better than neutral faces with averted gaze (Mason, Hood, & Macrae, 2004; Vuilleumier, George, Lister, Armony, & Driver, 2005), suggesting that direct gaze faces engage more attention. Nakashima, Langton, and Yoshikawa (2012) measured LTM for faces with happy and angry facial expressions showing direct and averted gaze. As is typical in LTM faces tasks, participants were shown a series of faces, one-by-one, and asked to judge the age of each face. Thus, emotion and gaze were not task-relevant, and encoding into LTM was incidental. After a 5-minute break, participants were given a surprise old/new recognition task in which they had to state whether they had seen a face identity or not during the age-judgement phase (50% of test faces were old). Faces at test were shown with neutral expression with either direct or averted gaze. Independent of gaze direction at test, they found that recognition memory was significantly worse for angry face identities that were initially viewed showing averted gaze compared to direct gaze. In contrast, recognition of the happy faces was unaffected by gaze direction.

In contrast, Jackson (2018) measured working memory (WM) for face identity as a function of emotional expression and gaze. While LTM operates over minutes and longer, WM operates over a few seconds and allows us to track information from moment-to-moment. To measure WM for faces, a delayed match-to-sample task is commonly used, where participants intentionally encode a small number of face identities simultaneously (usually between 1 and 4 faces), and are tested on average 1-3 seconds later with a single neutral (or emotional) probe face (e.g., Jackson, Linden, & Raymond, 2014; Jackson, Wolf, Johnston, Raymond, & Linden, 2008; Jackson, Wu, Linden, & Raymond, 2009; Sessa, Luria, Gotler, Jolicœur, & Dell'acqua, 2011). Jackson (2018) showed two angry or two happy faces with direct or averted gaze for 2 seconds, and asked participants to encode face identity (expression and gaze were task-irrelevant). After a 1-second blank maintenance interval, a neutral test face (with either direct or averted gaze as per encoding) was shown and participants stated whether the identity of this face matched to one of the faces just seen or to none of them. Results showed that happy faces with averted eye gaze were remembered significantly better than happy faces with direct gaze, but eye gaze did not influence WM for angry faces. This is in direct contrast to the gaze effect found on LTM for angry faces (impaired for averted vs. direct) and lack of gaze effect on LTM for happy faces (Nakashima et al., 2012).

There are two potential explanations for these contrasting results in LTM versus WM. The first relates to differences in motivation within the LTM and WM systems – specifically, WM is for current, pressing information, and LTM is for information that would be useful in the future. Happy faces showing direct gaze are shown to be prioritised over angry direct-gaze faces in LTM in general (e.g., Chen et al., 2015; D'Argembeau, Van der Linden, Comblain, & Etienne, 2003; Liu, Chen, & Ward, 2014; Shimamura, Ross, & Bennett, 2006), so it may be reasonable to infer that maintenance in memory is not influenced by the faces' gaze behaviour during encoding due to positive emotional information being prioritised over gaze information. An angry face may become deprioritised in LTM if it is not looking at you, potentially due to dilution of the threat signal when gaze is averted from the observer

(Nakashima et al., 2012). In WM, however, participants performance in the identity matching task was better for angry faces with direct gaze than for direct-gaze happy faces, thought to occur because monitoring an angry individual during a current interactive episode is important in terms of social and emotional priorities at that moment in time (e.g., Jackson et al., 2008, 2009, 2014). Therefore, the immediate motivational value of an angry face may not change as a function of gaze, as suggested by Jackson's (2018) findings. An angry face looking away may be no less motivationally relevant than one with direct gaze during immediate processing, and the threat remains regardless of where they are looking. Enhanced WM for happy faces with averted versus direct gaze suggests that smiling faces looking away are particularly motivationally salient in some immediate way, perhaps due to ambiguity of the smile when not directed towards the observer, or as anecdotal feedback suggests they may seem suspicious, sly, and somewhat threatening (Jackson, 2018).

The second potential explanation for the contrasting results of Nakashima et al. (2012) and Jackson (2018) relates to East / West cultural differences in how emotional expression and eye gaze interact to influence perceived social intent. Nakashima et al.'s LTM study was conducted in Japan with Japanese faces and predominantly Japanese participants, while Jackson's WM study was conducted in the UK with Caucasian faces and predominantly Western participants. It is therefore possible that cross-cultural differences in perceptions of eye gaze could account for the contrasting results as it is not unusual in Japan for people to look away while smiling but this may be more unusual in the West.

To date there has been no systematic cross-cultural comparison of combined gaze and expression effects in any face perception or memory task. While Akechi et al. (2013) compared Finnish and Japanese participants in their face perception study outlined above, they used two Finnish and two Japanese (neutral) face stimuli but presented these between different participant groups with no cross-comparisons. In the current study, for the first time we directly assessed the influence of culture on combined gaze and emotional expression on WM for faces, comparing Eastern (Japan) and Western (Aberdeen) participants and using Japanese and Caucasian face stimuli. Added to the published study using Western participants and Caucasian faces (Jackson 2018), across three new experiments here we completed the full cross-cultural investigation.

In Experiment 1 Western participants viewed Japanese faces, and in Experiment 2 Japanese participants viewed Caucasian (Experiment 2a) and Japanese faces (Experiment 2b). Western participants were tested at the University of Aberdeen, UK, and Japanese participants were tested at Kyoto University, Japan. If cultural differences in emotion and gaze perception influence the motivational value of emotional faces in WM, then we should expect to see variation in the emotion-gaze interaction effects across different experiments. Specifically, for Western participants viewing Japanese faces in Experiment 1, we expect to replicate the original memory advantage for happy-averted versus happy-direct gaze faces, although this may be weaker with other-race faces (see Adams, Pauker, & Weisbuch, 2010). In Experiment 2, two possible outcomes were predicted. If Japanese participants perceive angry faces with averted gaze as less angry than those with direct gaze (see Akechi et al., 2013), we should expect to find poorer WM for angry-averted versus angry-direct gaze faces for both the Caucasian (Experiment 2a) and Japanese (Experiment 2b) face stimuli, with no influence of gaze on WM for happy faces. This would thus replicate the emotion-gaze interaction pattern seen in LTM by Nakashima et al. (2012) with Japanese participants and faces. Alternatively, if the differences seen between the interaction of gaze and expression on long-term versus working memory are due to functional differences between these memory systems over time, then we would expect to cross culturally replicate the happy averted versus direct gaze advantage (and lack of gaze effect on WM for angry faces) found by Jackson (2018).

General Methods

Stimuli

Caucasian faces

Six male face identities from the Ekman and Friesen (1976) database (all showing direct gaze) were chosen (as used in Jackson, 2018). There were 3 versions of each identity, showing angry, happy, and neutral expressions (18 images in total). Eye gaze for each of the faces was manipulated using Corel Paintshop Pro X5 by moving and blending the pupil and iris to show averted gaze. Face size was uniform, on screen size was 2.5 cm × 3.5 cm, and faces were presented in greyscale and cropped to remove hair and other external features. Face images are available upon request.

Japanese faces

Six male face identities were taken from the ATR Japanese face database (Ogawa, Oda, Yoshikawa, & Akamatsu, 1997), as used in Nakashima et al. 2012. This database was created by asking Japanese individuals aged between 19 and 29 to pose with expressions mimicking examples from the standard Ekman and Friesen (1976) set. All other facial information and manipulations matched those described for the Caucasian face set, except

GNU Image Manipulation Program was used for eye-gaze manipulation. The stimuli used are available upon request, please see Figure 1 for an example of the Japanese stimuli used.

Design and procedure

The design and procedure matched that of Jackson (2018) Experiment 1a. Eye gaze (direct, averted) and facial expression (angry, happy) were randomised across trials. Before starting the main experiment, but after being given instructions for the study, participants were shown the 6 identities of the faces in each of the 3 expressions (happy, angry, neutral) to familiarise themselves with the identities used in the study. A 16 trial (8 direct gaze, 8 averted gaze) practice preceded the main experiment. This matched the main experimental procedure with the exception that accuracy feedback was provided during the practice but not during the main experiment. There were 240 trials in the main experiment in total: 120 direct gaze (60 angry, 60 happy) and 120 averted gaze (60 angry, 60 happy). The participant initiated each trial with a button press to allow them to take regular breaks. Each trial proceeded as follows: a central fixation cross was presented for 1000 ms, followed by the encoding array of two faces with matching expressions (both angry or both happy, see Figure 1) and matching gaze directions (both direct or both averted) for 2000 ms presented either side of the fixation cross. Participants were instructed that eye gaze and facial expression were not task relevant, and instead they were to remember face identity. After a blank 1000 ms maintenance interval with only a fixation cross on screen, participants were shown a single test face with neutral expression and a gaze direction which matched that shown at encoding. A neutral test expression was used in order to ensure participants were using identity information, and not simply using template matching to compare two identical images. Using a button press, participants stated whether the test face matched the identity of one of the two faces seen at encoding (50% match, 50% non-match trials, randomised; P for match, Q for non-match). Participants had 3000 ms to respond[1]. Non-match faces were selected at random from those identities not seen at encoding. See Figure 1 for a trial example.

[1] Experiment 1, average response time = 986 ms, 0.22% of trials timed out. Experiment 2a, average response time = 1149 ms, 2.6% of trials times out. Experiment 2b, average response time = 892 ms, 1.02% of trials timed out. Timed out trials were not analysed.

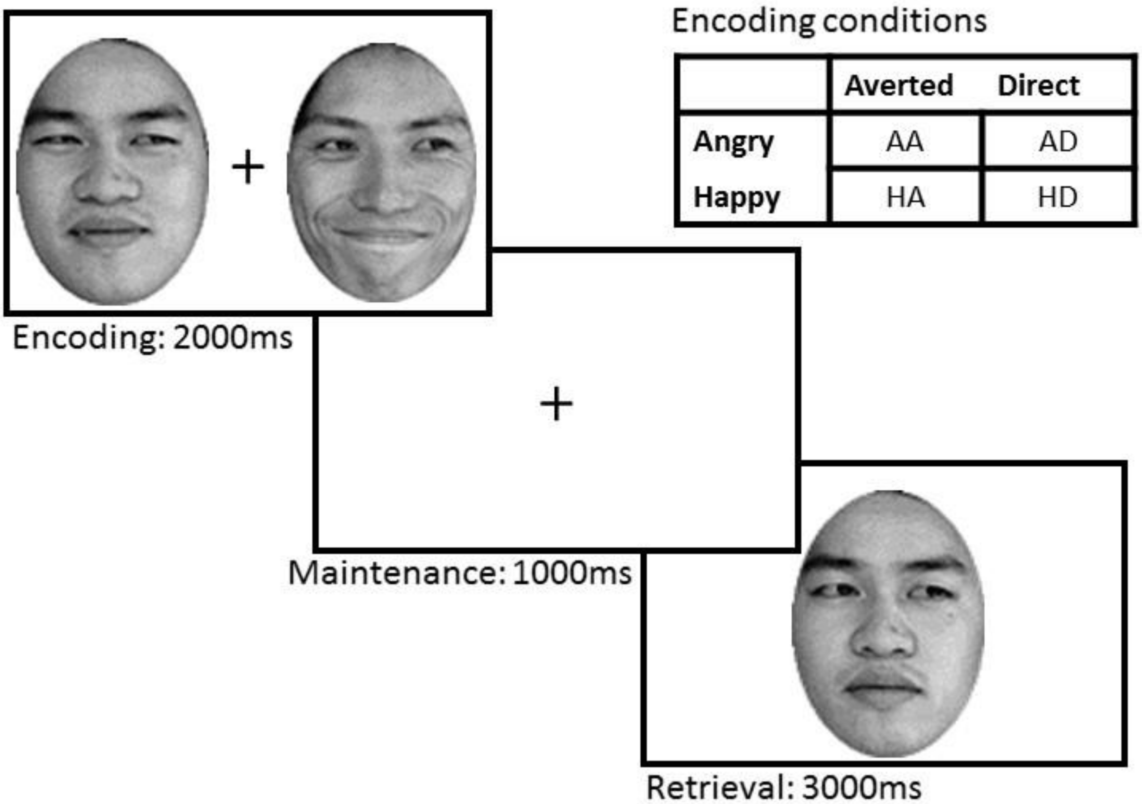

Figure 1. Example trial procedure of WM task. Faces at encoding were shown with either direct or averted gaze and showed either a happy or an angry facial expression. Both encoding faces were always shown with the same gaze direction and same facial expression, Japanese happy-averted (HA) faces are illustrated here, face images used are available on request. The test face was always shown with the same gaze state as the faces shown at encoding but with a neutral expression (NA = neutral-averted). The four encoding conditions are specified: angry-averted (AA), angry-direct (AD), happy-averted (HA), happy-direct (HD).

Data analysis

Hit rates (the proportion of correct "yes" responses on match trials) and false alarms (FA; the proportion of incorrect "yes" responses on non-match trials) were computed into *d*' scores (*d*' = zHits - zFA). This provides a sensitive measure of memory discrimination as it accounts for response bias (Green & Swets, 1966). Specifically, a *d*' of 0 would indicate no discrimination at retrieval; this could be achieved by participants always choosing to say the target matched, thus they would have a perfect score in match trials, but an accuracy score of 0 in the non-match trials (i.e., 50% accuracy). Alternatively, a *d*' = of 4.66 would indicate perfect performance in both match and non- match trials (100% accuracy). Data is accessible here: https://osf.io/qru7g/. We conducted repeated-measures ANOVAs using *d'* values as a measure of WM accuracy with expression (angry, happy) and gaze (direct, averted) as within factors.

Experiment 1: Western participants - Japanese faces

Here, we re-ran Experiment 1a from Jackson (2018, Western participants / Caucasian faces), in order to investigate whether a replication could be achieved of enhanced WM for averted vs. direct gaze happy faces, and no gaze effect for angry faces, using a different face database with Japanese faces.

Participants

Thirty participants (15 female; mean age 23 years) were recruited from the University of Aberdeen. All had normal or corrected-to-normal vision, and all University of Aberdeen ethics requirements were upheld. Power analysis (G*Power 3.1.9.2) using the effect size from Jackson (2018) determined 12 participants sufficient to find an effect (assuming power = .95, f= .47, and alpha = .05), however due to the potential weakening of the effect because of interference from possible other-race effects (Adams, Pauker, et al., 2010), we used a sample size closer to the original (Jackson, 2018).

Results and discussion

There were non-significant main effects of expression $F(1, 29) = 0.607$, p=.442, ηp^2 = .021 and gaze $F(1,29) = 1.722$, p= .200, ηp^2 = .056. However, there was a significant interaction between expression and gaze $F(1, 29) = 5.788$, p = .023, ηp^2 = .166, as can be seen in Figure 2a. Planned (uncorrected) paired t-tests were conducted on separate angry and happy face data to understand this interaction. There was a non-significant difference in WM accuracy for angry faces encoded with direct gaze (M = 2.257, SD = 0.960) versus averted gaze (M = 2.184, SD = 0.914); t (29) = 0.627, p = .536, Cohen's d = . 114. However, when faces were happy, WM was significantly more accurate when they were encoded with averted (M = 2.334, SD = 0.856) versus direct gaze (M = 1.988, SD = 0.862); t(29) = 2.268, p = .031, Cohen's d = 0.414. Therefore, these cross-race results from Western participants viewing Japanese faces replicate the original within-race pattern of effects found when Western participants viewed Caucasian faces (Jackson, 2018). To confirm this replication, we ran an additional cross-experiment analysis comparing these data with those from Western participants viewing Caucasian faces from Jackson (2018, note that the methods were identical except for the face database used). We found that while performance overall was better for Japanese (M = 2.191, SD = 0.791) than Caucasian (M = 1.577, SD = 0.912) faces ($F(1,58) = 7.754$, $p = .007$, $\eta p^2 = .118$), the analysis showed the significant interaction between expression and gaze $F(1, 58) = 12.156$, $p = .001$, $\eta p^2 = .173$, and all interactions of group with emotion and gaze were non-significant (all $Fs \leq 2.077$, all $ps \geq .155$). Thus, among Western participants WM for happy faces was boosted when they showed averted vs. direct gaze regardless of face race.

Experiment 2: –Japanese participants

Here, we ran the same experiment again but with Japanese participants viewing the Caucasian faces used in Jackson (2018) (Experiment 2a), or the same Japanese faces as we used in Experiment 1 here (Experiment 2b). These experiments can help determine whether the finding with Western participants replicates cross culturally with the original Caucasian faces used and for the Japanese faces used. The results of this study will help us to understand whether the differences seen between LTM and WM for averted vs direct happy and angry faces in Nakashima et al. (2012) and Jackson (2018) are due to functional differences between these memory systems over time or if they are due to cultural differences related to eye gaze and expression. Therefore, if the findings consistently show enhanced memory for happy faces with averted gaze as compared to happy faces with direct gaze in both cultural groups, then this indicates that the findings are due to differences in LTM compared to WM. If, however, the findings show reduced memory for averted gaze angry faces as compared to direct gaze angry faces (as per the Japanese study conducted by Nakashima et al., 2012), then this indicates that the differences are more likely to be cultural.

Experiment 2a: Japanese participants - Caucasian faces

Participants

Twenty participants (7 female; mean age 21 years) were recruited from Kyoto University. All had normal or corrected-to-normal vision, and Kyoto University ethics requirements were upheld. Participant numbers were fewer here due to time constraints, however based on power analysis using the original Jackson (2018) study 20 participants was deemed sufficient.

Results and discussion

There were non-significant main effects of expression $F(1, 19) = 2.316$, $p = .144$, $\eta p^2 = .109$ and gaze $F(1,19) = 1.808$, $p = .195$, $\eta p^2 = .087$. However, as can be seen in Figure 2b, a significant interaction between expression and gaze was found, $F(1, 19) = 8.378$, $p = .009$, $\eta p^2 = .306$. Planned (uncorrected) paired t-tests were conducted on separate angry and happy face data to understand this interaction and assess whether the study replicated Jackson's (2018) finding that gaze modulated WM for happy but not angry faces. The results did not replicate these WM findings, and instead showed the opposite effect. There was a non-significant difference in WM accuracy for happy faces encoded with direct gaze (M = 1.357, SD = 0.171) versus averted gaze (M = 1.450, SD = 0.215); $t(19) = 0.618$, $p = .544$, Cohen's $d = .138$. However, WM was significantly more accurate when angry faces were encoded with direct (M = 1.434, SD = 0.798) versus averted gaze (M = 1.064, SD = 0.614); $t(19)=3.439$, $p = .003$, Cohen's $d = .769$. Thus, when viewing other-race Caucasian faces, Japanese participants showed the same pattern of effects as was found in Nakashima et al.'s (2012) Japanese within-race LTM task. Memory was impaired for angry-averted versus angry-direct faces, but there was no influence of gaze on memory for happy faces.

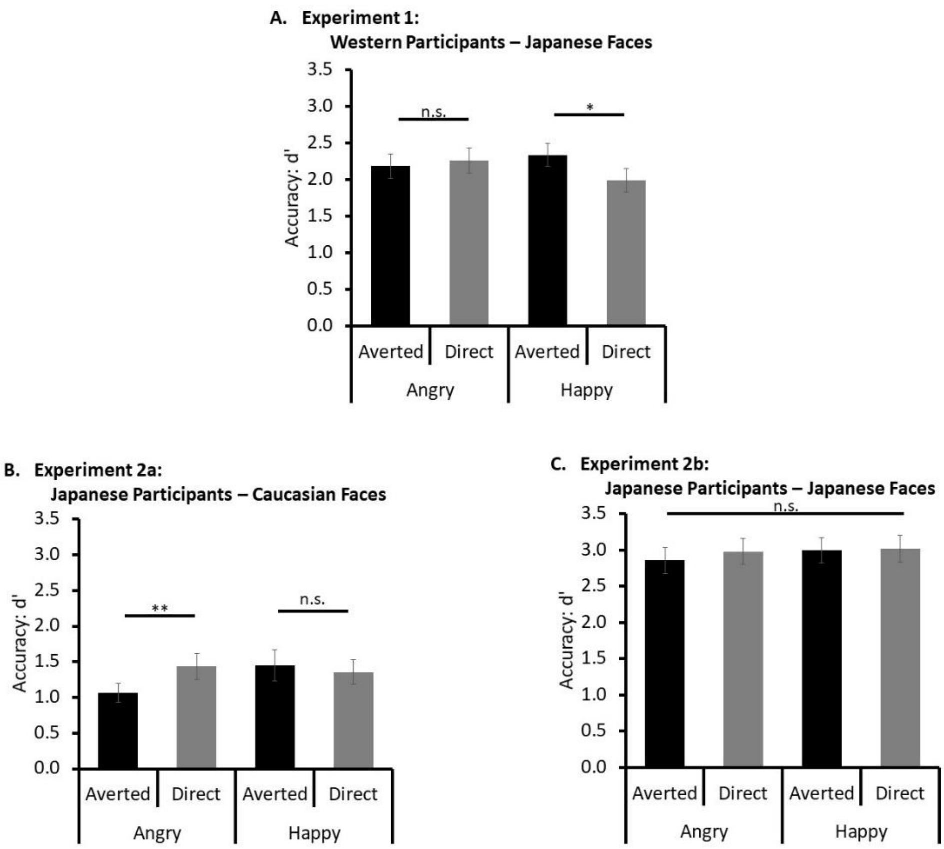

Figure 2. A) Results from Experiment 1, in which Japanese faces were used as memory items in a WM study with Western participants. B) Results from Experiment 2a, in which Caucasian faces were used as memory items in a WM study with Japanese participants. C)

Results from Experiment 2b, in which Japanese faces were used as memory items in a WM study with Japanese participants. * = p < .05, ** = p < .01. Error bars represent 1 standard error above and below the mean.

Experiment 2b: Japanese participants - Japanese faces

Here we directly replicated our Experiment 1 where Japanese faces were used, but now with Japanese participants.

Participants

Forty-three participants (19 female; mean age 22 years) were recruited from Kyoto University. All had normal or corrected-to-normal vision, and Kyoto University ethics requirements were upheld. Participant numbers were higher here due to a number of individuals recruiting participants concurrently. These participants were different to those recruited in Experiment 2a.

Results and discussion

There were non-significant main effects of expression $F(1, 42) = 1.702$, $p = .199$, $\eta p^2 = .039$ and gaze $F(1,42) = 1.111$, $p=.298$, $\eta p^2 = .026$. There was also a non-significant interaction between expression and gaze $F(1, 42) = 0.351$, $p = .557$, $\eta p^2 = .008$. The data are presented in Figure 2c. Thus, Japanese participants were equally able to remember the identities of own-race Japanese faces regardless of emotional expression and eye gaze direction.

Though participants were on average (across all 4 face conditions) below perfect performance (confirmed by statistically significant one-sample *t* tests comparing mean performance in each condition to the maximum *d*' value of 4.66; all *p*s < .001), nine reached ceiling performance on one or more of the conditions. Removing these participants from the analysis gave very similar results: expression $F(1, 33) = 1.443$, $p = .238$, $\eta p^2 = .042$; gaze $F(1,33) = 0.217$, $p = .644$, $\eta p^2 = .007$; expression x gaze $F(1, 33) = 0.58$, $p = .811$, $\eta p^2 = .002$.

Therefore, Japanese participants do not appear to show impaired memory for angry faces with averted gaze when the faces are Japanese, but do for Caucasian face stimuli. Due to the unequal sample sizes and a significant outcome of Levene's test for homogeneity of variance, a non parametric Mann Whitney test was applied comparing the mean memory performance (collapsed across expression and eye gaze) across Experiments 2a and 2b. This showed that WM performance was significantly better overall for Japanese participants viewing Japanese faces (Experiment 2b; M = 2.962, SD = 1.107) compared to Japanese participants viewing Caucasian faces (Experiment 2a; M = 1.326, SD = 0.703) (U = 763.5, $p < 0.00$). We cannot readily interpret this as an own-race bias, however, because Western participants also found Japanese faces easier to remember overall than Caucasian faces (Experiment 1 here compared to Jackson, 2018). In order to understand whether this general memory difference caused the faces to be viewed differently, we also created difference scores for the angry and happy memory data related to whether the faces showed averted or direct gaze (i.e. angry-direct minus angry-averted) and performed non parametric Mann Whitney tests comparing the difference in memory for the two groups. These showed that the two groups were not statistically different in the magnitude of gaze effects, angry (U = 344.5, $p = .207$), happy (U = 458.5, $p = .421$)[2]. However, it is possible that highly accurate memory among Japanese participants for Japanese faces masked any effects that may have been present in the data. Regardless, we cannot conclude whether or not the detrimental effect of averted eye gaze on angry faces seen in LTM in Nakashima et al.'s (2012) Japanese within-race LTM task replicates in WM for Japanese participants viewing Japanese faces.

General discussion

The aim of the experiments presented here was to investigate if different effects of emotional expression and gaze on face recognition seen in LTM and WM could be accounted for by cross-cultural East/West differences. In a LTM study conducted with Japanese participants viewing Japanese faces it was previously found that LTM for happy faces was not affected by eye gaze direction, but angry faces encoded with direct gaze were remembered better than angry faces with averted gaze (Nakashima et al., 2012). In direct contrast, a WM study conducted with Western (UK) participants and Caucasian faces found that WM for angry faces was not affected by gaze direction, but happy faces encoded with averted gaze were remembered better than happy faces encoded with direct gaze (Jackson, 2018).

In Experiment 1, we replicated Jackson's (2018) original finding using instead Western participants and Japanese face stimuli: WM for angry faces was not affected by eye gaze direction, but WM was better for happy faces with averted vs. direct gaze. In Experiment 2 we attempted to replicate this pattern of effects with Japanese participants viewing Caucasian faces (Experiment 2a) and Japanese faces (Experiment 2b). Among

[2] For reference, despite uneven sample sizes a mixed ANOVA was conducted with Experiment 2a vs. 2b as a between factor, and confirms a non-significant 3-way interaction between emotion, gaze, and experiment, $F(1, 61) = 1.705$, $p = .197$).

Japanese participants viewing Caucasian faces, WM for happy faces was not affected by gaze direction, but WM for angry faces encoded with averted gaze was worse than for angry faces encoded with direct gaze. Thus we did not replicate the original effect found among Western participants viewing Caucasian faces (Jackson, 2018), but this does replicate the effects of gaze and emotion on LTM for faces found by Nakashima et al. (2012) with a Japanese sample (viewing Japanese faces). When Japanese participants viewed Japanese faces in Experiment 2b, there was no influence of eye gaze or expression on face WM.

Taken together, these findings suggest that there are culture-specific differences in how eye gaze direction influences WM for expressive faces. In both Nakashima et al's (2012) LTM study (Japanese participants and Japanese faces) and our WM Experiment 2a presented here (Japanese participants and Caucasian faces), Japanese participants showed a memory deficit for angry faces with averted vs. direct gaze. This result is in line with research that suggests that Japanese individuals perceive angry faces that are looking away as less angry than those with direct gaze, an effect not seen in Western participants (Akechi et al., 2013). If averted gaze dilutes the signal of anger, then angry faces looking away from the observers may have been deemed less important and motivationally salient and thus deprioritised in WM.

However, it is important to note that unlike for the LTM study (Nakashima et al., 2012), this effect of averted gaze on memory for angry faces was not found in WM for Japanese participants vewing the Japanese faces presented here in Experiment 2b, and in fact this experiment showed no influence of emotion or gaze nor their interaction on WM. One possible explanation relates to our finding that Japanese participants showed very good WM for Japanese faces, although additional analyses showed that even when removing the best performers there were no effects of gaze or emotion in this group. While face recognition in general is considered to recruit both featural and holistic processes (dual-route hypothesis; e.g., see Bartlett, Searcy, & Abdi, 2003), visual expertise is thought to engage more holistic processing (e.g., Bilalic, Langner, Ulrich, & Grodd, 2011; Diamond & Carey, 1986; Gauthier, Curran, Curby, & Collins, 2003) and facilitate exemplar individuation (e.g., Curby & Gauthier, 2010; Gauthier, Williams, Tarr, & Tanaka, 1998). Therefore, speculatively, perhaps superior WM for own-race faces among Japanese individuals engaged more holistic processes and fewer featural processes when face identification was the key task, and as a result reduced attention to gaze and emotional expression features of the to-be-remembered faces, thus accounting for their lack of influence in Experiment 2b. Using data from the original study (Jackson, 2018, Experiment 1a) compared with data from Experiment 1 here showed better WM performance overall for Japanese compared to Caucasian faces. This does indicate that the Japanese face stimuli used may have been easier to remember than the Caucasian face stimuli overall, but we cannot rule out the possibility that between-group differences in general WM capacity may also have led to these findings. However, when these faces were used in Experiment 1 with Western participants, we replicated the original Jackson (2018) finding. Therefore, though these faces may be easier to remember, this does not in and of itself undermine the findings.

A second possible interpretation of the absence of gaze and emotion effects in Experiment 2b relates to cultural differences in gaze behaviour evaluation within the context of tracking current events and thoughts in WM. For Japanese participants, seeing averted gaze when interacting with other Japanese people is normal due to Japanese people engaging less in mutual gaze (e.g., McCarthy et al., 2006; Uono & Hietanen, 2015). Therefore, directional gaze signals may have been deprioritised in this task. Alternatively, when the faces displayed were Caucasian (Experiment 2a), perhaps gaze signals were viewed as more motivationally relevant due to different display rules for Western individuals. Specifically, it may be that Japanese people are aware that Western individuals engage in more mutual gaze, and therefore the eye gaze signals were percieved to be more relevant in this context. As stated earlier, Japanese participants specifically rated angry faces looking away as less angry (Akechi et al., 2013), and so when paying attention to gaze signals from Caucasian faces it is possible that angry faces looking away received less attention and were therefore more poorly encoded into WM.

If eye gaze signals are indeed not relevant for Japanese individuals when viewing Japanese faces in a WM context, why then did Nakashima et al. (2012) find that eye gaze modulated LTM for angry faces? The task in their LTM study was fundamentally different from that in the WM study, so a methodological explanation is worth considering. In the WM task the participants were aware that they were required to encode the faces into memory, however, in the LTM study participants were asked to rate the age of the faces, and the memory task was a surprise. It is possible that when rating the age of the faces the eye region was used as a reference for the age rating, as it has been found that the eye region conveys numerous cues for age estimation (Rhodes, 2009). This would then make the eye region highly relevant, and so gaze related effects may be found in this particular context. Here, we were exclusively interested in cross-cultural variations in how the interaction of eye gaze and expression modulated WM for faces, but it would be of interest for future research to investigate how emotion and gaze interact cross-culturally in LTM, using both incidental and explicit identity encoding tasks. A replication of the Nakashima et al. (2012) LTM study with Western participants and Caucasian faces would be an important first step.

Turning more directly to our findings from Western participants, they showed the same pattern of emotion-gaze interaction regardless of whether they viewed Caucasian faces (Jackson, 2018) or Japanese faces (Experiment 1 here): better WM for happy faces with averted vs. direct gaze and no influence of gaze on WM for angry faces. This finding aligns with research that showed no gaze modulation of anger perception among Western (Finnish) individuals (Akechi et al., 2013), and indicates that angry faces are prioritised equally in WM regardless of gaze direction. Lack of threat dilution by averted gaze in angry faces in Western samples further supports the notion that within this culture gaze aversion does not tend to serve as a signal of deference (to thus soften a threatening signal) as it does in Eastern cultures (McCarthy et al., 2009; Uono & Hietanen, 2015). The consistent replication of enhanced WM for happy faces with averted vs. direct gaze among Western individuals, regardless of the race of the face, suggests that gaze aversion renders smiling faces of higher immediate priority, perhaps due to increased ambiguity of the valence of intent if for example a happy expression appears less happy, approachable, and trustworthy with averted gaze (Adams & Kleck, 2003, 2005; Bindemann et al., 2008; Willis et al., 2011). The fact that Japansese participants were unaffected by the gaze direction of smiling faces here can be reconciled with the fact that gaze aversion is seen as a positive social signal in this culture, thus smiling faces twinned with averted gaze may still be perceived as unambiguously positive.

It is worthwhile noting that here we only used male faces, while in Nakashima et al. (2012) a mixture of both male and female faces were used. We used only male faces because this replicated the original Jackson (2018) study design in WM. This approach was taken in order to avoid gender effects, as studies have shown that displays of anger in males and females are processed differently (Goos & Silverman, 2002; He, Liu, Wang, & Zhang, 2018; Williams & Mattingley, 2006). Further, research shows that women that show gaze avoidant behaviour are percieved more negatively, while no such judgement is placed on gaze avoidant males (Larsen & Shackelford, 1996). It would therefore be of interest for future research to investigate gender effects that may further modulate the interaction between emotion and gaze in memory. An additional note is the use of different Caucasian and Japanese face stimuli from different databases. This can be seen as a strength of the study, as among Western participants the effect shown for the Caucasian faces replicates with the different Japanese faces, indicating that this is not simply an effect of one particular type of database. Further, using the Caucasian faces with Japanese participants we show a replication of an effect seen in the long term memory paradigm using the Japanese set used in our study. Therefore the use of the different databases demonstrates that the effects aren't anomalies of the databases used.

There are a number of limitations in the study that are important to address. First, the ideal approach for a question such as this one would be to have tested all conditions in our study for all participants in a full within-subjects design. Relatedly the unequal participant numbers across our experimental conditions also limits between subjects analysis. These sampling limitations occurred due to constrained time in Japan to conduct the research. A further limitation related to the Japanese faces used, as already noted, was that these faces were somewhat more memorable than the Caucasian face set, leading to particularly high accuracy in Experiment 2b (Japanese participants). It is difficult to determine exactly why the Japanese faces were more memorable here, but one possibility is that they look younger than the Caucasian faces and this may have yielded what might be an own-age bias in face WM for our young adult participants (see Rhodes & Anastasi, 2012 for a review of own-age biases in face recognition). For future studies, face sets and participants that are matched for age might therefore be an important methodological consideration, and there should be more research on own- vs. other-age effects in face WM more generally as our current understanding of this is severely lacking. These limitations should be noted when forming conclusions based on our findings. Despite them, we feel that the data presented here allow us to draw adequate conclusions to advance this area of research.

In conclusion, across three experiments we have demonstrated cross-cultural variations in how eye gaze and expression interact in WM, which may be driven by variations in display rules between Eastern and Western cultures. These differences demostrate how culture can shape the way stimuli are processed in memory and therefore the findings are important to consider when designing, interpreting and extrapolating from social perception and memory studies conducted in different cultures. These results highlight a need for reserachers to go beyond the own race effect and consider the influence of cultural background on working memory. This is important because the purpose of working memory is to keep current information in mind to allow individuals to follow an event. During a social encounter, this is particularly important in ensuring the encounter runs smoothly, therefore it is important to understand how factors such as eye gaze and emotion can influence working memory both within and between cultures in our diverse social world. Future work should seek to further examine the exact role of cultural display rules in emotion and gaze perception, as well as their influence on attention and memory.

References

Aavik, T., Abu-Hilal, M., Ahmad, F. Z., Ahmed, R. A., Alarco, B., Amponsah, B., … Zhang, Y. (2006). A world of lies. *Journal of Cross-Cultural Psychology*, *37*(1), 60–74. https://doi.org/10.1177/0022022105282295

Adams, R. B., Franklin, R. G., Rule, N. O., Freeman, J. B., Kveraga, K., Hadjikhani, N., … Ambady, N. (2010). Culture, gaze and the neural processing of fear expressions. *Social Cognitive and Affective Neuroscience*, *5*(2–3), 340–348. https://doi.org/10.1093/scan/nsp047

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science*, *14*(6), 644–647. https://doi.org/10.1046/j.0956-7976.2003.psci

Adams, R. B., & Kleck, R. E. (2005). Effects of direct and averted gaze on the perception of facially communicated emotion. *Emotion*, *5*(1), 3–11. https://doi.org/10.1037/1528-3542.5.1.3

Adams, R. B., Pauker, K., & Weisbuch, M. (2010). Looking the other way: The role of gaze direction in the cross-race memory effect. *Journal of Experimental Social Psychology*, *46*(2), 478–481. https://doi.org/10.1016/j.jesp.2009.12.016

Akechi, H., Senju, A., Uibo, H., Kikuchi, Y., Hasegawa, T., & Hietanen, J. K. (2013). Attention to eye contact in the West and East: Autonomic responses and evaluative ratings. *PLoS ONE*, *8*(3), e59312. https://doi.org/10.1371/journal.pone.0059312

Bartlett, J. C., Searcy, J. H., & Abdi, H. (2003). What are the routes to face recognition? In Mary A. Peterson & G. Rhodes (Eds.), *Perception of Faces, Objects, and ScenesAnalytic and Holistic Processes* (pp. 21–53). Oxford, England: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195313659.003.0002

Bilalic, M., Langner, R., Ulrich, R., & Grodd, W. (2011). Many faces of expertise: Fusiform face area in chess experts and novices. *Journal of Neuroscience*, *31*(28), 10206–10214. https://doi.org/10.1523/JNEUROSCI.5727-10.2011

Bindemann, M., Burton, A. M., & Langton, S. R. H. (2008). How do eye gaze and facial expression interact? *Visual Cognition*, *16*(6), 708–733. https://doi.org/10.1080/13506280701269318

Chen, W., Liu, C. H., Li, H., Tong, K., Ren, N., & Fu, X. (2015). Facial expression at retrieval affects recognition of facial identity. *Frontiers in Psychology*, *6*(780), 1–9. https://doi.org/10.3389/fpsyg.2015.00780

Curby, K. M., & Gauthier, I. (2010). To the trained eye: Perceptual expertise alters visual processing. *Topics in Cognitive Science*, *2*(2), 189–201. https://doi.org/10.1111/j.1756-8765.2009.01058.x

D'Argembeau, A., Van der Linden, M., Comblain, C., & Etienne, A.-M. (2003). The effects of happy and angry expressions on identity and expression memory for unfamiliar faces. *Cognition & Emotion*, *17*(4), 609–622. https://doi.org/10.1080/02699930302303

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, *115*(2), 107–117. https://doi.org/10.1037/0096-3445.115.2.107

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect*. Palo Alto, CA: Consulting Psychologists' Press.

Freeth, M., Foulsham, T., & Kingstone, A. (2013). What affects social attention? Social presence, eye contact and autistic traits. *PLoS ONE*, *8*(1). https://doi.org/10.1371/journal.pone.0053286

Gauthier, I., Curran, T., Curby, K. M., & Collins, D. (2003). Perceptual interference supports a non-modular account of face processing. *Nature Neuroscience*, *6*(4), 428–432. https://doi.org/10.1038/nn1029

Gauthier, I., Williams, P., Tarr, M. J., & Tanaka, J. W. (1998). Training 'greeble' experts: A framework for studying expert object recognition processes. *Vision Research*, *38*(15–16), 2401–2428. https://doi.org/10.1016/S0042-6989(97)00442-2

Goos, L. M., & Silverman, I. (2002). Sex related factors in the perception of threatening facial expressions. *Journal of Nonverbal Behavior*, *26*(1), 27–41. https://doi.org/10.1023/A:1014418503754

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics. Signal detection theory and psychophysics.* Oxford, England: John Wiley.

He, Z., Liu, Z., Wang, J., & Zhang, D. (2018). Gender differences in processing fearful and angry body expressions. *Frontiers in Behavioral Neuroscience*, *12*(July), 1–9. https://doi.org/10.3389/fnbeh.2018.00164

Jackson, M. C. (2018). Eye gaze influences working memory for happy but not angry faces. *Cognition and Emotion*, *32*(4), 719–728. https://doi.org/10.1080/02699931.2017.1345720

Jackson, M. C., Linden, D. E. J., & Raymond, J. E. (2014). Angry expressions strengthen the encoding and maintenance of face identity representations in visual working memory. *Cognition and Emotion*, *28*(2), 278–297. https://doi.org/10.1080/02699931.2013.816655

Jackson, M. C., Wolf, C., Johnston, S. J., Raymond, J. E., & Linden, D. E. J. (2008). Neural correlates of enhanced visual short-term memory for angry faces: An fMRI study. *PLoS ONE*, *3*(10). https://doi.org/10.1371/journal.pone.0003536

Jackson, M. C., Wu, C.-Y., Linden, D. E. J., & Raymond, J. E. (2009). Enhanced visual short-term memory for angry faces. *Journal of Experimental Psychology. Human Perception and Performance*, *35*(2), 363–374. https://doi.org/10.1037/a0013895

Kleinke, C. L. (1986). Gaze and eye contact. *Psychological Bulletin*, *100*(1), 78–100.

Land, M., & Tatler, B. W. (2009). *Looking and acting: vision and eye movements in natural behaviour*. Oxford: Oxford University Press.

Larsen, R. J., & Shackelford, T. K. (1996). Gaze avoidance: Personality and social judgments of people who avoid direct face-to-face contact. *Personality and Individual Differences*, *21*(6), 907–917. https://doi.org/10.1016/S0191-8869(96)00148-1

Liu, C. H., Chen, W., & Ward, J. (2014). Remembering faces with emotional expressions. *Frontiers in Psychology*, *5*(DEC), 1–7. https://doi.org/10.3389/fpsyg.2014.01439

Mason, M. F., Hood, B. M., & Macrae, C. N. (2004). Look into my eyes: Gaze direction and person memory. *Memory*, *12*(5), 637–643. https://doi.org/10.1080/09658210344000152

McCarthy, A., Lee, K., Itakura, S., & Muir, D. W. (2006). Cultural display rules drive eye gaze during thinking. *Journal of Cross-Cultural Psychology*, *37*(6), 717–722. https://doi.org/10.1177/0022022106292079

N'Diaye, K., Sander, D., & Vuilleumier, P. (2009). Self-relevance processing in the human amygdala: gaze direction, facial expression, and emotion intensity. *Emotion (Washington, D.C.)*, *9*(6), 798–806. https://doi.org/10.1037/a0017845

Nakashima, S. F., Langton, S. R. H., & Yoshikawa, S. (2012). The effect of facial expression and gaze direction on memory for unfamiliar faces. *Cognition & Emotion*, *26*(7), 1316–1325. https://doi.org/10.1080/02699931.2011.619734

Ogawa, T., Oda, M., Yoshikawa, S., & Akamatsu, S. (1997). Evaluation of facial expressions differing in face angles: Constructing a database of facial expressions [In Japanese with English abstract]. *Technical Report of Institute of Electronics, Information and Communication Engineers (IEICE), HIP*, *97*(136), 47–52.

Parkinson, B. (2005). Do facial movements express emotions or communicate motives? *Personality and Social Psychology Review*, *9*(4), 278–311. https://doi.org/10.1207/s15327957pspr0904

Rhodes, M. G. (2009). Age estimation of faces: a review. *Applied Cognitive Psychology*, *23*(1), 1–12. https://doi.org/10.1002/acp.1442

Rhodes, M. G., & Anastasi, J. S. (2012). The own-age bias in face recognition: A metaanalytic and theoretical review. *Psychological Bulletin*, *138*(1), 146–174. https://doi.org/10.1037/a0025750

Sander, D., Grandjean, D., Kaiser, S., Wehrle, T., & Scherer, K. R. (2007). Interaction effects of perceived gaze direction and dynamic facial expression: Evidence for appraisal theories of emotion. *European Journal of Cognitive Psychology*, *19*(3), 470–480. https://doi.org/10.1080/09541440600757426

Sato, W., Kochiyama, T., Uono, S., & Yoshikawa, S. (2010). Amygdala integrates emotional expression and gaze direction in response to dynamic facial expressions. *NeuroImage*, *50*(4), 1658–1665. https://doi.org/10.1016/j.neuroimage.2010.01.049

Sato, W., Yoshikawa, S., Kochiyama, T., & Matsumura, M. (2004). The amygdala processes the emotional significance of facial expressions: An fMRI investigation using the interaction between expression and face direction. *NeuroImage*, *22*(2), 1006–1013. https://doi.org/10.1016/j.neuroimage.2004.02.030

Sessa, P., Luria, R., Gotler, A., Jolicœur, P., & Dell'acqua, R. (2011). Interhemispheric ERP asymmetries over inferior parietal cortex reveal differential visual working memory maintenance for fearful versus neutral facial identities. *Psychophysiology*, *48*(2), 187–197. https://doi.org/10.1111/j.1469-8986.2010.01046.x

Shimamura, A. P., Ross, J. G., & Bennett, H. D. (2006). Memory for facial expressions: The power of a smile. *Psychonomic Bulletin & Review*, *13*(2), 217–222. https://doi.org/10.3758/BF03193833

Strongman, K. T., & Champness, B. G. (1968). Dominance hierarchies and conflict in eye contact. *Acta Psychologica*, *28*, 376–386. https://doi.org/10.1016/0001-6918(68)90026-7

Uono, S., & Hietanen, J. K. (2015). Eye contact perception in the west and east: A cross-cultural study. *PLoS ONE*, *10*(2), 1–15. https://doi.org/10.1371/journal.pone.0118094

Vuilleumier, P., George, N., Lister, V., Armony, J., & Driver, J. (2005). Effects of perceived mutual gaze and gender on face processing and recognition memory. *Visual Cognition*, *12*(1), 85–101. https://doi.org/10.1080/13506280444000120

Williams, M. A., & Mattingley, J. B. (2006). Do angry men get noticed? *Current Biology*, *16*(11), 402–404. https://doi.org/10.1016/j.cub.2006.05.018

Willis, M. L., Palermo, R., & Burke, D. (2011). Judging approachability on the face of it: The influence of face and body expressions on the perception of approachability. *Emotion*, *11*(3), 514–523. https://doi.org/10.1037/a0022571