The effect of facial expression and gaze direction on memory for unfamiliar faces

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Short title: EFFECTS OF GAZE AND EXPRESSION ON FACE MEMORY

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Abstract

We report data from an experiment that investigated the influence of gaze direction and facial expression on face memory. Participants were shown a set of unfamiliar faces with either happy or angry facial expressions, which were either gazing straight ahead or had their gaze averted to one side. Memory for faces which were initially shown with angry expressions was found to be poorer when these faces had averted as opposed to direct gaze, whereas memory for individuals shown with happy faces was unaffected by gaze direction. We suggest that memory for another individual's face partly depends on an evaluation of the behavioural intention of that individual.

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Introduction

Human faces are significant nonverbal stimuli for communication in daily social situations. When encountering strangers we use their faces to draw inferences about their ages and genders, their emotional dispositions, mental states, current foci of attention, and their personalities. As well as perceiving the dynamic and invariant features of others' which allow us to make these inferences, it is important for humans, as social species, to encode faces into memory so that we can take appropriate action should we encounter these particular individuals again in the future. To what extent are our memories of unfamiliar faces influenced by the social signals that we perceive in those faces when we first encounter them?

Given that certain facial expressions represent strong cues to another's intentions (Fridlund, 1994) and emotional states (Ekman, 2003), it may be that these signals are particularly influential in face memory; indeed, some recent research has supported this suggestion (D'Argembeau & Van der Linden, 2007; D'Argembeau, Van der Linden, Comblain, & Etienne, 2003). For example, D'Argembeau et al. (2003) reported that participants showed poorer memory for unfamiliar faces that were initially encountered with angry versus happy facial expressions, all with direct gazes. They suggest that the "meaning of emotional expressions for the self" (p.620) causes them to be processed differently at study: happy expressions denote approval or satisfaction, while angry faces signal disapproval; consequently, we tend to elaborate the encoding of the former and/or avoid elaboration of the latter.

Direction of gaze is another important facial signal conveying information to perceivers about gazers' attention direction, their intentions and their emotional states (Langton, Watt, & Bruce, 2000). As with facial expressions, some studies have shown that gaze direction can affect recognition memory for unfamiliar faces. For instance, Mason, Hood and Macrae

(2004) observed that memory for unfamiliar faces that were encountered by participants in the learning phase with a direct gaze was superior to memory for faces initially shown with averted gaze. Vuilleumier, George, Lister, Armony and Driver (2005) obtained a similar advantage for direct over averted gaze faces, specifically when faces were presented in three-quarters view and were of the opposite gender to the participants. They suggest that perceived eye contact engages observers' attention and elaborates the encoding of the face. Along similar lines, Mason et al. (2004) suggest that a direct gaze triggers the firing of a mutual gaze detector that, in turn, promotes the elaborated encoding of faces with this gaze configuration.

Separate lines of evidence therefore suggest that upon encountering an unfamiliar face, its facial expression and its gaze direction may influence the encoding of that face into memory and its subsequent recognition. Notice, however, that facial expressions will almost always be accompanied by some kind of eye gaze; indeed, in D'Argembeau et al.'s (2003) study, the faces were always displayed with a direct gaze. A relevant question is, therefore, how faces containing both kinds of social cue influence recognition memory. Mason et al.'s (2004) account appeals to a mutual gaze detector in explaining the advantage that faces with direct gaze have in recognition memory over those with averted gaze. According to this account, separate mechanisms mediate the influence of gaze and facial expressions on recognition memory. Indeed, Bruce and Young's (1986) influential model of face perception included a functionally separate system for the analysis of facial expression; while subsequent neurophysiological and neuropsychological studies suggested that a "Direction of Attention detector" (DAD) might be added to the model which pools information from gaze direction, head angle and body posture to yield a representation of the organism's direction of "social" attention (e.g., Perrett & Emery, 1994). If information about eye gaze direction and facial expression are extracted from the face by separate mechanisms, then it seems likely that these signals will exert independent effects on the encoding of that face into memory.

D'Argembeau et al.'s account of the influence of facial expression on recognition memory leads to a rather different prediction about how the encoding of faces into memory might be influenced by gaze and expression. Their suggestion is that an evaluation of social significance (or social meaning) intervenes between the extraction of facial expression information and the encoding of a face into memory. On any account of "social meaning" or "social significance", its evaluation would surely include an assessment of, among other things, *both* facial expression and eye-gaze direction: the kind of meaning one attaches to an angry-looking individual, for instance, will be different depending on where this person's anger is directed. For example, angry faces looking away from perceivers may be evaluated as less socially significant than ones gazing directly at them; on the other hand, people with happy faces may be evaluated as highly socially significant wherever they are looking, perhaps because these people are evaluated as having socially desirable personalities irrespective of gaze direction.

We therefore argue that an account based on some kind of social evaluation predicts that facial expression and gaze direction will exert an interactive effect on recognition memory for faces. Some support for this position comes from work by Bayliss and colleagues (e.g., Bayliss, Griffiths & Tipper, 2009). They showed that judgements about the trustworthiness of previously presented faces was more sensitive to the gaze direction of faces that were shown with positive (happy) rather than threatening (angry) expressions of emotion. In these studies, however, participants seem to have been implicitly learning that certain happy faces always gazed towards a target, whereas other happy faces consistently misdirected attention away from a target; Bayliss et al. (2009) did not test whether the relationship between gaze and expression can influence the *explicit* recognition of faces; that is, the ability to discriminate between faces that have been seen before and those that have not.

The purpose of the experiment reported here was therefore to examine whether facial expression and gaze direction interact in explicit recognition memory for unfamiliar faces. Following D'Argembeau et al. (2003) we used a standard recognition memory paradigm and investigated happy and angry expressions of emotion. In the learning phase of the experiment, participants were presented with the faces of a number of different individuals wearing either happy or angry facial expressions. Half of the faces wearing each expression had a direct gaze and half had an averted gaze. In the test phase of the experiment, participants were asked to recognize versions of these faces with neutral expressions. The independent systems account, predicts that gaze and expression will exert additive effects on recognition memory with better memory for faces with happy versus angry expressions (following D'Argembeau et al., 2003), regardless of gaze direction, and better memory for faces with direct as opposed to averted gaze (following Mason et al., 2004) irrespective of facial expression. The social evaluation account, on the other hand, predicts that gaze and expression will produce interactive effects, with gaze direction modulating the influence of facial expression information on recognition memory.

Method

Participants

Forty-six undergraduates from Kyoto University participated in the experiment (19 men and 27 women; mean age = 19.57). Of these, 23 (9 men, 14 women) were allocated to the direct gaze test condition, and 23 (10 men, 13 women) were allocated to the averted gaze test condition.

Materials and apparatus

We selected 144 face photos from the ATR Japanese face data base (Ogawa, Oda, Yoshikawa, & Akamatsu, 1997)[1]. These comprised 48 Japanese individuals (24 females and 24 males) who each expressed a happy, angry or neutral facial expression[2]. None of the faces had any distinctive marks, or wore glasses or a beard. We performed grayscale transformation on all of the photos, the head size of each individual was equalized, and the background of each photo was cropped using Adobe Photoshop software. These photos were validated by twelve Japanese postgraduates (six women and six men) from Kyoto University. These participants made judgements about the emotional category of faces using a 4-forced choice response (angry, happy, neutral, sad). Faces were judged as expressing the appropriate emotion (angry = 94.62%, happy = 98.09%, neutral = 87.50%).

The gaze direction of the faces was manipulated using Adobe Photoshop software to produce a left and right averted gaze for each face (96 averted for each expression). This manipulation was done to ensure that any differences were driven by facial expression or gaze direction and not by any other distinctive appearances. In order to insure that gazes were equivalently discriminable for each facial expression, nine additional participants were presented with averted and direct-gaze versions of each of the happy and angry faces, each for 2000 ms, and were asked to respond by indicating whether they thought each face was looking at them, or not. The average proportion of correct judgements was high for all conditions (angry-direct = 0.97; angry-averted = 0.99; happy-direct = 0.96; happy-averted = 0.98). A 2 (facial expression) x 2 (gaze direction) repeated measures analysis of variance, yielded only a main effect of gaze direction, F (1, 8) = 5.72, $p < .05$, $\eta_p^2 = .42$, but no effect of facial expression nor any interaction between facial expression and gaze direction (both p's > 0.1). Participants therefore had no difficulty discriminating direct from averted gazes and were equally able to do so for both facial expressions.

In summary, a total of 432 pictures (48 angry-direct, 96 angry-averted, 48 happy-direct, 96 happy-averted, and 48 neutral-direct, 96 neutral-averted) were used in this experiment. The expressive faces were used in the learning phase of the experiment and the neutral faces were used as the test items (Figure 1.).

The images of the 48 different individuals were divided into two sets of 24 (12 male and

12 female). The expressive faces from one set were studied in the learning phase of the experiment; the neutral faces from the second set were used as unstudied items and appeared as distracters in the test phase of the experiment. The allocation of the two sets to learning or test items was counterbalanced across participants. The 24 faces studied in the learning phase comprised faces of 12 individuals wearing a happy expression and 12 individuals wearing an angry expression. Half of these expressive faces had direct gaze (3 males and 3 females) and half had averted gaze. The allocation of expressions and gazes to particular identities was counterbalanced across participants so that, across the experiment, each face identity appeared equally often displaying each expression and with either a direct or averted gaze. The test phase consisted of images of all 48 individuals wearing a neutral expression. The participants who were allocated to the direct test condition were tested using neutral faces with direct gaze; those assigned to the averted test condition were tested using averted gaze versions of the faces.

The stimuli were presented on a PC monitor using SuperLab software. Face stimuli appeared in the center of the computer screen with 150 x 225 pixels. The presentation order of the stimuli was randomized by the computer.

Figure 1 about here please

Design

The materials were tested in a mixed design with facial expression (angry/happy) and gaze direction at learning (direct/averted) as within-subject factors and gaze direction at test (direct/averted) as a between-subjects factor.

Procedure

Participants were tested individually. The experiment comprised a learning phase, a retention interval and a subsequent test phase. Participants were not informed that a memory test would follow the learning phase nor were they told that there would be differences in the facial expression and gaze direction among the stimuli. During the learning phase, a fixation cross was displayed for 800ms followed by a blank screen for 200ms. Each face was then shown to the participants for 2000ms after which the screen went blank. Participants were asked to concentrate on the face while it was displayed on the screen and then, upon its disappearance, to estimate the age of the face and to note this down on a response sheet. They were asked to perform this task at their own pace and to initiate the next trial by pressing a designated key on the keyboard. Immediately after the learning phase, participants were asked to complete a “Sudoku" puzzle. This task was used to prevent participants engaging in rehearsal of the faces during the retention interval.

Following the five minute retention interval, participants completed the recognition test. They were informed that they would be shown a series of faces, some of which would be those of the individuals whose faces they had seen in the earlier phase of the experiment. Each face was presented on the computer screen and participants were asked to respond “yes” if they had seen the face before, even if it was shown with a different facial expression, otherwise they were asked to respond “no”. Responses were made by pressing the B key for a “yes” response and the N key for a “no” response on a standard keyboard. Faces were displayed on the screen until participants made their response. Instructions to participants stressed accuracy, as opposed to speed of responding.

Results

Accuracy data

Hit rates and the false alarm rate were calculated for each participant in each condition of the experiment[4]. The inter-participant means of these scores are displayed in Table 1. The pattern of results for participants tested with direct and averted gazes was strikingly similar: recognition memory performance for angry faces was better for those initially encountered with direct versus averted gaze. Memory for happy faces, on the other hand, was unaffected by gaze direction.

The hit rates data were analyzed using a 2 (facial expression: angry/ happy) x 2 (gaze direction at learning: direct/averted) x 2 (gaze direction at test: direct/averted) mixed design analysis of variance (ANOVA). The results of this analysis supported the above observations. There were significant main effects of facial expression, $F(1, 44) = 6.20$, $p < .05$, $\eta_p^2 = .12$, and gaze direction at learning, $F(1, 44) = 6.44$, $p < .05$, $\eta_p^2 = .13$, which were qualified by a significant interaction between these factors, $F(1, 44) = 7.55$, $p < .01$, $\eta_p^2 = .15$. Post hoc analysis revealed a significant simple main effect of gaze direction at learning for angry faces, $F(1, 44) = 18.70$, $p < .001$, $\eta_p^2 = .30$, with better memory for angry faces learned with direct gaze ($M = 0.63$) than with averted gaze ($M = 0.48$). However, memory for happy faces with direct gaze ($M = 0.62$) and averted gaze ($M = 0.63$) was equivalent, $F(1, 44) = 0.06$, $p > 0.10$, $\eta_p^2 = .001$. No other interactions or main effects approached significance (all p's > 0.1).

A comparison of false alarm rates between the two test conditions confirmed that the task was no harder for participants tested with direct gaze faces ($M = 0.25$) than for those tested with averted gaze faces ($M = 0.26$), $t\ (44) = 0.26$, $p > 0.10$.

(Table 1 about here please)

Reaction time data

Participants were not asked to make speeded responses in the experiment; nevertheless, mean response times for yes/no judgements for target faces were computed subjected to a 2 (facial expression: angry/happy) x 2 (gaze direction at learning: direct/averted) x 2 (gaze direction at test: direct/averted) mixed design analysis of variance (ANOVA). Only the main effect of facial expression was significant, $F(1, 43) = 4.55$, $p < .05$, $\eta_p^2 = .10$, with faster reaction times for faces that were originally seen with angry expressions (*M* = 2077ms) than those seen with happy expressions (*M* = 2333ms). No other interactions or main effects approached significance (all *p*'s > 0.1).

Discussion

The aim of the experiment reported here was to determine whether memory for unfamiliar faces is interactively influenced by facial expression and eye gaze direction. The results indicated that participants' recognition memory was poorer for faces with angry facial expressions whose gaze was averted from them, than for those of individuals that were looking directly at them. In contrast, memory for the faces of individuals shown with happy facial expressions was unaffected by their gaze direction. This pattern of results was shown to occur whether the faces used in the recognition test phase of the experiment were shown with direct or averted gaze. The latter result rules out an explanation based on consistency of gaze direction between the learning and test phase.

Facial expression and gaze direction have, in separate studies, previously been shown to influence recognition memory for unfamiliar faces: Mason et al. (2004) showed that direct gaze faces are remembered better than averted gaze faces, while D'Argembeau et al. (2003) showed that direct gaze faces with happy expressions are remembered better than faces with angry expressions, at least for participants who intentionally tried to learn these faces[4]. Our findings suggest that gaze and expressions do not exert their effects simply via the operation of functionally separable systems analyzing the face for these classes of social signal. Instead, we suggest that gaze and expression information are combined in an analysis of behavioural intent and that it is this that influences the encoding of faces into memory. Before elaborating on this suggestion, however, we discuss alternative accounts of our finding that locate the effect at earlier stages of processing, or through the combined influence of gaze and expression on attention.

One possibility is that the effect arises because gaze and expression interact to influence the perceptual salience of faces with certain combinations of gaze and expression. For example, certain gazes may enhance or reduce the perceptual salience of faces with particular facial expressions resulting in elaborated or inhibited encoding of those faces; alternatively, or additionally, certain facial expressions may influence the salience of faces with particular gaze directions leading to effects on the encoding of these faces. Perhaps the interaction effect we obtained in our experiment can be explained by this kind of crosstalk between otherwise functionally separate gaze and expression analysis systems.

Evidence for the modulation of gaze perception by facial expression information comes from a recent study by Lobmaier, Tiddeman, and Perrett (2008) who showed that happy faces are more likely to be categorized as having gaze directed toward the observer than are angry faces. Is it possible that observers in our study actually misperceived happy faces with averted gaze as having direct gaze? If the "averted" and "direct" gazes were actually perceived as being equivalent, then it is unsurprising that gaze direction did not modulate the encoding of these faces into memory. Furthermore, if this misperception effect is unique to happy faces, then participants in our experiment would have had no difficulty discriminating direct from averted gazes in angry faces, leading to the normal advantage for the direct gaze versions of these faces in recognition memory (cf. Mason et al., 2004).

However, the misperception of gaze direction in happy faces is an unlikely explanation of our finding: we suggest that the reader will have little difficulty categorizing the gazes shown in Figure 1; and the difference between direct and averted gazes, as illustrated, was equivalent for all faces used in the experiment. Indeed, participants involved in the validation of our stimuli were equally able to discriminate direct from averted gazes for both happy and angry faces.

So, although research has suggested that the perception of gaze direction may be influenced by facial expression (see also Ewbank, Jennings, & Calder, 2009), it seems unlikely that the effects of gaze and expression on recognition memory are caused by a kind of cross-talk from the system processing gaze direction to the system extracting information about emotional expression from the face. However, there is also evidence for cross-talk in the opposite direction: from mechanisms processing gaze to those processing expression (Adams & Kleck, 2003; Bindemann, Burton, & Langton, 2008; Ganel, Goshen-Gottstein, & Goodale, 2005). If an averted gaze could somehow reduce the salience of angry, but not happy facial expressions, then this could explain why recognition memory was poor for the identity of faces shown with angry faces and averted gaze. Unfortunately, however, the evidence suggests that gaze direction exerts equivalent effects on the processing of both happy and angry faces: categorizations of both types of expression are slower when gaze is averted than when it is direct (Adams & Kleck, 2003; Bindemann, Burton, & Langton, 2008). It is therefore difficult to see how this kind of modulation of expression processing by gaze direction could then, in turn, produce the effects on the encoding of faces into memory that we have observed.

It seems, then, that the effect obtained in our experiment cannot be explained by modulation of the perceptual salience of the faces by either gaze or facial expression. Another possibility is that various combinations of gaze and expression produce different effects on the allocation of attention to the face and that this, in turn, influences the likelihood that a face will be sufficiently encoded so as to be recognised in the future. Specifically, the pattern of results could be explained if happy faces attract attention regardless of where they are looking, whereas angry faces are more attention grabbing with direct, than with averted gaze. Once again, however, the available data do not support these suggestions. Results from visual search, spatial cueing, and the flanker paradigm suggest that, if anything, angry or threat-related faces have a tendency to capture attention compared with happy or non-threatening faces (for a recent review see Horstmann, Borgstedt, & Heumann, 2006) and that gaze direction does not modulate this effect (e.g., Cooper & Langton, 2006). There is also no evidence that attention has a greater tendency to be diverted by the gaze direction of angry compared with happy faces, at least with statically displayed emotional expressions (Hietanen & Leppänen , 2003).

A related possibility is that attention is actually drawn to the salient mouth region of a smiling face and therefore away from the eyes; the eyes then become less relevant for smiling faces and do not influence encoding of the face into memory. One problem with this suggestion is that an absence of attention to the eye region of happy faces is very likely to result in an overall decrease in recognition memory performance for these faces relative to angry faces where, presumably, the eye region will have been attended (e.g., Ellis, Shepherd, & Davies, 1975; McKelvie, 1976); however, performance was found to be equivalent overall for angry and happy faces.

Although an attention-based explanation for our finding is unlikely for the reasons described above, ultimately future research may be required to resolve the issue. For example, eye-tracking could be used to examine where attention is deployed when encoding the various faces, or cueing techniques could be used to manipulate which facial features are selected when faces are initially encoded.

The preceding discussion suggests that it is unlikely that the influence of gaze and facial expression on recognition memory for unfamiliar faces has a perceptual or attention-based origin. Instead, following D'Argembeau et al. (2003), we suggest that a higher-level representation encoding "social meaning", "social significance" or, the term we prefer, "behavioural intention" may mediate the effect. In some respects, the account we offer is consistent with Haxby, Hoffman, and Gobbini's (2000) model of the distributed neural systems involved in face perception and its recent modification by Gobbini and Haxby (2007).

Both models allow for a degree of separation in the extraction of gaze and expression information from the face, but the modified version also suggests that the encoding of invariant aspects of the face (i.e., information used to code identity) in what is called the "core system" can be influenced by modulatory feedback from the "extended system", which is involved in the extraction and retrieval of other kinds of information that faces are able to convey. This includes the retrieval of personality traits, attitudes and biographical information about people we know; but also the encoding of mental states and intentions, which we can extract from the faces of both familiar *and* unfamiliar people. Our suggestion, then, is that this extended system integrates information about gaze and expression to encode behavioural intention and that, through top-down modulatory feedback, this information can then promote further encoding of information used for recognizing *unfamiliar* faces in the future. So, when presented with an angry-looking individual, the core system will initially extract visual information about the facial expression and gaze direction of this face. This information will then be pooled in an analysis of the individual's likely behavioural intention by the extended system. If the outcome of this evaluation is somehow significant for the self (e.g., this person is angry and this person is looking at me; therefore, this person is angry with me), then feedback to the core system will, in turn, promote further encoding of the structural aspects of the face that will enable it to be recognised should it be encountered again in the future. If the analysis of behavioural intention instead yields a result that is not relevant to the self (this person is angry and this person is not looking at me; therefore, this person is not angry with me), then no elaborated structural encoding takes place and the face will not be as reliably recognised in the future. Our findings suggest that if the analysis of behavioural intent is positive (i.e. a happy face), whether self- or other-directed, then feedback to the core system always promotes elaborated encoding of the face into memory.

Gobbini and Haxby's (2007) model also includes feedback from emotion-related neural structures (the amygdala, insula and striatum) to neural structures encoding face identity (inferior occipital gyrus and lateral fusiform gyrus). A further possibility is therefore that the interaction between expression and gaze direction in recognition memory for face identity has an affective etiology. For example, an angry face with direct gaze may induce a more fearful reaction than an angry face with averted gaze; the former may then enhance the encoding of face identity relative to the latter. Indeed, at least one study has suggested that the amygdala – a structure that has been associated with the emotion of fear – shows an elevated response when participants viewed angry faces directed towards them relative to angry faces gazing elsewhere or neutral faces with direct gaze (Sato, Yoshikawa, Kochiyama and Matsumura, 2004). Happy faces, on the other hand, may induce a more positive affective state regardless of where they are looking, with the positive affect somehow elaborating the encoding of face identity relative to faces generating neutral affective responses.

However, our RT data argue against such an account. To the extent that speed of response reflects confidence in that response, and furthermore that confidence might be based, at least in part, on an affective reaction to the stimuli when they are presented in the test phase, the RT data rather suggest that participants' affective reactions to angry faces, regardless of gaze direction, produced a greater emotional response than did happy faces. If affect influences the encoding of faces into memory, we might have expected recognition memory accuracy to be higher for angry than for happy faces; but, of course, this is not the result we obtained.

We must be cautious in drawing conclusions from the RT data, however: participants were instructed to respond as accurately as possible and they were told that speed is unimportant. Our data therefore do not really permit us to discriminate between an account based on an evaluation of behavioural intent and one based on the emotional reaction to faces when first encountered; indeed, it is entirely possible that the influence of gaze and expression on the recognition of unfamiliar faces involves both cognitive and affective components. One way of exploring this issue may be to extend the study to different emotional expressions. The affective account predicts that expressions of positive emotions (e.g., happiness) should not show sensitivity to gaze direction, whereas expressions that induce negative affect (anger, fear, disgust, sadness) may do so. On the other hand, it seems unlikely that expressions of, say, fear or sadness would have negative consequences for the self in the same way that anger does; the behavioural intention account would therefore predict no influence of gaze direction on the recognition of faces with these emotions. The use of other dependent measures such as galvanic skin response or fMRI would also be useful in exploring the extent to which the emotional reaction to faces contributes to the effect we have observed.

In conclusion, this study demonstrated an interaction between facial expression and gaze direction on memory for unfamiliar faces. Participants showed poorer memory for unfamiliar faces that were initially encountered with angry facial expressions whose gaze was averted from them, than for those of angry individuals that were looking directly at them. Meanwhile, participants' recognition memory for happy faces was unaffected by gaze direction. We suggest that gaze and expression information are combined in an analysis of behavioural intent and that it is this that influences the encoding of faces into memory.

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Footnotes

1. This database includes standardized Japanese facial photographs. Posers were 122 adults (61 male and 61 female, aged from 19 to 29) who were asked to pose expressions by mimicking examples from the standard Ekman and Friesen (1976) set. All of the pictures were taken in a studio under similar lighting conditions with the same camera positioned at a fixed distance from the poser.

2. We only used photos of faces with closed mouths (see Figure 1). Images of smiling faces with bared teeth will contain high-contrast areas around the mouth which might be expected to draw participants' attention from the eye-region, which is important in face recognition.

3. It is not possible to compute independent estimates of the false alarm rate in each experimental condition because participants always responded to neutral faces in the test phase. Consequently we did not apply a signal detection analysis to the data.

4. Participants in the D'Argembeau et al (2003) study who, like our participants, learned direct gaze faces incidentally (i.e. without instructions to study the faces in preparation for a recognition test) showed no memory advantage for happy over angry faces. Similarly, our data indicate equivalent recognition memory performance for happy and angry faces that were initially encountered with direct gazes.

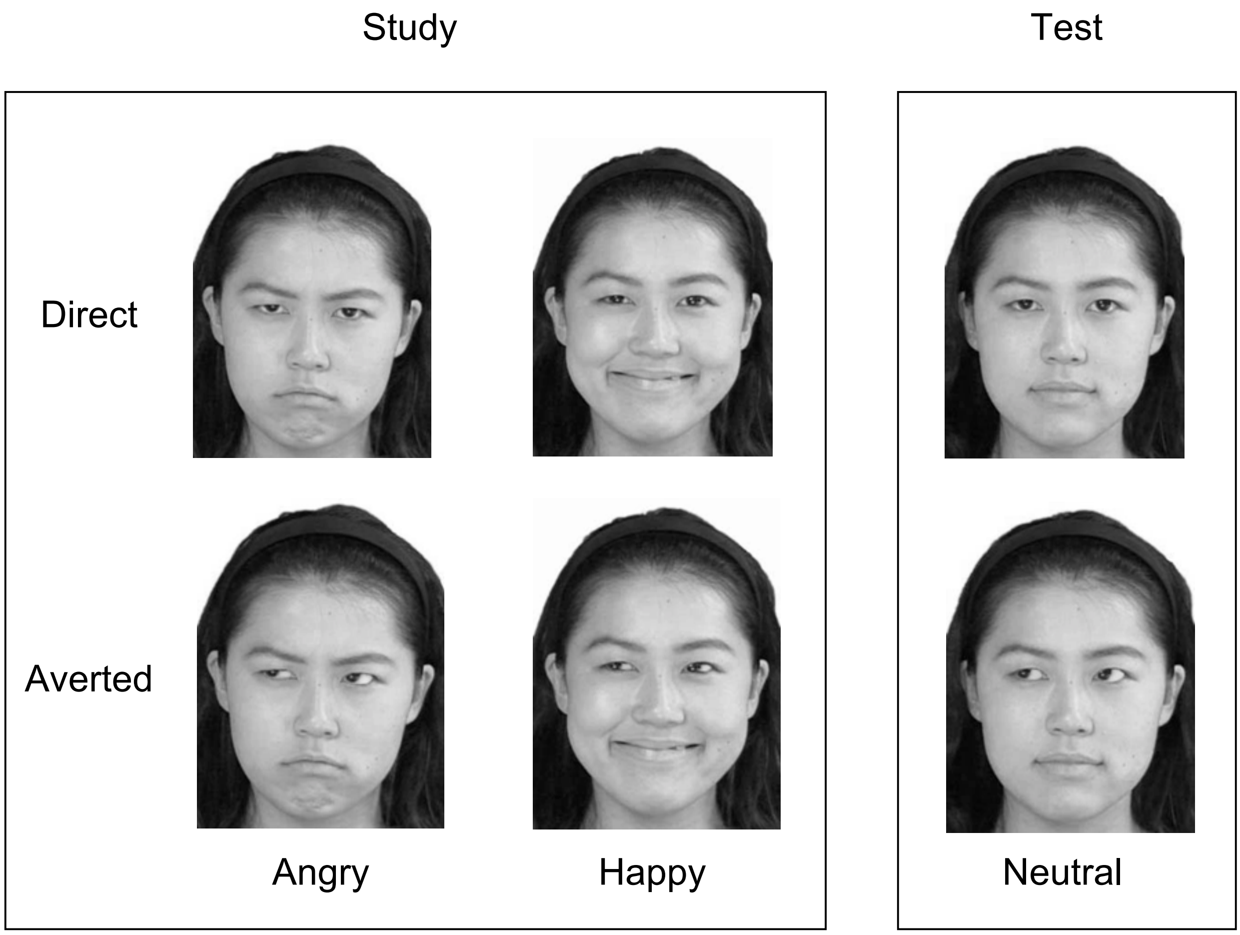
Table 1.

The mean proportion of hits and false alarms obtained in the experiment (standard errors in parentheses). Hits are shown as a function of facial expression at learning, gaze direction at learning, and gaze direction at test. False alarms are shown as a function of gaze direction at test.

	Direct-test			*Averted-test*		
Learning	*Angry*	*Happy*	*False Alarm*	*Angry*	*Happy*	*False Alarm*
Direct	0.62 (0.04)	0.64 (0.05)	0.25 (0.03)	0.65 (0.04)	0.59 (0.04)	0.26 (0.02)
Averted	0.46 (0.03)	0.62 (0.04)		0.50 (0.04)	0.65 (0.04)	

Figure Caption

Figure 1. Examples of the stimuli used in the experiment. In the study phase, faces wore either angry or happy expressions with direct or averted gaze. Faces at test had neutral expressions but, for one group of participants, gazes were direct and, for the other, gazes were averted.


Study
Test
Direct
Averted
Angry
Happy
Neutral