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Angry and happy faces perceived without awareness:

A comparison with the affective impact of masked famous faces

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Running Head: angry and happy faces without awareness

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Abstract

Two experiments investigated the effects of masked happy and angry faces exposed for only 17 milliseconds. Three questions were posed: do happy and angry faces attract attention equally to their spatial location? Does explicit detection of facial emotionality differ between happiness and anger? Do happy or angry faces give rise to stronger perceptual impressions? Results were compared with those previously reported for faces of positively and negatively evaluated famous persons. There was no evidence of attention orientation to either happy or angry faces, contrasting with previous evidence of orientation to / away from the faces of positively / negatively evaluated famous persons (Stone & Valentine, 2005b). Explicit detection of emotionality was more accurate for happy than angry faces, and the consciously experienced visual percept was stronger for happy than angry faces, both effects being similar to those previously reported for the faces of positively / negatively evaluated famous persons (Stone & Valentine, 2004; 2005a; 2005c). It appears that facial emotion and facial identity have some similar effects when perceived without awareness, dependent on positive or negative invoked affect. The attentional properties of famous faces may exceed those of emotional faces under some circumstances.

Introduction

There is much evidence that facial expressions of emotion can be detected pre-consciously and can influence psychophysiological and behavioural responses without awareness (e.g. Dimberg & Ohman, 1996; Dimberg, Thunberg & Elmehed, 2000; Johnsen & Hugdahl, 1991; 1993; Mogg & Bradley, 1999; Murphy & Zajonc, 1993; Niedenthal, 1990; Ohman, Esteves & Soares, 1995; Robinson, 1998; Saban & Hugdahl, 1999; Whalen, Rauch, Etcoff, McInerney, Lee & Jenike, 1998; Wong, Shevrin & Williams, 1994). All of these studies presented masked faces for very brief exposure duration (target-to-mask stimulus onset asynchrony of less than 35ms). In most of these studies, participants were at chance in two-alternative forced-choice tasks of identifying the expression, confirming the absence of awareness. The pre-conscious recognition of facial expression is often interpreted in terms of the importance to the individual of responding appropriately to the emotions of others. Facial expression is a valuable indication of the likely tone and outcome of a social interaction.

Facial identity is also an important predictor of the probable nature of a social interaction. Knowledge of a familiar person, including their personality and past behaviours, sets expectations for any future encounter. Though fewer studies have investigated the pre-conscious recognition of facial identity, recent evidence suggests that famous faces can be recognised as specific individuals without awareness of facial identity or familiarity (Banse, 1999; 2001; Stone, Valentine & Davis, 2001; Stone & Valentine, 2004; 2005a; 2005b; 2005c). These studies all presented faces for very brief, masked exposures (less than 17ms). The reported experimental effects were generally dependent on whether the famous person invoked positive or negative affect.

It is interesting to consider whether facial expressions and facial identities might give rise to analogous experimental effects when perceived without awareness, dependent on their positive or negative affective impact. There are several reasons for supposing that this might be the case. Both are very important social stimuli and the references cited above show that both are processed for meaning, in terms of identification of the particular expression or identity, when perceived without awareness. In terms of visual processing, recognition of both facial expression and facial identity is dependent on a structural analysis of the internal features of the face. Both facial identity and facial expression have value for predicting the likely outcome of a social interaction and enable the individual to prepare for an encounter.

Results have already been reported from several experiments on masked famous faces (Stone & Valentine 2004; 2005a; b; c). The present paper will present two experiments investigating the effects of masked emotional faces in the same tasks previously reported for famous faces. The General Discussion will compare results of the present study of facial emotion with the results of previous studies of facial identity.

Experiment 1 employed two tasks using angry, happy and neutral faces as stimuli. The tasks will be described and predictions will be explored.

Attention Orientation.

The purpose of this task was to investigate whether angry or happy faces have greater power to attract attention to their spatial location when perceived without awareness. Masked 17ms faces were presented in simultaneous pairs of one emotional and one neutral face, depicting the same person, one face in the left visual field (LVF) and the other in the RVF. The emotional face displayed either happiness or anger. The faces were followed by a dot-probe consisting of two small dots, either horizontal (..) or vertical (:), presented in either the LVF or the RVF, in a location corresponding to the centre of one of the stimulus faces. Participants performed a speeded, two-alternative forced-choice discrimination on the type of dot-probe. Orientation of attention to the emotional face in a pair would be shown by faster or more accurate responses to the dot-probe in the same visual field as the emotional face than in the opposite visual field.

Attention may be oriented towards happy facial expressions, since these are a source of positive affect and an indication of a pleasant social interaction. In support of this prediction, Williams, Moss, Bradshaw and Mattingley (2005, Experiment 1) reported that happy faces captured attention more efficiently than neutral faces. Angry faces are likely to invoke fear in the participant and so attention should be oriented towards the angry faces as a potential threat. Regarding the relative power of angry and happy faces to capture attention, Mogg and Bradley (1999) reported that attention was oriented to angry faces but not towards happy faces. Also, Calvo and Esteves (2005) considered that although all expressive faces might capture attention in isolation, angry faces are especially likely to capture and engage attention in competition with other stimuli. This suggests that angry faces will attract and hold attention more strongly than happy faces in the present study.

Regarding laterality, Mogg and Bradley (1999) reported that attention was oriented towards angry faces presented in the LVF but not the RVF. Alternatively, if information relevant to the orientation of attention is transmitted rapidly between the hemispheres (e.g. Banich, 1998) then attention might be oriented equally to angry faces presented in both visual fields.

Explicit detection of facial emotionality.

This task was conceived originally as a check for awareness of the face stimuli. Masked 17ms emotional-neutral face pairs were presented as in the attention orientation task and participants attempted to select the emotional face in each pair. Overall performance at chance would indicate the absence of awareness of facial emotionality, and by assumption, the absence of awareness of the particular expression.

Alternative predictions are as follows. If participants are unable to detect facial emotion, even implicitly, then accuracy of responses to both happy and angry faces will be equivalent to chance. If participants are unable to intentionally distinguish between an emotional and a neutral face, but can detect emotion implicitly, then responses may be based on preference. Happy faces should be preferred over neutral faces and neutral faces over angry faces, so happy faces should be selected more often than angry faces.

Regarding laterality, the instruction to select the emotional face in each pair should lead to more accurate responses in the LVF, given the often-observed right hemisphere superiority in the processing of facial expression (e.g. Burt & Perrett, 1997; Christman & Hackworth, 1993; Drebing, Federman, Edington & Terzian, 1997; Magnussen, Sunde & Dyrnes, 1994; Workman, Peters & Taylor, 2000; see Heller, Nitschke & Miller, 1998; Hellige, 1993, for reviews). However, the possible preference for happy faces over angry faces yields an alternative prediction, considering the left hemisphere association with approach responses and the right hemisphere with avoidance responses (e.g. Davidson, 1995; Davidson, Ekman, Saron, Senulis & Friesen, 1990; Heller et al, 1998; Hellige, 1993). The RVF face should be selected on face pairs with the more positive face in the RVF (left hemisphere association with approach) and the more negative face in the LVF (right hemisphere association with avoidance), i.e. the LVF-neutral – RVF-happy and LVF-angry – RVF-neutral pairs. Conversely, there may be smaller preference and responses closer to chance accuracy for pairs with the more negative face in the RVF and the more positive face in the LVF, i.e. the LVF-happy – RVF-neutral and LVF-neutral – RVF-angry pairs. Overall, accuracy should be higher for expressive faces (both happy and angry) presented in the RVF than in the LVF. Combining these two alternatives for laterality, it seems reasonable to suppose that the simple detection of facial emotion, which predicts higher accuracy in the LVF, might occur earlier than activation of the left / right hemisphere for approach / avoidance, which predicts higher accuracy in the RVF. In this case, higher accuracy in the LVF might be observed on fast trials, giving way to higher accuracy in the RVF on slower trials.

There may seem to be an apparent contradiction between the prediction of attention orientation towards angry facial expressions and selection of the paired neutral face in preference to the angry face in the explicit detection. These effects are not incompatible when it is considered that the tasks require participants to perform different decisions. In the attention orientation, responses are not made directly to the expressive face but to the subsequent dot-probe, while in the explicit detection, responses are made directly to the stimulus faces. It is quite conceivable that an angry facial expression might attract attention but not inspire an approach response, especially if the angry face invokes fear in the observer. Harmon-Jones (2001; 2003) has reported that the emotion of anger is associated with approach responses, however, the anger in this case is the anger experienced by the experimental participant, not the anger depicted by a stimulus face.

Experiment 1

Method

Participants

These were 29 undergraduate students of the Goldsmith's College Psychology Department. Five participants were excluded for selecting more expressive faces than were expected by chance in the explicit detection (binomial distribution, one-tailed, cut-off at 0.65, alpha = 0.05) since for these participants the possibility of some awareness cannot be ruled out. The remaining 24 participants were aged between 18 and 37; mean 20.6, s.d. 5.2 years. None of the experimental participants had taken part in the pre-experimental stimulus-rating task. Participants performed tasks for both facial expression and facial identity, in a counterbalanced sequence. [The identity tasks used different stimuli and were presented in separate blocks. The identity tasks are reported elsewhere (Stone & Valentine, 2004; 2005b)]. Results for facial expression will be reported here and effects of task sequence will be explored. There were 23 females and only 1 male so results will not be analysed by gender of participant.

Stimuli.

Photographs of 30 unfamiliar faces (selected from a larger set of around 200 faces) of a uniform high quality were digitised to produce images of 16 greys, 150 x 200 pixels in size. The faces portrayed three facial expressions, angry, happy and neutral. The angry and happy faces were rated by 6 participants (mean age 31.2 years, s.d. 7.2) to assess the strength of the anger or happiness displayed and the extent to which the target expression was deemed to be contaminated by any other expression. The same participants rated the neutral faces to assess the degree to which any emotional expression was deemed to be present. Five pairs of angry and neutral faces were selected such that (a) the photographs in each pair were of the same individual, (b) the angry faces displayed strong anger with minimal contamination from any other expression, and (c) the neutral faces displayed minimal emotion of any kind. Five pairs of happy and neutral faces, posed by different five models, were similarly selected. The angry-neutral face pairs comprised 3 males and 2 females while the happy-neutral face pairs comprised 2 males and 3 females. These stimuli were not perfectly balanced on gender, but this is not relevant to the present study. The important point is that each pair of faces represented the same person, so gender was constant on each trial.

The faces were approximately 4.5cm x 6cm and were presented simultaneously at a distance of 9cm apart with each face subtending a visual angle of approximately 4° from fixation. The mask was a rectangle containing a collage of parts of unfamiliar faces, of the same size as the stimuli.

Apparatus.

A personal computer running MEL2 software was used to display the faces at a 640 x 480 screen resolution. Response times and accuracy of response were measured and recorded by the computer.

Design.

For the attention orientation task there were three independent within-participant factors: expression (angry vs. happy), expressive face visual field (LVF or RVF) and probe visual field (LVF or RVF). Task sequence (expression first vs. identity first) was a between-participant factor. The dependent variables were response time (calculated from dot-probe onset) and response accuracy. Each face pair was presented 8 times, once for each combination of face visual field x probe visual field x probe type, giving a total of 80 trials for the 8 combinations of 10 face pairs.

For the explicit detection task there were three within-participant factors of expression, expressive face visual field and response speed (fast vs. slow, defined by median split for each participant). Task sequence (expression first vs. identity first) was a between-participant factor. The dependent variable was accuracy of response and a correct response was the selection of the visual field of the expressive face. Each face pair was presented 4 times, twice with the expressive face in LVF and RVF, for a total of 40 trials. Responses were categorised as fast or slow after the data were collected.

Procedure.

Participants performed individually in a darkened, air-conditioned room. Each task was described immediately before it was performed. Participants performed tasks for both classes of stimuli, facial expression and facial identity, with the two attention orientation tasks in a counterbalanced sequence followed by the two explicit detection tasks, also in a counterbalanced sequence.

In the attention orientation task, 8 practice trials preceded the 80 experimental trials, presented in a sequence randomised by the program for each participant. The sequence of events in each trial was as follows: fixation cross in the screen centre for 500ms, forward masks in LVF and RVF for 500ms, expressive and neutral face for 17ms, backward masks for 500ms, dot-probe displayed in a location corresponding to the centre of one of the stimulus faces. Thus, the total stimulus onset asynchrony (SOA) between the faces and the dot-probe was 517ms. The dot-probe was displayed until a response was made. The procedure is illustrated in Figure 1.

Figure 1 about here

Participants responded by pressing one of two keys on the keyboard to indicate which type of dot-probe had appeared. Response times were calculated from the onset of the dot-probe. Each trial was initiated by the response to the previous trial after an inter-trial interval of 1 second. Participants were informed that two masked faces would be displayed very briefly, that they would find it very difficult to see the faces, and that this should be no cause for concern. They were asked to attend to the screen, wait for the dot-probe and respond. Participants were asked to look at the central fixation cross before each trial and to respond as quickly and accurately as possible.

In the explicit detection, 8 practice trials preceded the 40 experimental trials, presented in a sequence randomised by the program for each participant. The sequence of events on each trial was the same as the attention orientation except that instead of the dot-probe, the question “left or right?” was displayed until the response was made. Participants responded by pressing one of two keys; to the left of the keyboard to indicate that they thought the expressive face was in the LVF, and to the right of the keyboard to indicate the expressive face in the RVF. Each trial was initiated by the response to the previous trial after an inter-trial interval of 1 second. Participants were informed that in each pair of faces, there would be one emotional expression, either happy or angry, and one neutral expression. Each pair of faces would be photographs of the same person but the person would vary from trial to trial. Participants were asked to look at the central fixation cross before each trial and to respond as accurately as possible.

Following the computer tasks, participants were asked whether they had been able to recognise any of the expressions. Finally, participants were debriefed and thanked for their participation.

Results

Attention orientation.

Trials with incorrect responses to the dot-probe were excluded (4.9% of trials), and trials on which the response was slower than 955ms were excluded as outliers (4.2% of trials).

Mean response times were calculated for each combination of expression (happy vs. angry), expressive face visual field (LVF vs. RVF) and probe visual field (LVF vs. RVF). ANOVA was performed with these three within-participant factors and one between-participant factor of task sequence (expression first vs. identity first). There was a marginal interaction of expression with visual field, $F(1,22) = 3.27$, $MSE = 1210$, $p < 0.09$, showing a tendency for responses to be faster following angry faces in the LVF but following happy faces in the RVF. No other effects were significant, all $F < 2.3$, $p > 0.14$. The proportion of errors was calculated for the same factors as response times. No effects were significant, all $F < 1.7$, $p > 0.20$. There was no evidence of orientation to emotional faces ($F < 1$ for the interaction of face VF and probe VF), or of differential orientation to happy versus angry faces ($F < 1$ for the interaction of emotion with face VF and probe VF) in either the analysis of response times or errors.

Explicit detection of facial emotionality.

After excluding participants with above chance accuracy, only 1 participant claimed to have been able to recognise facial expressions, and this participant selected exactly 50% of the expressive faces. All other participants insisted they were unable to recognise facial expressions. Mean accuracy was 0.496, s.e. = 0.015, which does not differ from chance in a one-sample t-test, $t(23) = -0.24$, ns.

ANOVA was performed with three within-participant factors of expression, visual field and response speed (fast vs. slow; defined by median split per participant; mean of the median response time was 1039ms calculated from face onset). Task sequence (expression first vs. identity first) was a between-participant factor. The dependent variable was the proportion of correct responses, defined as selection of the visual field in which the expressive face had appeared. Trials with response time in excess of 5000ms from face offset were excluded.

The main effect of expression was significant, $F(1,22) = 8.21$, $MSE = 0.025$, $p < 0.01$, showing more accurate responses to happy faces (mean = 0.535, s.e. = 0.015) than to angry faces (mean = 0.468, s.e. = 0.021). There was also a marginal interaction of expression with visual field, $F(1,22) = 3.28$, $MSE = 0.056$, $p < 0.09$. Paired-samples t-tests (alpha = 0.025 using the Bonferroni correction) revealed that happy faces were selected more often than angry faces in the LVF, $t(23) = 2.55$, $p < 0.02$, but with equivalent frequency in the RVF, $t(23) = 0.21$, ns. This is consistent with right hemisphere superiority in processing facial expression. See Figure 2, panel A.

There was a significant interaction of visual field with response speed, $F(1,22) = 17.62$, $MSE = 0.066$, $p < 0.001$, investigated with paired-samples t-tests (alpha = 0.025 using the Bonferroni correction). Fast responses were more accurate for emotional faces in the LVF (mean = 0.564, s.e. = 0.038) than the RVF (mean = 0.440, s.e. = 0.035), $t(23) = 2.39$, $p = 0.025$. Slow responses were more accurate for emotional faces presented in the RVF (mean = 0.573, s.e. = 0.036) than in the LVF (mean = 0.388, s.e. = 0.030), $t(23) = 3.71$, $p = 0.001$. See Figure 2, panel A. One-sample t-tests compared performance against chance for slow trials. Angry faces presented in the LVF were selected significantly less often than chance, $t(23) = -3.67$, $p = 0.001$. Happy faces presented in the RVF were selected significantly more often than chance, $t(23) = 2.52$, $p < 0.02$. Angry faces in the RVF, and happy faces in the LVF, were selected at chance, $t(23) = 0.76$, ns, and $t(23) = -1.28$, ns, respectively.

Figure 2 about here

The main effect of task sequence was significant, $F(1,22) = 7.99$, $MSE = 0.037$, $p < 0.02$, showing higher accuracy when the expression task was performed after the identity task than when it was performed first. However, none of the interactions involving the factor of task sequence were significant, all $F < 1.3$, $p > 0.28$. This suggests that neither the main effect of higher accuracy for happy than angry faces, nor the interaction of visual field with response speed, were affected by task sequence.

Concerning the interaction of response speed with visual field, a possible confound is that responses tended to become faster over the course of the task, so that response speed was confounded with practice. It may be that the interaction should be more properly attributed to practice rather than response speed. This was investigated by repeating the ANOVA with an additional within-participant factor of task half (first 20 trials vs. second

20 trials). The interaction of response speed with visual field remained significant, $F(1,22) = 20.44$, $MSE = 0.077$, $p < 0.001$, but the interaction of task half with visual field was non-significant, $F(1,22) = 1.76$, ns, as was the three-way interaction, $F < 1$. This suggests that response speed, and not practice, influenced laterality of response accuracy.

Discussion

From the observation of chance overall performance in the explicit detection, and participants' insistence that they were unable to recognise the expressions, the conclusion may be drawn that there was no awareness of the facial expressions. At the same time, explicit detection of emotionality was more accurate for happy than angry faces. This is attributed to selection of the preferred face in each pair; participants selected the happy face of a happy-neutral pair, and the neutral face of an angry-neutral pair.

The interaction of visual field with response speed was as predicted. Independent of expression, responses on the fast trials were more accurate to emotional faces in the LVF than the RVF, attributed to right hemisphere superiority in processing facial emotion. Responses on the slow trials were more accurate when the expressive face was presented in the RVF than in the LVF, consistent with the prediction based on the left hemisphere association with approach responses and the right hemisphere association with avoidance responses. The one-sample t-tests for slow trials support this explanation: angry faces presented in the LVF (right hemisphere avoidance) were selected less often than chance, and happy faces presented in the RVF (left hemisphere approach) were selected more often than chance, while angry faces presented in the RVF and happy faces presented in the LVF were selected at chance. The observation of a different effect of laterality on the fast trials suggests that the left / right hemisphere association with approach / avoidance responses increases gradually in strength following stimulus presentation.

There was no evidence of attention orientation towards angry or happy faces. One possible reason for the failure to find an effect of attentional orientation is that the 500ms backward mask was relatively long compared to Mogg and Bradley (1999) who used 14ms, 136ms and 68ms in Experiments 1, 2 and 3. It is possible that attention was oriented as predicted but that 500ms was sufficient time for participants to release their attention from the expressive face and return to focus on the centre of the screen in anticipation of the dot-probe.

Posner and Cohen (1984) reported evidence on the timing of attentional orientation towards a peripheral stimulus. They found that attention is oriented towards a peripheral cue stimulus at about 100ms after cue stimulus onset, shown as facilitation of responses to a target stimulus in the cued peripheral location. However, after around 300ms, if attention is summoned back to a central location, there is inhibition of responses to a target stimulus in the peripheral cued location. Muller and Rabbitt (1989) broadly agree with these approximate timings while Bachmann (1997) cites 60 – 150ms as the optimum cue-to-target SOA to produce attentional orientation leading to facilitation of speed and accuracy of responses to the target. In the present experiment it is quite possible that attention may have returned to the centre, because there was an equal probability of the dot-probe in either visual field. Hence, the 500ms duration of the backward mask may have meant that the dot-probe appeared during the period when detection of a target in the peripheral cued location was sometimes inhibited rather than facilitated. In the experiment reported by Lambert and Sumich (1996), this inhibitory effect was strong in comparison to the predicted experimental effect. Driver, Davis, Ricciardelli, Kidd, Maxwell and Baron-Cohen (1999) point out that the process of encoding a facial stimulus will also require some duration. The timing reported by Posner and Cohen (1984) was in relation to simple peripheral flashes of light and so timing involving more cognitively complex stimuli may be extended. Nevertheless, it does appear that a 500ms backward mask may have hampered detection of the predicted effect. Consequently, the duration of the backward mask was shortened in Experiment 2 to 100ms.

Experiment 2

There were three major changes from Experiment 1. First, participants performed tasks only for facial expression, not facial identity, so any possible effects of task sequence were avoided. Second, the duration of the backward mask was shortened to 100ms, reducing the SOA between face and dot-probe to 117ms, in order to improve the prospect of finding an effect of attention orientation. The third major change was the introduction of the new perceptual comparison task.

Perceptual comparison.

The rationale for this task was the observation, offered by participants in Experiment 1 during debriefing, that they were able to gain some vague visual impression of the stimulus faces, or at least the impression of “something there”. Two questions arise: will the strength of the visual percept vary with emotional expression, and will it vary with visual field? To investigate these questions, a third task of perceptual comparison was introduced in Experiment 2. Stimuli were presented as in the other tasks and participants were asked to select the face in each pair that made the stronger visual impression.

Method

Only the differences from Experiment 1 will be described.

Participants

These comprised 30 students, staff and visitors at Goldsmiths College, London. The majority, around 90%, were not psychologists. One participant was excluded for selecting more expressive faces than were expected by chance in the explicit detection (binomial distribution, one-tailed, cut-off at 0.65, alpha = 0.05) since for this participant the possibility of some conscious awareness cannot be ruled out. Another participant was excluded for failing to follow instructions. The remaining 28 participants were aged between 18 and 40; mean 26.5, s.d. 6.0. There were 21 females and only 7 males, so the results will not be analysed by gender of participant.

Design

The duration of the backward mask was shortened to 100ms, to reduce the SOA between face and dot-probe to 117ms.

The new task of perceptual comparison was introduced. This used the same design as the explicit detection task, with two changes: participants were asked to select which of the two faces generated the stronger visual impression, and a third response option of "about equal" was allowed. The sequence of tasks was always attention orientation, then explicit detection, and finally perceptual comparison.

Results

Attention orientation.

Trials with incorrect responses to the dot-probe were excluded (4.4% of trials), as were trials on which the response was slower than 1139ms (5.4% of trials).

Mean response times were calculated for each combination of expression (happy vs. angry), expressive face visual field (LVF vs. RVF) and probe visual field (LVF vs. RVF). ANOVA was performed with these three within-participant factors. The main effect of probe visual field approached significance, $F(1,27) = 3.82$, $MSE = 3281$, $p < 0.07$, showing a tendency to faster responses to probes in the LVF compared to the RVF. The main effect of expression also approached significance, $F(1,27) = 3.03$, $MSE = 2724$, $p <$

0.1, showing a tendency to faster responses following angry than happy faces. No other effects were significant, all $F < 1$.

The mean proportion of errors was calculated for the same factors as the analysis of response times. The main effect of probe visual field was significant, showing more errors to dot-probes in the LVF than the RVF, $F(1,27) = 7.24$, $MSE = 0.0055$, $p < 0.02$. No other effects were significant, all $F < 1$.

Explicit detection of facial emotionality.

Mean accuracy was 0.518, s.d. = 0.08, which does not differ from chance in a one-sample t-test, $t(27) = 1.26$, ns.

ANOVA was performed with three within-participant factors of expression, visual field and response speed (fast vs. slow; defined by median split for each participant; mean of the median response time was 1044ms calculated from face onset). The dependent variable was the proportion of correct responses, a correct response being defined as selection of the visual field in which the expressive face had appeared. Trials with response time in excess of 5000ms from face offset were excluded.

The main effect of expression was significant, $F(1,27) = 6.08$, $MSE = 0.049$, $p = 0.02$, showing more accurate responses to happy faces (mean = 0.555, s.e. = 0.022) than to angry faces (mean = 0.482, s.e. = 0.019). The interaction of visual field with response speed was significant, $F(1,27) = 4.41$, $MSE = 0.043$, $p < 0.05$, showing the same pattern of data as Experiment 1. Fast responses tended to be more accurate for emotional faces presented in the LVF (mean = 0.531, s.e. = 0.04) than in the RVF (mean = 0.514, s.e. = 0.04), $t(27) = 0.32$, ns, and slow responses tended to be more accurate for emotional faces presented in the RVF (mean = 0.564, s.e. = 0.03) than in the LVF (mean = 0.466, s.e. = 0.04), $t(27) = 1.96$, ns. See Figure 2, panel B. No other effects were significant, all $F < 1$.

Perceptual comparison

Data were excluded from one participant who selected the "equal" option on 63% of trials. Considering the remaining participants, the "equal" option was selected on fewer than 23% of trials, and on a similar proportion of trials with angry and happy faces, presented in the LVF and RVF, and so will not be analysed further. The single participant who had scored above chance in the explicit detection was included in the analysis of the perceptual comparison, even though this participant may have had some awareness of the masked faces. This participants' data had been excluded from the analysis of the attention orientation and explicit detection on the grounds that these tasks were specifically investigating effects of perception without awareness. In contrast, the perceptual comparison was designed to measure participants' partial awareness of the masked faces, so it was relevant to include data from a participant for whom the visual percept of the faces may have occasionally been particularly strong.

ANOVA was performed with three within-participant factors of expression (angry vs. happy), expressive face visual field (LVF vs. RVF) and response speed (fast vs. slow; defined by median split for each participant; mean of the median response time = 993ms calculated from face onset). These were the factors used to analyse the explicit detection.

There was a main effect of expression, $F(1,27) = 5.38$, $MSE = 0.036$, $p < 0.03$, showing that happy faces (mean = 0.419, s.e. = 0.025) were selected more often than angry faces (mean = 0.360, s.e. = 0.027). The main effect of visual field was significant, $F(1,27) = 4.24$, $MSE = 0.146$, $p < 0.05$, showing that expressive faces were selected more often in the LVF (mean = 0.442, s.e. = 0.038) than in the RVF (mean = 0.337, s.e. = 0.030). See Figure 3. No other effects were significant, all $F < 2.8$, $p > 0.11$. In particular, the interaction of visual field with response speed was non-significant, $F < 1$. Note that mean accuracy was below 0.50 because of the "about equal" response option.

Figure 3 about here

Discussion

There was no evidence of attention orientation towards angry or happy faces. The reduction in the face-to-probe SOA failed to result in a significant orientation effect. This differs from the results of Mogg and Bradley (1999) who reported orientation towards angry faces presented in the LVF but not in the RVF. The failure to observe the same effect in the present study could be due to many causes and does not rule out the possibility that angry faces do attract attention in competition with neutral faces under certain circumstances. Some of the possible reasons for the discrepancy between the present study and the previous work of Mogg and Bradley (1999) will be noted. (1) Response times from onset of the dot-probe were slower in the present study (overall mean response time of around 620 and 680ms in Experiment 1 and 2, respectively) than the previous work (mean response time around 510ms). If the orientation of attention to angry faces is transient, then it may be necessary to encourage participants to respond more rapidly in order to observe the effect. (2) The previous work found orientation of attention to angry faces only in highly anxious participants, whereas participants in the present study were not sorted according to trait or state anxiety. The combination of these causes might suggest that the orientation of attention to angry faces is transient and occurs only for highly anxious participants.

Another factor (3) is that there are interpretational problems with the previous work of Mogg and Bradley (1999, Experiment 3). They reported that attention was oriented to angry faces presented in the LVF but not the RVF. This was inferred from the observation that responses to LVF dot-probes were significantly faster following LVF angry faces than following RVF angry faces. The problem is that the speed of responses to RVF dot-probes was the same following LVF angry faces and RVF angry faces; the orientation to LVF angry faces should have slowed responses to subsequent RVF dot-probes, but this was not observed. Thus, the effect reported by Mogg and Bradley (1999) is not entirely clear.

The results of the explicit detection replicated Experiment 1. Emotional faces were detected more accurately when the expression showed happiness than when it showed anger. The interaction of visual field with response speed showed the same pattern as Experiment 1 although with a reduced level of significance. Fast responses tended to be more accurate for emotional faces presented in the LVF, and slow responses tended to be more accurate for emotional faces in the RVF.

The perceptual comparison showed that visual percepts were stronger for happy than for angry faces, and stronger for emotional faces in the LVF than in the RVF on fast and slow responses. This suggests a general effect such that the right hemisphere constructs stronger visual percepts than the left hemisphere, which would obviously lead to more frequent selection of expressive faces in the LVF than in the RVF. Note that for angry faces in the LVF, two effects were in partial opposition: weaker visual percepts of angry than happy faces, and stronger visual percepts of emotional faces in the LVF than the RVF.

<u>The possible effect of teeth.</u>

The possibility must be considered that stronger visual percepts of happy than angry faces were due to the visibility of teeth exposed by the smile, given that a white patch might be particularly difficult to extinguish by the mask and therefore make a stronger visual percept. This seems unlikely, because although four of the happy faces showed teeth, and no neutral faces, three of the angry faces also showed teeth, so if the visibility of teeth had resulted in a stronger visual percept this should have had a similar effect for happy and angry faces. Nonetheless, in order to investigate the possible effect of the visibility of teeth, ANOVA was performed with two factors of teeth (visible or not) and facial expression. The main effect of expression was similar to that previously reported, showing marginally stronger visual percepts of happy than angry faces, $F(1,27) = 3.22$, $p < 0.09$. There was no main effect of teeth, $F < 1$, and no interaction, $F < 1$. Thus, it is unlikely that the exposure of teeth on happy faces contributed to accuracy. ANOVA was also performed with two factors of teeth (visible or not) and visual field. The main effect of visual field was similar to that previously reported, showing marginally stronger visual percepts in the LVF than the RVF, $F(1,27) = 3.47$, $p < 0.08$. There was no main effect of teeth, $F(1,27) = 1.94$, ns, and no interaction $F < 1$. It seems that the visibility of teeth did not lead to stronger visual percepts.

In the explicit detection, it is possible that accuracy of responses may have depended on the visibility of teeth, since these are a good indicator of an emotional as opposed to a neutral facial expression. To examine whether the visibility of teeth moderated the main effect of expression, ANOVA was performed with two within-participant factors of teeth and expression, and one between-participant factor of experiment (Experiment 1 vs. 2). The main effect of expression was similar to that previously reported, showing more accurate responses to happy than to angry faces, $F(1,50) = 8.42$, $p = 0.005$. The main effect of teeth approached significance, $F(1,50) = 3.04$, $p < 0.09$, showing a tendency to more accurate responses for faces showing teeth than for those not showing teeth. The three-way interaction was also significant, $F(1,50) = 4.04$, $p < 0.04$, showing that the marginal main effect of teeth was stronger for angry faces in Experiment 1 and for happy faces in Experiment 2, although none of the simple contrasts reached significance with Bonferroni-corrected alpha level. All other effects were non-significant, $F < 1.4$, $p > 0.25$.

To examine whether visibility of teeth may have moderated the interaction of visual field with response speed, ANOVA was performed with three within-participant factors of teeth, visual field and response speed, and one between-participant factor of experiment. The interaction of response speed with visual field was similar to that previously reported, $F(1,47) = 14.11$, $p < 0.001$. There was also a main effect of teeth, $F(1,47) = 5.40$, $p < 0.03$, showing more accurate responses for faces showing teeth than for those not showing teeth. All other effects were non-significant, $F < 1.1$, $p > 0.3$.

It seems the visibility of teeth may have led to more accurate detection of emotion, for both happy and angry faces, and for fast and slow responses in the LVF and RVF. The non-significance of interactions involving the factor of teeth ($F < 1$ for the interaction of teeth with expression and $F < 1$ for the interaction of teeth with response speed and visual field) suggests that the visibility of teeth was not responsible for main effect of emotion, or for differential accuracy in LVF and RVF on fast and slow trials.

Since the visibility of teeth appeared to have affected the accuracy of explicit emotion detection, the attention orientation task was also re-examined, to investigate whether there may have been an effect of orientation for faces showing teeth that was obscured by including faces with no teeth. Experiment 1 and 2 were analysed separately because the SOA in Experiment 2 may have been more conducive to finding an effect of attention orientation than Experiment 1. ANOVA was performed with three within-participant factors of expression, face visual field and dot-probe visual field. In Experiment 1, there were no significant effects in the analysis of response times, all $F < 1.4$, $p > 0.25$, or in the analysis of errors, all $F < 2.5$, $p > 0.12$. In Experiment 2, the analysis of response times yielded only a main effect of probe visual field, $F(1,27) = 4.63$, $p < 0.05$, all other $F < 2.7$, $p > 0.11$. The analysis of errors yielded only a main effect of probe visual field, $F(1,27) = 4.31$, $p < 0.05$, all other $F < 1$. Responses were faster and less accurate for dot-probes in the LVF than in the RVF. There was still no evidence of attention orientation towards either happy or angry faces, when only faces showing teeth were included in the analysis.

General Discussion

The results of the attention orientation, explicit detection and perceptual comparison for masked emotional faces will be considered first, followed by a comparison of the effects of masked emotional faces with the results previously reported for masked famous faces.

There was no evidence of attention orientation towards either happy or angry faces. It appears that happy and angry faces did not affect the orientation of attention to a degree detectable within the current method. The significant effects of facial expression in the other tasks rule out the possibility that facial expression was simply not detected. The contrast with the other tasks may be due to the incidental nature of the masked faces in the attention orientation, where responses were made to a subsequent dot-probe, compared with direct responses to the masked faces in the explicit detection and the perceptual comparison. Perhaps facial expression influenced responses only when the task instructions induced an intention to gain information from the masked faces. This raises the possibility that facial expression might affect the orientation of attention in a design where the particular expression had predictive power for the location of the subsequent dot-probe. It is also possible that angry faces might attract and retain attention in a selected sample of highly anxious participants (e.g. Mogg & Bradley, 1999). Other facial expressions, perhaps fear, might have more powerful effects on attention than angry or happy faces.

Explicit detection of facial emotion was more accurate for happy than angry faces, attributed to selection of the preferred face in each stimulus pair: happy faces were preferred over neutral and neutral over angry. Perhaps the participants, being unable to intentionally distinguish between emotional and neutral faces but compelled to make a decision on every trial, simply selected the preferred face. This could have arisen from a two-step process, in which participants first detected preference for one stimulus face over the other and then attributed this preference to possession of the attribute they had been asked to detect, i.e. facial emotionality. Another example of a two-step process was offered by Kleider and Goldinger (2004), who reported that faces were more likely to be declared as “old” rather than new if presented with less visual noise. They proposed a two-step process whereby the fluency of processing was detected and then attributed (wrongly) to familiarity of the stimulus.

The consciously experienced visual percept was stronger for happy than angry faces. There are several conceptual models with the potential to explain how the strength of the visual percept could depend on the affect invoked by the stimulus. Vogel, Luck and Shapiro (1998) proposed that processing of visual stimuli proceeds in two stages: the perceptual stage that identifies stimuli and occurs without awareness, and a post-perceptual stage of processing that may result in awareness. They suggested that the visual system is able to identify stimuli faster than they can be processed by post-perceptual systems. One implication is that the affect invoked by the stimulus might modulate post-perceptual processing and so result in enhanced or weakened awareness of the stimulus.

Martens, Wolters and van Raamsdonk (2002) cite converging evidence that awareness of the presence and meaning of a visual stimulus requires an attentional process consisting of a feedback mechanism from high-level representations to preceding low-level representations. This follows a feedforward cycle that activates representations in subsequent processing levels, up to stimulus meaning. Visual awareness is critically dependent on the feedback cycle re-activating early representations in primary visual cortex. Such feedback can be interpreted as a process of binding the high-level representations to the lower-level representations that caused their activation. This would seem to allow the possibility that high-level stimulus properties, e.g. positive or negative affective impact, could modulate the feedback mechanism and so influence the low-level visual representations.

Both of these models (Vogel et al, 1998; Martens et al, 2002) appear to have conceptual similarity with the theorising of Kanwisher (2001) that awareness of a stimulus requires a link between semantic “type” information and spatio-temporal “token” information. This link might occupy the same conceptual function as the post-perceptual stages of Vogel et al and the feedback cycle of Martens et al.

Di Lollo, Enns and Rensink (2000) developed an explicit computational model (CMOS) along similar lines of reasoning. The CMOS model explains that processing of a visual stimulus proceeds through sequential levels increasing in abstractness from the visuo-spatial event. Re-entrant neural projections from association cortex attempt to connect with low-level representations in primary visual cortex (a post-perceptual feedback process). Awareness of a stimulus depends on a match between the re-entrant high-level visual representation and ongoing lower level activity in primary visual cortex. The CMOS model accounts for the effectiveness of backward masking by proposing that the mask replaces the masked stimulus as the object of ongoing lower level activity, producing a mismatch with the re-entrant visual representation of the stimulus, and so precluding awareness of the stimulus. If the masked stimulus is still generating some attenuated lower level activity then presumably, a partial match with the re-entrant visual representation can be made, and so a vague, partial visual percept can be experienced. Affective modulation of the re-entrant neural projections from association cortex to primary visual cortex would result in a consciously experienced visual percept whose strength depends on the affect invoked by the stimulus.

All of these conceptual accounts have the potential to explain how an attribute of a stimulus (e.g. invoked affect) can modify the strength of the consciously experienced visual percept in the absence of awareness of the nature of the stimulus.

The pattern of laterality differed between the explicit emotion detection and the perceptual comparison tasks. In the explicit detection, fast responses were more accurate to emotional faces in the LVF than in the RVF, while slow responses were more accurate to emotional faces in the RVF than the LVF. In the perceptual comparison task, both fast and slow responses were more accurate to emotional faces in the LVF than the RVF. It is simplest to assume that fast responses in the explicit detection and all responses in the perceptual comparison were influenced by similar underlying factors. A plausible explanation is right hemisphere superiority in constructing a visual percept of a face. This would be consistent with electroencephalography studies that have consistently reported stronger face-specific neural responses (e.g. the N170) in the right hemisphere than in the left hemisphere (e.g. Barrett & Rugg, 1989; George, Evans, Fiori, Davidoff & Renault, 1996; Henson, Goshen-Gottstein, Ganel, Otten, Quayle & Rugg, 2003; Watanabe, Kakigi, Koyama, & Kirino, 1999).

The laterality of slow responses in the explicit detection is attributed to the left hemisphere association with approach and the right hemisphere association with avoidance that appears to have gradually gained in strength following stimulus onset. The question then arises of why this pattern of laterality did not occur in the perceptual comparison. It seems likely that the instructions given to participants in the perceptual comparison caused them to focus on the relative strength of the visual percept of the two stimulus faces and so this was the criterion that dominated their responses. In the explicit detection task, no such instruction was given, and participants appear to have used a preference decision to select their slower responses. Other studies have reported that responses to stimuli perceived without awareness (e.g. Snodgrass, Shevrin & Kopka, 1993) or early ERP components (e.g. Rossion, Campanella, et al, 1999; Streit, Ioannides, Liu, Wolwer, Dammers, Gross, Gaebel & Muller-Gartner, 1999) vary according to the task.

The relationship between laterality and response speed raises the question of causation. The speed of response on any particular trial may have been coincidental, in which case responses were influenced by the information that happened to be available at the time the response was selected. Alternatively, speed of response may have depended systematically on what information was activated on each trial. One approach to investigating this question could be to impose a defined response speed on participants, by either requiring responses to be made before a deadline or not permitting responses until after a delay. The problem with the latter is that not only response execution but also response selection would have to be delayed, and it might not be possible in practice to be sure that participants had complied with such an instruction. If a way could be found to overcome this problem then this would be a useful future experiment.

The discussion will now turn to a comparison of the results of the present study with the results previously reported for positively and negatively evaluated famous persons (Stone & Valentine, 2004; 2005a; b; c). The designs were analogous to those employed in the present study. Masked 17ms faces were presented in simultaneous pairs of one famous and one unfamiliar face, one face in the LVF and the other in the RVF. Each pair of faces was matched on age, sex, race, pose and facial expression. Each participant evaluated each famous person on a positive-negative dimension in a rating procedure subsequent to the experimental tasks. So the negatively evaluated, positively evaluated and unfamiliar faces were analogous to the angry, happy and neutral faces of the present study. The same three questions were investigated: whether attention is oriented towards famous faces, and equivalently for persons evaluated positively and negatively; whether explicit detection of familiarity differs between positive and negative famous persons; and whether the strength of the visual percept differs according to valence.

The explicit familiarity detection asked participants to select the visual field in which the famous face had appeared (Stone &Valentine, 2004; 2005a). Although participants were unable to become aware of facial familiarity, and by assumption, were unable to become aware of facial identity, explicit familiarity detection was more accurate to positive than negative famous persons. This effect is analogous to that observed in the present study of explicit emotionality detection and for both classes of stimuli, the effect is attributed to selection of the preferred face in each stimulus pair. Happy faces were preferred to neutral and neutral to angry; positive famous persons were preferred to unfamiliar and unfamiliar to negative famous persons.

The perceptual comparison task (Stone &Valentine, 2005c) on famous and unfamiliar faces asked participants to select the face in each stimulus pair that made the stronger visual impression. The results were analogous to the present study of facial emotion, in that visual percepts of the famous faces were stronger when the famous persons were evaluated positively than when they were evaluated negatively. Regarding laterality, there was an interaction of visual field with response speed, such that famous faces were selected more often in the LVF than in the RVF on fast responses, but equally often in both visual fields on slow responses. This can be attributed to the right hemisphere ability to detect facial familiarity more rapidly than the left hemisphere. The left hemisphere can detect facial familiarity, but more slowly than the right hemisphere.

The attention orientation task on famous-unfamiliar faces (Stone &Valentine, 2005b) showed evidence of orientation, in contrast to the present study of facial emotion.

Fewer errors were made when the dot-probe was presented in the same visual field as the famous face, as long as the famous person was evaluated positively. The opposite effect was observed, fewer errors in the visual field of the unfamiliar face, when the famous person was evaluated negatively. This was interpreted as orientation of attention to the faces of positive famous persons and away from the faces of negative famous persons. The latter effect was attributed to an association between negative evaluations and the emotion of disgust, both of which result from perceived violations of social and moral norms. The emotion of disgust is one of the basic emotions and its significance is that it motivates the turning of attention away from the invoking object (e.g. Charash & McKay, 2002; Druschel & Sherman, 1999; Izard, 1977; Levenson, 1994; Nabi, 2002; Newhagen, 1998; Rozin, Haidt & McCauley, 1999). Disgust has been specifically related to the avoidance of ideas or persons regarded as morally corrupt (Izard, 1977; Nabi, 2002; Rozin et al., 1999).

Happy faces can be considered analogous with faces of positively evaluated famous persons, since both present a pleasant stimulus and an indicator of a rewarding social interaction. Angry faces were predicted to attract and hold attention more powerfully than happy faces. It is, therefore, interesting that expressive faces had no apparent effect on attention. The contrast between facial identity and facial expression is particularly striking given the similarity of experimental designs for the two classes of stimuli. Attentional effects of famous faces were apparent with face-to-probe SOA of both 117ms and 517ms, and attentional effects of emotional faces were absent at the same two SOA. The attention orientation tasks for famous faces and for emotional faces used the same size of stimulus, presented in the same screen location, with the same exposure duration, and an identical mask. The exact stimuli differed between the two classes of stimuli, but in the direction of higher clarity and contrast of photographic image for the emotional-neutral pairs. All other aspects of the experimental procedure were the same. It is also noteworthy that facial expression and facial identity yielded similar results in the explicit detection and perceptual comparison tasks, contradicting the possibility that facial identities were simply more easily recognised than facial expressions.

It seems that famous faces have more powerful effects on attention than emotional faces, at least under the present experimental conditions. The previously reported attentional effects of famous faces occurred for the whole participant sample, unsorted by anxiety, and were observed with a face-to-probe SOA of 117ms or 517ms, suggesting that the effects arose swiftly and persisted for at least a few hundred milliseconds. Both of these factors suggest that famous faces have a powerful effect on attention.

The difference in the attention capturing properties of famous and expressive faces may stem from their status as trait or state. An expression may be transient and so may provide only a weak predictor of the likely tone of a social interaction. In contrast, identity is a stable characteristic, and if a person is regarded in a positive or negative light as a result of past deeds this could be seen as a strong predictor of the pleasantness or unpleasantness of a potential encounter.

The observation of orientation away from the faces of famous persons invoking disgust because of their personality or past behaviour (Stone & Valentine, 2005b) raises the question of what kind of unfamiliar face might invoke disgust. It is possible that a face depicting an expression of disgust might invoke a sympathetic emotional response, but there is (to our knowledge) no evidence for this. Perhaps a strongly unattractive face, or one that appears diseased, might invoke such an affective response, but this is a very different kind of aspect than either facial identity or facial expression.

Overall, it appears that facial expression and facial identity have analogous effects in experimental tasks requiring a response directly to the masked faces. The response appears to depend on the positive or negative direction of invoked affect. It is perhaps not surprising that the two classes of stimuli should have analogous effects since both present essentially the same stimulus, a human face, since detection of facial expression and facial identity both require an analysis of the internal facial features, and since both have predictive value for the likely tone of a social interaction.

For future studies, since there is evidence that facial identity and expression can be recognised non-consciously, the obvious question arises of how they will interact. Will one of these aspects, identity or expression, override the other? Alternatively, will one aspect modify responses to the other? For example, does a smile have the same meaning regardless of whether the person is regarded positively, negatively or is unknown?

Three main conclusions arise. First, that facial expression and facial identity have some analogous effects when recognised without awareness, dependent on positive or negative invoked affect. Second, that the attentional properties of famous faces may exceed those of unfamiliar expressive faces under certain circumstances. Third, the observation that laterality can differ for the same stimuli dependent on task instructions suggests that responses to non-consciously recognised expressive faces are not a simple unitary phenomenon. Instead, consciously held intention interacts with non-consciously derived stimulus-dependent information to determine responses.

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Figure Captions

Figure 1. Illustration of the procedure in the attention orientation task.

Figure 2. Explicit detection of facial emotionality: mean accuracy of the fast and slow responses in the LVF and RVF to angry and happy faces. Panel A and B show data from Experiment 1 and 2, respectively. Bars represent standard errors.

Figure 3. Perceptual comparison: mean accuracy of fast and slow responses in the LVF and RVF to angry and happy faces. Only participants in Experiment 2 performed the perceptual comparison. Bars represent standard errors.

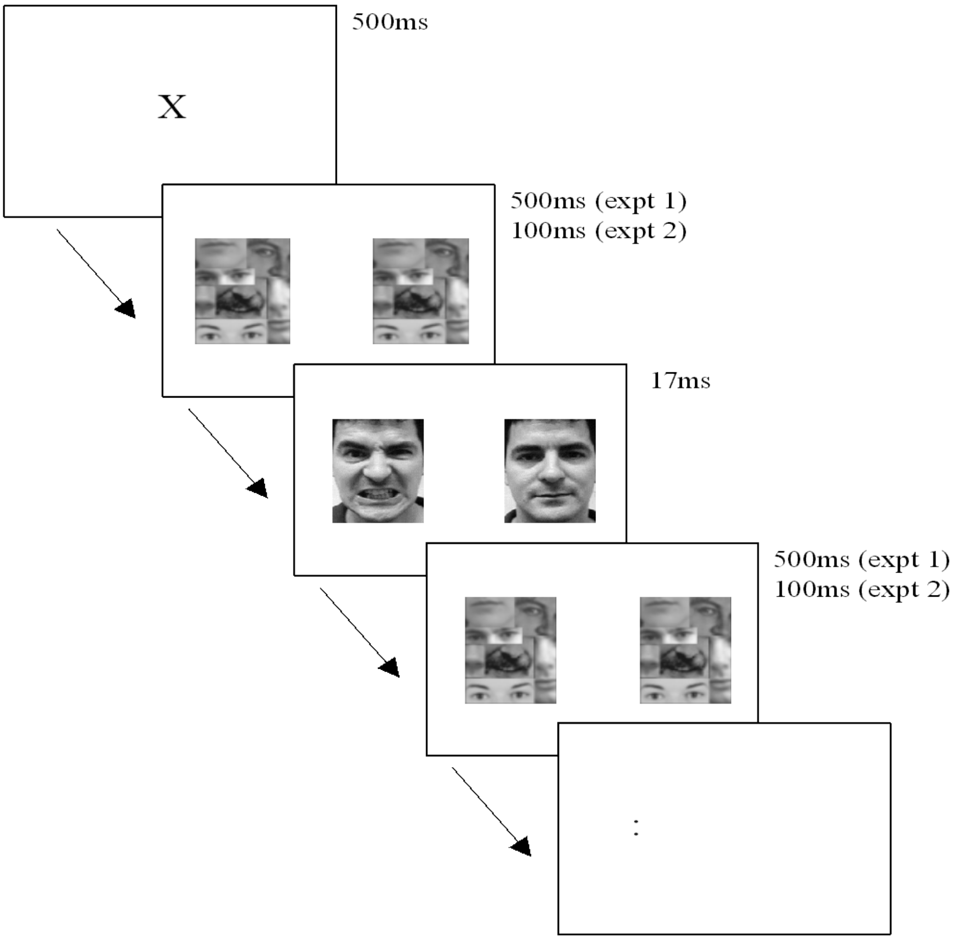
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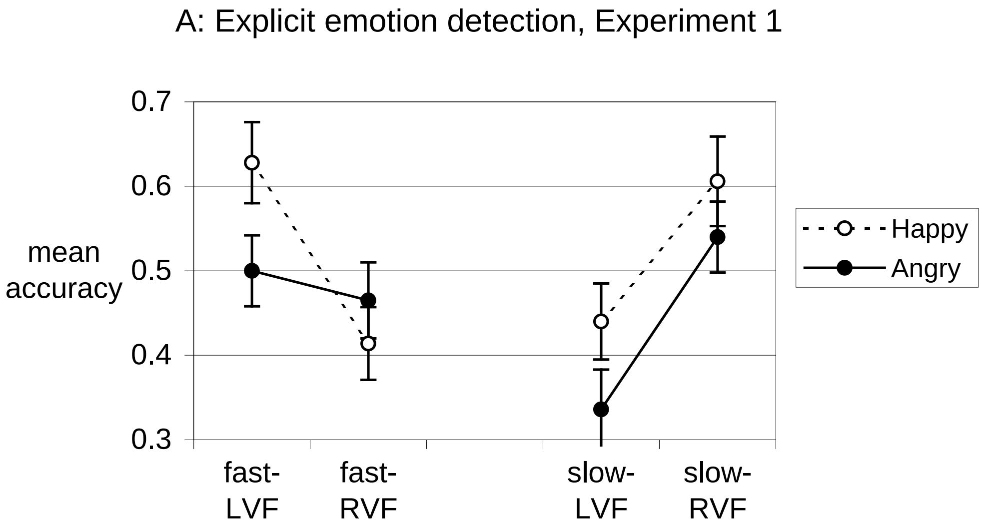
Figure 1


A: Explicit emotion detection, Experiment 1
0.7
0.6
0.5
0.4
0.3
mean
accuracy
Happy
Angry
fast-
LVF
fast-
RVF
slow-
LVF
slow-
RVF

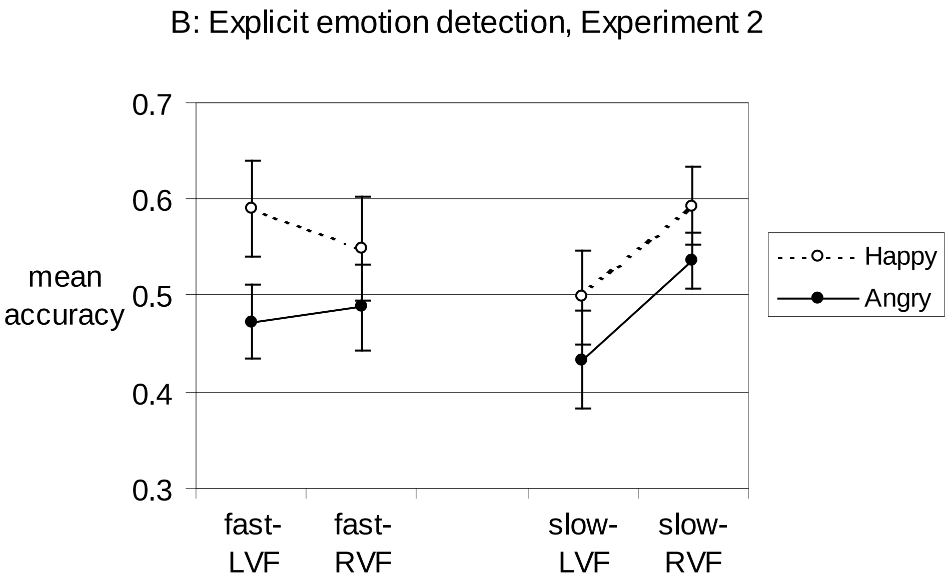

B: Explicit emotion detection, Experiment 2
0.7
0.6
0.5
0.4
0.3
mean
accuracy
Happy
Angry
fast-
LVF
fast-
RVF
slow-
LVF
slow-
RVF

Figure 2

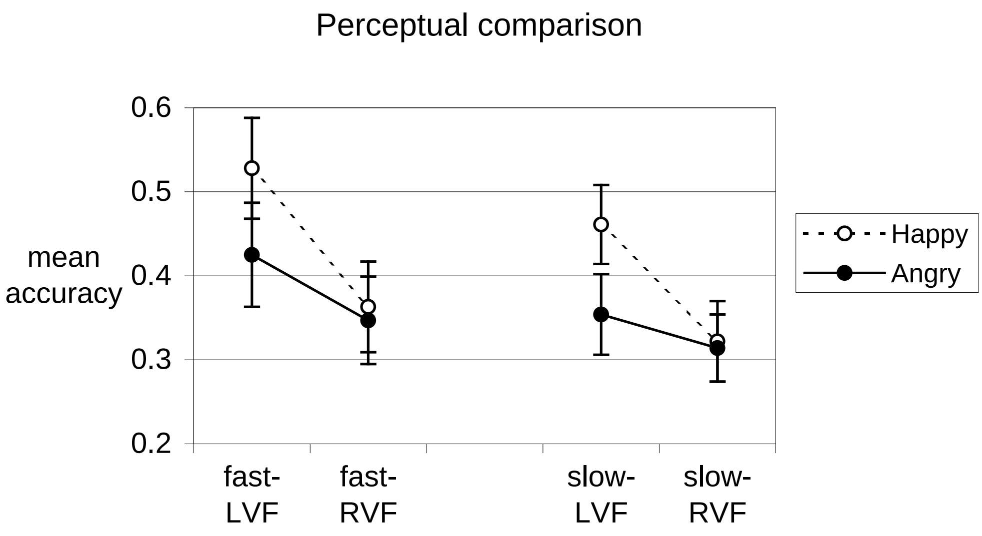

Perceptual comparison
0.6
0.5
0.4
0.3
0.2
mean accuracy
fast-LVF
fast-RVF
slow-LVF
slow-RVF
Happy
Angry

Figure 3