BRIEF REPORT

Emotional facial expressions differentially influence predictions and performance for face recognition

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This study examined how participants' predictions of future memory performance are influenced by emotional facial expressions. Participants made judgements of learning (JOLs) predicting the likelihood that they would correctly identify a face displaying a happy, angry, or neutral emotional expression in a future two-alternative forced-choice recognition test of identity (i.e., recognition that a person's face was seen before). JOLs were higher for studied faces with happy and angry emotional expressions than for neutral faces. However, neutral test faces with studied neutral expressions had significantly higher identity recognition rates than neutral test faces studied with happy or angry expressions. Thus, these data are the first to demonstrate that people believe happy and angry emotional expressions will lead to better identity recognition in the future relative to neutral expressions. This occurred despite the fact that neutral expressions elicited better identity recognition than happy and angry expressions. These findings contribute to the growing literature examining the interaction of cognition and emotion.

Keywords: Cognition; Emotion; Memory; Metamemory; Emotional facial expressions; Face recognition.

Although the interaction of memory and emotion has been widely explored (see LaBar & Cabeza, 2006, for a review), few studies have examined how emotional stimuli may influence participants' predictions of future memory performance (but see Zimmerman & Kelley, 2010). Because the emotional nature of stimuli often exert significant influences on cognition and behaviour, it is important to understand the degree to which individuals appreciate the influence of intrinsic emotional properties of stimuli on memory performance. In fact, to our knowledge, only one study has examined the influence of emotional properties of stimuli on participants' predictions of future memory performance (Zimmerman & Kelley, 2010). The current study sought to further explore how emotional stimuli may influence predictions of future memory performance. Specifically, we examined how positive, negative, and neutral emotional facial expressions impact...
participants’ ability to predict future recognition of a studied face.

Research examining awareness of our own cognitive processes (i.e., metacognition) has focused in part on the efficacy of prospective judgements of memory performance (i.e., monitoring). Prospective judgements are frequently examined by soliciting judgements of learning (JOLs) whereby participants predict the likelihood (typically on a 0–100% scale) of recalling or recognising some bit of information on a future memory test. JOLs may then be compared with the overall level of memory performance to assess calibration (i.e., the overall level of correspondence between memory performance and predictions). If participants’ predictions are not significantly different than their memory performance, they are said to be well calibrated. Poor calibration indicates that memory performance is either significantly higher (i.e., underconfidence) or significantly lower (i.e., overconfidence) than JOLs.

While JOLs are often moderately accurate, a number of discrepancies between JOLs and actual memory performance have been documented. For example, characteristics of the stimulus may influence JOLs even when these characteristics are independent of memory performance (Begg, Duft, Lalonde, Melnick, & Sanvito, 1989; Busey, Tunnicliff, Loftus, & Loftus, 2000; Rhodes & Castel, 2008). For example, Busey et al. (2000) demonstrated that longer presentation times and brighter luminance of studied faces influenced memory predictions but not memory performance for those faces. That is, participants gave higher JOLs to faces presented for longer durations and in higher luminance in the mistaken belief that these cues would be diagnostic of recognition accuracy. Discrepancies between JOLs and memory performance such as these suggest that participants do not have direct access to memory representations. That is, a direct access model (cf. Hart, 1965) would posit that participants’ predictions would be highly sensitive to variables that influence memory performance. Instead, participants often follow a cue-utilisation framework where memory predictions are based on cues and information available to the rememberer regardless of their predictive validity (Koriat, 1997).

To our knowledge, no study has yet explored the impact of emotional facial expressions on JOLs for future face identity recognition, and only one study has examined the impact of emotional stimuli on JOLs and memory performance. Zimmerman and Kelley (2010) had participants make JOLs on neutral and emotionally valenced pairs of words predicting free- and cued-recall on a future memory test. Results showed that calibration depended on the type of test and the valence of the stimuli. In free recall, both positive and negative words elicited higher JOLs and recall performance than neutral words, consistent with participants’ predictions. However, for cued recall, while both positive and negative word pairs elicited higher JOLs than neutral word pairs, negative word pairs were less likely to be recalled than neutral and positive word pairs. Thus, participants deemed emotional word pairs to be more memorable than neutral word pairs. This was consistent with performance for tests of free recall but not on tests of cued recall, where heightened predictions led to overconfidence for negative words and strong calibration for positive words. Because participants were not able to accurately predict their memory performance the authors argued their pattern of findings was consistent with a cue-utilisation framework rather than a direct access framework. The current study sought to further explore how JOLs are influenced by emotional stimuli by utilising a different stimulus type and different type of memory test. The current study utilised faces with happy, angry, and neutral emotional expressions in a two-alternative forced-choice recognition test.

THE CURRENT STUDY

The current experiment expands the examination of how emotional stimuli may influence metacognitive judgements by investigating whether
emotional facial expressions would impact JOLs and memory performance differently. Because identity recognition is a crucial skill necessary for social interaction, it is important to understand how memorable people believe a face is based on its emotional expression. Accordingly, because emotional expression recognition and identity recognition rely on different neural networks (Nomi et al., 2008) the recognition of an emotional expression does not necessarily ensure future identity recognition. Therefore, one’s knowledge of how emotional expressions may influence beliefs about future identity recognition would be a valuable social skill.

Based on the single prior study examining emotion and JOLs (Zimmerman & Kelley, 2010) it is possible that participants will provide higher JOLs to faces studied with emotional expressions, regardless of the type of expression (happy or angry). However, given that this prior work was with word pairs, it is also possible that emotional facial expressions may influence metacognitive judgements differently than emotional word pairs. Recognition of words and faces are hemispheric-specific processes with word recognition mainly being a left-hemispheric process with face recognition mainly being a right-hemispheric process (Kim et al., 1999). Also, people typically have more everyday experience with recognising faces rather than remembering word lists; thus, there is some reason to believe that memory monitoring for faces may be different than memory monitoring for words. Therefore, although emotional word pairs influence metacognitive judgements on the basis of arousal, emotional facial expressions may have a different influence on metacognitive judgements.

Accordingly, there is evidence to suggest that facial expressions may influence participants’ JOLs according to valence. For example, positive expressions are processed more fluently (Leppänen & Hietanen, 2004) and are judged as more familiar (Baudouin, Gilibert, Sansone, & Tiberghien, 2000) than negative expressions. Because JOLs have been shown to increase when processing fluency or familiarity of the stimulus increases (Begg et al., 1989), it may be the case that happy expressions will elicit higher JOLs than angry expressions. Therefore, it is unclear if JOLs will be elevated for emotional expressions compared to neutral expressions in general (i.e., Zimmerman & Kelley, 2010), or if there will also be a difference such that happy expressions lead to higher JOLs than angry expressions.

Additionally, we sought to replicate previous findings demonstrating that happy expressions lead to better identity recognition than angry expressions (D’Argembeau, Van Der Linden, Comblain, & Etienne, 2003; D’Argembeau & Van Der Linden, 2007) by using a slightly different methodology. While previous studies employed single yes/no forced-choice recognition tests, the current study utilised a two-alternative forced-choice recognition test consisting of two neutral faces facing 45 degrees to the left or right. Such a bias-free forced-choice test precludes the possibility that recognition responses reflect differences in response criterion for emotional and neutral faces.

METHOD
Participants
One-hundred and fourteen Colorado State University students enrolled in an introductory psychology course participated in exchange for course credit ($M_{age} = 18.73, SD = 1.27; 75\% \text{ female}; 87\% \text{ right-handed}$).

Materials
Stimuli were chosen from a pool of 60 faces (30 male/30 female) facing directly forward, each displaying one of three expressions (happy, angry, and neutral; also included were neutral faces facing 45 degrees to the left and right for the test portion) taken from the Karolinska Directed Emotional Faces (KDEF) face set (Calvo & Lundqvist, 2008, 2008; Lundqvist, Flykt, & Öhman, 1998). The stimulus set for each participant consisted of 30 faces (15 male, 15 female) divided equally among happy, angry, and neutral
expressions. Stimulus sets were randomly assigned to participants so that emotional expressions for each studied face varied across participants along with study or test foil status and left/right test presentation; the angles of test-face pairs were also randomly presented facing either 45 degrees to the left or right.

Procedure

Participants were told that they would be viewing a series of faces at study and would be asked to identify the emotional expression displayed in preparation for a test of memory. During the encoding phase participants were presented with 30 faces (15 male, 15 female) facing straight forward, divided equally among happy, angry, or neutral expressions. Each studied face was presented in the centre of the screen for 4 s before being replaced by a box asking participants to identify the emotional expression of the face by pressing either “h” for “happy”, “a” for “angry”, or “n” for “neutral”. A second box then appeared asking for a JOL of future identity recognition on a scale of 50–100%. JOLs were self-paced with the next face appearing immediately after the JOL was made.

At test, 30 face-pairs (divided equally among males and females) displaying neutral expressions were presented; 15 male face-pairs and 15 female face-pairs consisted of a studied face and a new foil that randomly appeared on the left or right and also randomly angled to face 45 degrees to the left or right. Participants either pressed “l” in order to designate the left face as “studied” or pressed the “r” in order to designate the right face as “studied”. They then made retrospective confidence judgements on a scale of 50–100% indicating how confident they were that they chose the studied face. After participants made a retrospective confidence judgement, the next face-pair immediately appeared until participants had been tested on all 30 face-pairs.

RESULTS

We first report the accuracy of emotion classification by participants. This was done to ensure that participants were classifying each emotional expression in accordance with the classification of the emotional expression within the KDEF face set (Calvo & Lundqvist, 2008). In addition, we wanted to ensure that participants were attending to the emotional expression in order to minimise the possibility that JOLs were based on other types of cues or irrelevant information such as attractiveness.

Calibration was examined by comparing JOLs and retrospective confidence judgements to recognition memory performance by creating a “measure” factor, common in metacognitive research (Zimmerman & Kelley, 2010). Thus, calibration was examined via a 3 Emotion (happy, angry, neutral) x 2 Measure (JOL/retrospective, recognition) repeated-measures analysis of variance (ANOVA). One-way ANOVAs and paired samples t-tests were then conducted for JOLs, correct recognition, and retrospective confidence judgements. The alpha level was set at .05 for all ANOVAs and a Bonferroni corrected alpha level of .017 was used for all post hoc t-tests.

1 The scale was 50–100 because two-alternative forced-choice testing entails that 50% is equivalent to chance performance.
2 All participants completed two short study/test practice blocks prior to completing the main portion of the experiment. Each study/test practice block consisted of two studied faces facing straight ahead with a happy and neutral emotional expression and two test face pairs at 45 degree angles with neutral expressions utilising the same method outlined above.
3 A second experiment using an implicit encoding condition of gender identification (i.e., Is this person male/female?) was conducted on an additional 114 CSU students (M_age = 18.77, SD = 1.84; 75% female, 91% right-handed). Whether the encoding task was explicit or implicit did not impact the overall patterns found, as no interactions were found. A 2 Condition (implicit, explicit) x 3 Emotion (happy, angry, neutral) mixed-model ANOVA produced no significant interactions for judgements of learning (JOLs); F(2, 225) = 1.56, p = .21, identification rates, F(2, 225) = 0.12, p = .89, or retrospective confidence ratings, F(2, 225) = 1.01, p = .36. This demonstrated that the influence of happy, angry and neutral emotional expressions on JOLs, identity recognition, and retrospective confidence judgements persists even when attention is not explicitly directed at the studied expression within the context of this experiment.
Emotional expression identification

The percentage of agreement between participants’ subjective classification of emotion and the categorised emotion of the KDEF face set was 99% for happy (SD = 0.05), 96% for angry (SD = 0.09) and 97% for neutral (SD = 0.07) expressions. Paired samples $t$-tests indicated that happy expressions were classified more consistently than angry, $t(113) = 3.26, p = .001, d = 0.41$, and neutral, $t(113) = 2.52, p = .013, d = 0.16$, expressions, with no difference between angry and neutral expressions ($p = .22$). Data analyses were conducted based on the classification of emotion provided by the KDEF face set as well as the subjective classification of emotion of participants for all dependent variables. No differences in the pattern of data were evident. Thus, we only report data conditionalised on the emotional expression categorisation of the KDEF face-set.

JOLs and recognition

As is customary with forced-choice testing procedures, our primary measure of memory was the mean percentage of correct recognition. Thus, mean JOLs and the mean percentage of correct responses (see Figure 1) were examined in a 3 Emotion (happy, angry, neutral) $\times$ 2 Measure (JOL, recognition) repeated-measures ANOVA. A main effect of Emotion was evident, $F(2, 112) = 5.43, MSE = 604.92, p = .006, \eta^2_p = .09$, as was an Emotion $\times$ Measure interaction, $F(2, 112) = 30.02, MSE = 96.14, p < .001, \eta^2_p = .35$. Follow-up tests were conducted on JOLs and recognition, separately, in order to explore this interaction. A one-way ANOVA showed that JOLs for happy, angry, and neutral study faces reliably differed, $F(2, 339) = 5.91, p = .003$. In particular, JOLs for happy ($M = 77.77, SD = 8.61$) and angry ($M = 76.75, SD = 8.94$) faces reliably exceeded JOLs for neutral faces ($M = 73.75, SD = 9.92$); happy vs. neutral: $t(113) = 6.07, p < .001, d = 0.43$; angry vs. neutral: $t(113) = 4.12, p < .001, d = 0.32$. JOLs for happy and angry faces did not reliably differ ($p = .10$). Thus, at study, participants believed that happy and angry faces would both lead to better face recognition than neutral faces.

A one-way ANOVA for the percentage of correct recognition responses showed that recognition performance reliably differed across happy, angry, and neutral expressions, $F(2, 339) = 11.63, p < .001$. Paired samples $t$-tests demonstrated that neutral expressions ($M = 78.33, SD = 15.34$) led to significantly better face recognition than happy ($M = 70.44, SD = 16.26$) and angry ($M = 69.86, SD = 16.06$) expressions; neutral vs. happy: $t(113) = 4.52, p < .001, d = 0.50$; neutral vs. angry: $t(113) = 5.37, p < .001, d = 0.60$, while no difference existed between happy and angry expressions ($p = .41$). Thus, predictions and performance were dissociated. That is, while emotional faces, whether happy or angry, were
regarded as more memorable than neutral faces, memory performance was actually superior for neutral faces compared with emotional faces. This suggests that participants were unaware of differences in memorability between neutral faces and emotional faces.

**Confidence ratings**

A 3 Emotion (happy, angry, neutral) × 2 Measure (retrospective confidence ratings, recognition) repeated-measures ANOVA produced a main effect of Emotion, $F(2, 112) = 34.82$, $MSE = 110.42$, $p < .001$, $\eta_p^2 = .22$, and a significant Emotion × Measure interaction, $F(2, 112) = 3.30$, $MSE = 102.80$, $p = .04$, $\eta_p^2 = .06$ (Figure 2). A one-way ANOVA conducted on retrospective confidence judgements for happy, angry, and neutral emotional expressions was significant, $F(2, 339) = 10.68$, $p < .001$. Paired samples $t$-tests on retrospective confidence judgements demonstrated that faces studied with neutral expressions ($M = 77.47$, $SD = 9.72$) received reliably higher retrospective confidence ratings than test faces studied with happy expressions ($M = 72.71$, $SD = 9.33$) or faces studied with angry expressions ($M = 72.58$, $SD = 8.19$); neutral vs. happy: $t(113) = 6.25$, $p < .001$, $d = 0.50$; neutral vs. angry: $t(113) = 7.11$, $p < .001$, $d = 0.54$). No reliable difference emerged between test faces encoded with happy and angry expressions ($p = .83$). Thus, although participants’ retrospective ratings for neutral expressions were higher than both happy and angry expressions, they did not differentiate between happy and angry expressions.

**DISCUSSION**

To our knowledge, the results of the current study are the first to demonstrate that participants regard faces with happy or angry emotional expressions as more memorable than those with neutral expressions. This elevation in JOLs for emotional faces occurred despite the fact that neutral faces led to significantly better subsequent identity (i.e., person) recognition than both happy and angry expressions. These data demonstrate that participants were not able to accurately assess the impact of an emotional expression on memory encoding within the current experimental paradigm.

Koriat’s (1997) cue-utilisation framework offers one potential explanation for why JOLs were sensitive to emotional expression but insensitive to memory differences elicited by emotional compared with neutral expressions. This framework suggests that JOLs reflect inferences based on the cues available rather than direct access to the contents of memory. In contrast, a direct access account (Hart, 1965) would predict that JOLs would be higher for neutral expressions than for happy or angry expressions. That is, if participants were able to directly assess the successful encoding
of facial features crucial to identity recognition during study, JOLs would have been higher for neutral faces relative to happy or angry expressions (i.e., predictions would match memory performance). The higher JOLs given to studied faces displaying angry and happy expressions compared to neutral expressions suggests that participants’ erroneously believed that faces displaying an emotional expression would be more memorable than a face displaying a neutral expression. Thus, participants could not accurately predict their eventual memory performance, a finding that is more compatible with the cue-utilisation framework rather than a direct access framework.

Zimmerman and Kelley (2010) have likewise reported that word pairs of a positive and negative nature increased JOLs relative to neutral word pairs in tasks of free recall and cued-recall. This is despite the fact that only free recall demonstrated a memory advantage for emotional compared to neutral word pairs while cued-recall demonstrated that only positive word pairs performed better than neutral word pairs. They argued that arousal of the emotional stimuli was a more likely cue for JOLs than valence. Indeed, if participants’ JOLs were influenced by valence, positive and negative words should have elicited significantly different JOLs from each other. However, because participants gave higher JOLs to arousing stimuli regardless of positive or negative valence, they concluded it was more likely that participants were using arousal as a basis for their memory predictions. This interpretation also explains the results of the current study where JOLs differed according to emotionality (emotional vs. neutral) rather than valence (positive vs. negative) and would also explain why the possible JOL difference between happy and angry expressions mentioned in the introduction did not occur. Thus, participants may generally consider any manner of emotional stimuli as being more memorable than neutral stimuli because of the emotional experience elicited by an emotional stimulus (Magnusson et al., 2006).

The data from the current study also demonstrated that participants’ calibration between memory predictions and memory performance was better for retrospective confidence judgements than JOLs. That is, they were better at assessing if they had seen a face previously rather than predicting if they would recognise a face in the future. This finding can be attributed to two things. First, as mentioned above, within the cue-utilisation framework of metacognition, participants are often prone to relying on study cues that are not diagnostic of eventual memory performance (e.g., Rhodes & Castel, 2008). Because non-arousing faces led to better identity recognition than arousing faces, the use of arousal in the current experiment was not a proper cue diagnostic of future memory performance. Second, cues used at test such as how familiar a test item is (i.e., how familiar a test face may appear) are often reliable indicators that an item has been in fact previously experienced (Koriat, 1997). Thus, the cues used to assess memory performance are often more diagnostic of actual memory performance than cues used to predict memory performance.

The current study did not find an identity recognition advantage for positive expressions relative to negative expressions as demonstrated in the literature (D’Argembeau et al., 2003; D’Argembeau & Van Der Linden, 2007). There are two possible reasons for the discrepancy. First, mood has been demonstrated to affect memory performance such that participants with a negative emotional state often remember faces presented with a negative expression better than faces presented with a positive expression (Ridout, Astell, Reid, Glen, & O’Carroll, 2003). Thus, it may have been possible that a mood-congruent population bias affected the results such that negative mood-congruent bias for angry faces would eliminate the predicted advantage for happy expressions. This explanation is unlikely as mood-congruent effects on memory for faces have been shown to rely on explicit encoding of the emotional expression (Ridout et al., 2009). When implicit and explicit encoding conditions were directly compared (see Footnote 3) there were no differences in the patterns of data; thus, it is unlikely that mood-congruent effects were present within the context of the current study.
A second, and more likely, reason is that we used a different type of test procedure than previous experiments. Whereas previous studies presented test faces one at a time facing straight forward, the current study presented test faces in pairs facing at a 45 degree angle to the left or right. Angling test faces at a 45 degree angle has been shown to reduce both the speed and accuracy of recognising that a face has been previously presented during study (Bruce, 1982). Thus, it is possible that the advantage for happy expressions relative to angry expressions that have previously been demonstrated may rely on experimental situations that present a better study–test match between experimental conditions than the current experiment provided.

The use of a forced-choice recognition test with all faces facing at a 45 degree angle also makes it difficult to form a definitive conclusion about how emotional expression influences identity recognition. This is because although test faces presented at study with neutral expressions were recognised more often than test faces presented with happy and angry expressions, the neutral condition benefited from a better study–test match than the emotional conditions. That is, whereas the neutral condition only presented a change in viewing angle between study and test, the happy and angry conditions presented a change in viewing angle and emotional expression. Changing both dimensions of angle and expression can lead to poorer recognition performance than changing either dimension individually (Bruce, 1992). Because the current study did not orthogonally manipulate study expression and test presentation angle, it is difficult to draw definitive conclusions about the effect of emotional expression on identity recognition from the current paradigm.

It also should be mentioned that along with the difference in stimuli type (words vs. faces) another notable difference between the current study and Zimmerman and Kelley (2010) was the type of memory task employed. Whereas they employed both free-recall and cued-recall tasks, the current study utilised a two-alternative forced-choice recognition task. Just as recognition of words and faces rely on different underlying mechanisms, recall and recognition have also been shown to rely on different underlying mechanisms (Tulving, 1983). Therefore, memory monitoring of emotional material may depend on the nature of the stimuli (words vs. faces), the valence of the stimuli (positive vs. negative), and the type of memory task employed (recall vs. recognition). Although a pure recall task for unfamiliar faces is difficult, other types of face-recognition testing such as single forced-choice yes/no paradigms may elicit different calibration patterns from participants.

Finally, the results of the current study are also in accord with the emotional memory formation literature where it has been demonstrated that people often assume that emotional information is more memorable than non-emotional information. For example, people often assume that they accurately remember details about their day when “flashbulb” events, such as the 9/11 attacks, occur. In reality, these memories are often no more accurate than other memories for less emotional situations (Talarico & Rubin, 2003). Thus, the current results also extend this faulty assumption to the area of face recognition. That is, people believe emotional facial expressions make people more memorable when in fact they do not.

In sum, the current study demonstrated that participants’ believed that faces studied with happy and angry expressions would be more memorable than faces studied with neutral faces when in fact memory performance was best when faces were studied with neutral expressions. The findings are compatible with a cue-utilisation framework of metacognition, where participants’ predictions may be based on cues that are not diagnostic of future memory performance. These results contribute to the growing literature examining the interaction of cognition and emotion.
REFERENCES


