Neurocognitive Mechanisms of Social Influence on Emotion

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ABSTRACT

Social information can profoundly influence behavior, perceptual and evaluative judgments, and even physiological response to pain. Yet, few studies have looked at its influence on emotion experience, a construct that is inherently social. Here, we describe a study that investigated the effect of others' emotion ratings on self-reported and physiological indices of emotion in response to pleasant and unpleasant pictures. The results indicate that social information can influence subjective emotion experience to pleasant and unpleasant picture stimuli. Social information also modulated the late positive potential component of the event-related potential in response to unpleasant picture stimuli, providing support for a modulated encoding mechanism of social influence on emotion.

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LIST OF SYMBOLS AND ABBREVIATIONS

IET	Interpersonal Emotion Transfer
pMFC	Posterior Medial Frontal Cortex
ERP	Event-Related Potential
mPFC	Medial Prefrontal Cortex
GSR	Galvanic Skin Response
LPP	Late Positive Potential
EEG	Electroencephalography
IAPS	International Affective Picture System
ms	Milliseconds
EOG	Electrooculogram
kΩ	Kiloohm
μV	Microvolt

1. Introduction

Our interactions and relationships with others profoundly influence how we experience, express, and regulate our emotions (Manstead, 2001; Parkinson, 2011). Yet few studies of the emotion process have considered the influence of other people (Fischer & van Kleef, 2010; Manstead, 2005). The limited work on interpersonal emotion transfer (IET) has largely focused on two specific mechanisms, emotional contagion and social appraisal. Emotional contagion is a process by which emotions converge automatically when individuals are together through a direct mirroring or mimicking process (Hatfield, Cacioppo, & Rapson, 1994). Social appraisal, on the other hand, occurs when another person's emotions change how we evaluate the emotional value of a situation (Manstead, 2005). Both processes demonstrate social influence on emotional experience, but research on the specific mechanisms through which emotional contagion occurs remains inconclusive and research on social appraisal is limited (Parkinson, 2011). Social influence research provides one promising avenue for better understanding the general mechanisms that underlie IET. The field of social influence provides an expansive body of literature to inform such research and its simple paradigms provide ideal conditions for investigating the neurocognitive mechanisms that underlie social influence on emotion.

One recent study found that emotion ratings from others strongly influenced participants' subjective ratings of the emotional effects of music excerpts (Egermann, Kopiez, & Altenmuller, 2013). Furthermore, conformist behavior was stronger in social information conditions than in conditions in which the ratings came from a nonsocial source (i.e. computer-produced ratings). Although this study provides initial support for the social conformity of emotion, the findings are limited to the context of music stimuli, and it remains unclear whether the internal affective processes that give rise to subjective experience were influenced. Continued investigation of social influence on emotion from the lens of social conformity will allow for a better understanding of the motives and mechanisms responsible for the influence of social factors on the emotion process. First, the separate literatures on IET and social influence will be reviewed.

1.1 Interpersonal Emotion Transfer

1.1.1 Emotional Contagion

Emotional contagion is theorized to be a two-stage process comprised of behavioral mimicry and facial and postural feedback (Hatfield, Cacioppo, & Rapson, 1994). In the first stage, people automatically mimic the facial and postural behaviors of others. Behavioral mimicry is thought to be an automatic mechanism for blending in with the environment that often occurs outside of conscious awareness (Chartrand & Bargh, 1999). Desire for affiliation increases behavioral mimicry (Lakin, Chartrand, & Arkin, 2008) and the mimicking of negative emotions is specific to behaviors performed by in-group members (Bourgeois & Hess, 2008). Several studies have found that emotional mimicry relies on identifying the emotion being expressed, rather than simply copying its physical configuration (Halberstadt, Winkeilman, Niedenthal, & Dalle, 2009; Tamietto et al., 2010). Halberstadt and colleagues (2009) exposed participants to morphed facial expressions containing equal proportions of happy and angry features but paired with either the label "happy" or "angry." Participants' facial expressions during a second, non-matched viewing corresponded to the emotion label from the first viewing. The researchers concluded that participants responded to their interpretation of—rather than the content of—the facial expression. Tamietto and colleagues (2010) found that participants who were shown emotional posturing responded with facial expressions mimicking the emotion. Taken together, these studies suggest that emotional mimicry is a relatively automatic process for affiliating with others and blending into the environment. Furthermore, this process seems to depend upon identifying the emotion being expressed, rather than just responding to its physical configuration.

In the second stage of the emotional contagion process, individuals internalize the affective state related to the copied behavior through a feedback mechanism (Hatfield et al., 1994). Research on this second stage has produced mixed and inconclusive results (Parkinson, 2011). One of the most famous studies in support of this concept instructed participants to hold a pen with their mouths in such a way that their facial expression resembled a smile in one condition and a frown in the other (Strack, Martin, & Stepper, 1988). Participants in the smile condition subsequently rated cartoons as funnier and more amusing, however the effect size was small and based on liberal statistical criteria. More recent studies have failed to replicate this finding (Andreasson & Dimberg, 2008; Soussignan, 2002).

An alternative account for emotional contagion relies only on witnessing, rather than copying, others' emotional expressions (Neumann & Strack, 2000). Neumann & Strack (2000) argue that perceiving others' emotional expressions directly activates neural action codes that can trigger the associated emotion. For example, observing others' expressions of disgust produces similar brain responses to personally experiencing disgust (Wicker et al., 2003). One potential explanation for this brain response is an associative learning mechanism through which we learn to associate certain emotional expressions with the emotions themselves (Parkinson, 2011).

Whether emotional contagion occurs in the presence or absence of behavioral mimicry, it is a direct response to another person's emotional expression. Social appraisal, on the other hand, requires making a judgment about an emotional stimulus based upon the information gleaned from that social information.

1.1.2 Social Appraisal

Research on social appraisal has sought to improve upon the appraisal theory of emotion by considering the role of the social world in the construction of emotion (Manstead & Fischer, 2001). Manstead and Fischer (2001) suggest that people appraise the way others judge, evaluate, or behave in response to an emotional event and these appraisals influence the way the individual experiences and expresses emotions in response to that event. For example, watching a comedy depicting sexist humor in the presence of a friend who is sensitive to that humor might influence both your internal perception of the movie (e.g. how funny you find it) and how you express your emotions while viewing the film (e.g. how frequently you laugh).

Based on this account, social appraisal is often conceptualized as an inferential process in which people make judgments about the evaluative implications of others' emotions (Hareli & Hess, 2010). However, social appraisal might occur in the absence of such an explicit inferential process. Indeed, one study involving 1-year-olds too young to engage in such a reasoning process found that toddlers were more likely to crawl toward a visual cliff if their mothers were smiling and less likely if their mothers were expressing fear (Sorce, Emde, Campos, & Klinnert, 1985). Although the toddlers made judgments about the emotional value (relative risk) of the visual cliff in response to their mothers' emotional expressions, the judgment occurred outside of an explicit inferential process. More recently, Bayliss, Frischen, Fenske, and Tipper (2007) found that participants' liking of household objects was significantly affected by emotional expressions directed at the objects. None of the participants were able to identify these expressions as affecting their liking of the objects, providing support for an automatic social appraisal process.

Research on both emotional contagion and social appraisal have provided support for the automatic nature of IET. However, the underlying mechanisms responsible for these processes remain unclear. One area of research that might provide valuable insight into potential IET mechanisms is the literature on social influence. Both emotional contagion and social appraisal seem to rely on identifying the emotion being expressed. Once the emotion is identified, it becomes social information that might exert its influence on emotion experience in the same way that social information leads to conformity in other contexts. The existing literature on social influence is reviewed in the following section.

1.2 Social Influence

1.2.1 Motives of Social Conformity

Many underlying motives lead to agreement or disagreement with others. Deutsch and Gerard (1955) were the first to posit a dual-motive scheme that distinguishes between informational influence, which arises from a desire to form accurate perceptions of reality, and normative influence, which arises from the desire to form and maintain relationships with others. The extant literature has upheld the distinction between informational and normative influence (Cialdini & Goldstein, 2004), but the two are interrelated and can be difficult to disentangle (David & Turner, 2001). More recently, many researchers have adopted a tripartite distinction (e.g. Chaiken, Pomerantz, & Giner-Sorolla, 1996; Cialdini & Trost, 1998; Wood, 1999), which identifies goals related to accuracy, goals related to affiliation, and goals related to maintaining a positive self-concept.

The goals outlined above are not mutually exclusive and conformity behaviors often serve all three goals (Cialdini & Goldstein, 2004). Contributions from classic social psychological theory and the field of social cognitive neuroscience have sought to explain the mechanisms by which these goals lead to social influence. Traditionally, social influence researchers assumed informational and normative influences were related to unique mechanisms for generating changes in judgment as well as unique types of change. Specifically, informational influence was thought to instigate deeper processing of the stimulus and result in enduring, private changes in judgment. Normative influence, on the other hand, was believed to lead to less information analysis and to result in only public judgment changes (Wood, 2000). This traditional view has been challenged by the dual-mode processing model of persuasion (Petty & Wegener, 1998), which argues that motives for change are not preferentially related to specific change mechanisms or outcomes (Wood, 2000). Furthermore, recent advances in the literature have suggested that private, enduring changes in judgment are not necessarily the result of deeper processing, but may arise from modulated encoding of the object(s) being judged (Schnuerch & Gibbons, 2014). The various mechanisms by which social influence might be exerted are reviewed in the following sections.

1.2.2 Social Reinforcement Learning and Cognitive Inconsistency

The main theories of social influence's neural bases have arisen from a large body of work that has identified the detection of conflict as a central neurocognitive mechanism of social conformity (for a review see Schnuerch & Gibbons, 2014). One explanation for this conflict detection mechanism is that social conformity is based on social reinforcement learning (Klucharev, Hytçnen, Rijpkema, Smidts, & Fernandez, 2009). Conformist behavior is neurally reinforced through increased reward signaling when a judgment is made in line with the group and through negative error signaling when a judgment is made that conflicts with the group (Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010; Klucharev et al., 2009; Shestakova et al., 2013). Individuals adjust their behavior and act in conformist ways in order to reduce conflict and increase reward (Klucharev et al., 2009). These reinforcement signals likely rely on the posterior medial frontal cortex (pMFC) for the detection of errors (Klucharev et al., 2009) and striatal activity for coding expected reward (Campbell-Meiklejohn et al., 2012).

Social reinforcement learning as proposed by Klucharev and colleagues (2009) relies on the detection of a conflict between individual and group judgment. More recently, Izuma and Adolphs (2013) proposed an alternative account of reinforcement learning that relies on cognitive inconsistency when a judgment deviates from a liked group, as well as when judgment is in line with a disliked group. Izuma and Adolphs found similar pMFC activation under both conditions. Rather than signaling a simple prediction error, the authors suggested this activation reflected a discrepancy between what would have been cognitively consistent and what actually happened (Izuma & Adolphs, 2013).

1.2.3 Modulated Neural Representation of Task-Relevant Stimuli

The mechanisms of social influence discussed previously rely on the notion that conformity arises to avoid deviance from group norms. Another explanation is that social information can actually influence individuals' perception of the world. In his early observations of social conformity in a visual perception task, Asch (1951) suggested that social pressure might actually augment perception. More recently, social cognitive neuroscience has begun to explore Asch's proposition, finding support for modulated encoding of stimuli in the presence of social information.

Berns and colleagues (2004) first demonstrated that perception can be altered by social influence in an fMRI study of conformist behavior during a mental rotation task. Conformity was associated with functional changes in an occipital-parietal network, classically associated with perception. This functional change was especially salient when conformist judgments were made in line with other people rather than a computer. The authors concluded that social information influenced early information processing, rather than simply altering later decision-making processes.

Further support for social influence on early perceptual processes comes from an event-related potential (ERP) study of conformist behavior in a visual perception task (Trautmann-Lengsfield & Hermann, 2013). Decreased amplitude of the early visual P1 component and the later P3 component was observed when participants made a judgment in line with an incorrect group judgment. The early modulation of the ERP, occurring as early as 100 ms after stimulus onset, suggests an effect of social information on early unconscious visual perception and mental representation of task-relevant stimuli.

Social influence on basic encoding has also been demonstrated in the context of evaluative tasks that ask participants to make judgments about their preferences (Mason, Dyer, & Norton, 2009; Zaki, Schirmer, & Mitchell, 2011). Mason and colleagues (2011) found that activity in a brain region associated with the experience of reward—the caudate, a part of the striatum—differentiated socially tagged popular from unpopular symbols. Activity in the medial prefrontal cortex (mPFC), a brain region implicated in thinking about the attitudes and opinions of others, differentiated between symbols that were and were not socially tagged. The authors concluded that the mPFC and caudate likely work in concert to encode socially tagged stimuli. Indeed, previous studies have implicated the mPFC in coding for reward (Amodio & Frith, 2006; McClure, Laibson, Loewenstein, & Cohen, 2004), and the caudate might be particularly involved in representing reward that is socially derived (Sanfey, 2007; King-Casus et al., 2005). These findings suggest an interplay between normative and informational influence on the representation of reward and preference in the brain.

Brain regions associated with encoding subjective value have also been found to be susceptible to social influence (Zaki et al., 2011). When rating the attractiveness of faces for which peer judgments had already been presented, conformist judgments were accompanied with modulated engagement of the nucleus accumbens and orbitofrontal cortex. Zaki and colleagues (2011) concluded that exposure to group norms affected the neural representation of the stimuli's subjective value.

Socially induced memory errors have also been found to arise from modulated neural representations of the memory (Edelson, Sharot, Dolan, & Dadai, 2011). Persistent memory errors were related to greater activity in regions associated with memory encoding and maintenance at the time of exposure to social influence (Edelson et al., 2011). The researchers observed heightened activity in the hippocampal complex that they believe reflected the encoding of new stable representations. This process was mediated by heightened amygdala activity, a region that plays a key role in modulating memory-related hippocampal activity as well as social and emotional processing. Functional connectivity analysis performed by Edelson and colleagues revealed heightened functional connectivity between the left amygdala and bilateral anterior hippocampus. These findings suggest that external social information can change the way memories are represented in the brain, and this process likely involves intercedence from the amygdala.

Peripheral physiology has also provided important insight into social information's potential to influence sensation and perception. Using galvanic skin response (GSR), Koban and Wager (under review) found that physiological response to thermal heat pain was influenced by others' pain ratings. Although neuroimaging studies are necessary to elucidate the underlying mechanisms responsible for the modulated physiological pain response, these findings suggest that even basic sensory processes such as the experience of pain can be modulated by social information.

Taken together, these studies provide support for a theory of social influence that arises from early, unintentional modulation during the encoding process. If this is the case, conformist behavior does not only emerge to decrease the conflict that arises from disagreeing with the group or increase the reward signals associated with making a judgment that is in line with the group, but instead may result from an actual change in the neural representation of the object being judged.

One process by which basic encoding might be affected is through expectancies (Schnuerch & Gibbons, 2014; Koban & Wager, under review). Expectations have been shown to affect early, sensory stages of processing (Pessoa, Kastner, & Ungerleider, 2003; Shuler & Bear, 2006), and appear to mediate the effects of conditioning on pain reports (Kirsch, 2004). However, it is unclear whether early sensory processing, rather than later decision-making processes, was being influenced by expectancies in the case of pain reports. Koban and Wager (under review) addressed this question by measuring expectancies between the presentation of peer pain reports and the onset of pain stimuli. Expectancy effects fully mediated the relationship between social information and physiological pain response, providing support for expectancy as a process through which social information might influence basic encoding.

1.2.4 Summary of Neurocognitive Mechanisms of Social Influence

Social reinforcement learning and cognitive inconsistency arise from an error detection mechanism of social influence (Schnuerch & Gibbons, 2014). In social reinforcement learning, neural error signals indicate deviation from the group and neural reward signals indicate judgment that is in line with the group (Klucharev et al., 2009). Conformist behavior is learned through punishment and reward learning. A cognitive inconsistency account of this process suggests that error detection occurs not only when a judgment is made that deviates from the group, but also when a judgment is made that is in line with a disliked group (Izuma & Adolphs, 2013). Thus, this error detection is the result of cognitive inconsistency that arises when what happens deviates from what would be ideal.

A modulated encoding mechanism of social influence, however, relies on the assumption that social information can actually change the way the object being judged is neurally represented (Berns et al., 2004; Edelson et al., 2011; Mason et al., 2009; Trautmann-Lengsfield & Hermann, 2013; Zaki et al., 2011). Support for a modulated encoding mechanism of social influence does not necessarily stand in competition with other theories of social influence, such as social-reinforcement learning and cognitive inconsistency (Schnuerch & Gibbons, 2014). Certainly, more intentional adjustments of judgments toward group norms can occur in the absence of modulated representations of what is being judged. The mechanisms underlying conformity might work in concert with one another, or might occur separately depending upon the nature of the social information, the object being judged, and the context of the judgment task.

1.3 The Current Study

The aim of the current study is to elucidate the mechanisms underlying social influence on emotion experience. First, we seek to demonstrate the effects of social influence on self-reported emotion ratings in response to pleasant and unpleasant pictures. We hypothesize that self-reported emotion intensity ratings will be higher on trials with social information indicating high emotion intensity ratings from others than trials with social information indicating low emotion intensity ratings from others.

Second, we aim to test a modulated encoding mechanism of social influence on emotion. If the basic encoding of emotional stimuli is affected by the social information, we expect to see changes in the physiological response to emotional stimuli. Specifically, we expect to see an increase in the late positive potential (LPP) component of the ERP on trials with social information indicating high emotion intensity ratings. The LPP is a sensitive measure of the intensity of both negative and positive emotion experience (Hajcak & McNamura 2010). Modulated physiological response to the emotional stimuli would suggest an effect on early information processing, rather than later decision-making processes. Furthermore, we expect this process to be mediated by expectancy effects, based upon previous findings that expectancy mediates the relationship between social information and physiological response to pain (Koban & Wager, under review).

2. Method

2.1 Participants

38 healthy volunteers were recruited from undergraduate psychology classes at William and Mary. Four participants did not complete data collection due to equipment issues or environmental distractors on the day of the study. Five participants were excluded for insufficient artifact-free trials (<8 trials in any condition; Moran, Jendrusina, & Moser, 2013) for electroencephalogram (EEG) analysis. The final sample included 29 participants (20 females; *M* = 19.4 years, *SD* = .89 years). Participants were screened for psychiatric and neurologic conditions prior to participation in the study. All participants provided written informed consent and received partial course credit for their participation. The study was approved by the Institutional Review Board at the College of William and Mary.

2.2 Materials and Procedures

2.2.1 Stimuli. 72 unpleasant and 72 pleasant pictures were taken from the International Affective Picture System (IAPS; Lang, Bradley, &Cuthbert, 2008). Unpleasant pictures were selected based upon normative valence ratings below the 15th percentile, high normative arousal ratings, and for limited duplication of content. Within the negative stimulus set, 24 images were taken from below the 5th, 10th, and 15th percentiles of normative valence ratings, respectively. The 24 pictures with the highest arousal ratings in each interval, without duplicating content from another image in that interval, were included in the stimulus set. Pleasant pictures were selected based upon normative valence ratings above the 85th percentile. Within the pleasant stimulus set, 24 pictures were selected from the 85th, 90th, and 95th percentiles using the same criteria described above for unpleasant stimuli. This procedure resulted in 72 unpleasant pictures with a mean valence rating of 2.45 (*S.D.* = .396) and mean arousal rating of 6.058 (*S.D.* = .553) and 72 pleasant images with a mean valence rating of 7.415 (*S.D.* = .315) and a mean arousal rating of 5.672 (*S.D.* = .655).

The social information stimuli exactly resemble the stimuli used in Koban & Wager (under review). 144 different stimuli were generated (72 $Social_{Low}$ and 72 $Social_{High}$). Each social rating stimulus depicts 10 vertical lines ("others' ratings") on a horizontal line that closely resembles the visual analog scale used for participants' ratings. The $Social_{Low}$ stimuli were sampled from a normal distribution with M = 0.3 (*S.D.* = .015) and the $Social_{High}$ stimuli were sampled from a normal distribution with M = 0.7 (*S.D.* = .015).

2.2.2 Procedure. Experiment protocol closely resembled the procedures used by Koban and Wager (under review). Participants were instructed that we are interested in their subjective experience of emotion while viewing pleasant and unpleasant pictures and how well they are able to predict their own emotional experience based on the reported experiences of others. Participants were instructed that the social information stimuli reflected emotion intensity ratings from 10 previous participants. Participants then performed six blocks of 24 trials each. See Figure 1 for a representation of the sequence of a trial. In each trial, a social information stimulus was presented first for 4500 ms. Participants were then asked to predict their upcoming emotions on a visual analog scale. Following their prediction, a picture was presented for 3,000 ms. Participants were asked to rate their actual experienced emotions on the same visual analog scale immediately after picture presentation. Three of the blocks contained only pleasant pictures and three of the blocks contained only unpleasant pictures. Trial and block order was counterbalanced across participants. The pairing of social information and picture stimuli was randomized, therefore social information was non-predictive of picture valence. For the unpleasant picture blocks, the visual analog scale was explained such that the low (left) side of the scale represented neutral/no emotion and the high (right) side of the scale represented completely negative emotion. For the pleasant picture blocks, the visual analog scale was explained such that the low (left) side of the scale represented neutral/no emotion and the high (right) side of the scale represented completely positive emotion.

2.2.3 Late Positive Potential. In addition to self-reported emotion intensity ratings, the LPP component of the ERP was measured. The LPP is an ERP component that reflects facilitated attention to emotional stimuli. It is a sustained positive deflection that is larger for emotional compared to neutral stimuli (Hajcak & Macnamara, 2010). Emotion regulatory attempts have also been found to reliably reduce the magnitude of the LPP and the degree of the LPP modulation is positively related to reductions in self-reported emotion experience (Hajcak & Nieuwenhuis, 2006).

2.2.4 EEG Recording. Continuous EEG recordings were taken from 62 scalp electrodes based on the 10-20 system (Jasper, 1958), as well as two reference electrodes placed on the left and right mastoids. Horizontal electrooculogram (EOG) was recorded from two facial electrodes placed approximately 1 cm to the left of the left eye and 1 cm to the right of the right eye. Impedances were kept below 15 kΩ.

2.2.5 Data reduction. All data was re-referenced to the average of the two mastoids and band-pass filtered with cutoffs of 0.01 and 30 Hz. EEG epochs were extracted, starting 200 ms prior to picture onset and lasting for a total duration of 1200 ms (baseline correction: -200 to 0 ms). Artifacts were identified using the following criteria: a voltage step of more than 50 μV between sample points and a voltage difference of 200.0 μV within a trial (Foti & Hajacak, 2008). Contaminated epochs were dropped from subsequent analyses. Previous studies have shown that the LPP is typically most pronounced at centro-parietal electrodes (Hajcak & MacNamara, 2010; Moser, Krompinger, Dietz, & Simons, 2009). The LPP was evaluated as the mean amplitude at electrode CPz between 300 and 1000 ms post-stimulus (see Hajcak & Nieuwenhuis, 2006).

2.3 Statistical Analyses

Self-reported emotion ratings were subjected to a 2 (social information: high vs. low) x 2 (picture valence: pleasant vs. unpleasant) x 3 (picture intensity: low, moderate, high) repeated measures ANOVA. Because no main effect of picture intensity was found, it was dropped from all subsequent analyses. Mean LPP amplitude was subjected to a 2 (social information: high v. low) x 2 (picture valence: pleasant v. unpleasant) repeated measures ANOVA. Mediation was tested using a method for testing mediation in within-subject designs developed by Judd, Kenny, & McClelland (2001). First, difference scores were calculated for both expectancy ratings and emotion intensity ratings by subtracting the $Social_{Low}$ scores from the $Social_{High}$ scores. The emotion rating difference score was then regressed onto the expectancy rating sum and difference scores.

3. Results

There were statistically significant main effects of Valence, F (1, 28) = 12.943, p < .01, $\eta_p^2 = .316$, and Social Information, F (1,28) = 52.278, p < .001, $\eta_p^2 = .651$, on self-reported emotion intensity ratings. Figure 2 depicts mean self-reported emotion intensity ratings and indicates that subjective emotion experience was more intense for unpleasant pictures (*M* = 59.375, *S.D.* = 10.813) compared to pleasant pictures (*M* = 52.37, *S.D.* = 6.565), and for $Social_{High}$ trials (*M* = 61.76, S.D. = 7.415) compared to $Social_{Low}$ trials (*M* = 49.984, *S.D.* = 9.408).

Expectancy ratings were not a significant mediator of the relationship between social information and self-reported emotion intensity ratings. Using the within-subjects mediation method described above, we found both the expectancy sum and difference scores to be nonsignificant predictors of the emotion intensity ratings difference score, *p*s > .285.

Analysis of the EEG data revealed a statistically significant main effect of Valence, *F* (1,28) = 6.963, *p* < .05, $\eta_p^2 = .199$, on the mean amplitude of the LPP. There was also a significant Valence x Social Information interaction, *F* (1,28) = 7.167, p < .05, $\eta_p^2 = .204$. Paired sample *t*-tests revealed a statistically significant difference between $Social_{High}$ and $Social_{Low}$conditions for unpleasant pictures only, *t* (28) = 2.441, p = .021., and between pleasant and unpleasant pictures for the $Social_{High}$ condition only, *t* (28) = -3.133, *p* = .004. There was no significant difference between $Social_{High}$ and $Social_{Low}$conditions for pleasant pictures, *t* (28) = -0.270, *p* = .789, or between pleasant and unpleasant pictures in the $Social_{Low}$ condition, *t* (28) = -1.704, *p* = .099. False discovery rate for multiple comparisons was controlled for using Benjamini and Hoschberg's (1995) method. Figure 3 depicts the LPP at electrode CPz for unpleasant pictures only, and depicts greater amplitude for $Social_{High}$ trials compared to $Social_{Low}$ trials. Figure 4 depicts the LPP at electrode CPz for pleasant pictures only, and indicates no difference between $Social_{High}$ and $Social_{Low}$ conditions. Figure 5 depicts the LPP at electrode CPz in the $Social_{High}$ condition only, and depicts greater amplitude for unpleasant pictures compared to pleasant pictures. Figure 6 depicts the LPP at electrode CPz in the $Social_{High}$ condition only, and indicates no difference between pleasant and unpleasant pictures.

4. Discussion

The aims of the current study were 1) to test whether subjective emotion experience is influenced by others' emotion ratings in a simple social influence paradigm, and 2) to test a modulated encoding mechanism of this influence. The results indicate that emotion ratings from others can influence subjective emotion experience in response to pleasant and unpleasant pictures and physiological response to unpleasant pictures. The observed differences in self-reported emotion ratings and electrophysiological response between $Social_{High}$ and $Social_{Low}$ conditions adds to the literature on IET in two key ways. First, these findings establish the feasibility of investigating IET in a simple social influence paradigm. Second, these findings suggest that others' emotions serve as a form of informational influence on subjective emotion experience, leading to modulated encoding of emotional stimuli and conformity of emotion reports.

Most of the existing research on IET involves participants directly observing the emotion expressions of others (Parkinson, 2011). Some hypothesized mechanisms of IET (e.g., behavioral mimicry) even rely on witnessing these expressive behaviors (Hatfield et al., 1994). The current study demonstrates that subjective emotion experience can be influenced by information about others' emotional responses without directly witnessing these responses. The observation of IET in a simple social influence paradigm allows for investigations of its underlying mechanisms from the perspective of a field that has already made strides in neurocognitive research (see Schnuerch and Gibbons, 2014). Since Asch's famous line experiment in 1951, an extensive body of research has sought to explain social influences on human behavior. Developments in social cognitive neuroscience have allowed for investigations into the neurocognitive mechanisms responsible for conformist behavior. Because IET involves the conformity of emotional experience and expression to the emotions of others, it likely results from similar neurocognitive mechanisms as other forms of social conformity.

Research on social influence also offers insight into the potential motives behind IET. The most consistent distinction made in the social influence literature is between normative and informational influence. Normative influence arises from the desire to form and maintain relationships with others, whereas informational influence arises from the desire to form accurate perceptions of reality (Deutsch & Gerard, 1955). Because participants in the current study made their emotion ratings in private, the observed conformist behavior was likely not the result of a desire to form or maintain relationships with others. Instead, others' emotion ratings likely served as sources of information that participants used to help them make accurate judgments about the emotional value of the pictures. Indeed, previous research on social comparison suggests that the emotional responses of others are used to evaluate the intensity, nature, or appropriateness of one's emotional state (Schacter, 1959).

The second goal of the current study was to test a modulated encoding mechanism of social influence on emotion. If others' emotion ratings influenced the encoding of the pictures' emotional value, we expected to see increased LPP activity during picture viewing for $Social_{High}$ trials compared to $Social_{Low}$ trials. We found the hypothesized pattern of LPP activity for unpleasant pictures only, suggesting a modulated encoding mechanism of social influence on emotion in response to unpleasant picture stimuli. However, this pattern did not hold for pleasant picture stimuli.

Previous studies have demonstrated that attempts to decrease negative emotions can reliably reduce the magnitude of the LPP, and attempts to increase negative emotions can reliably increase the magnitude of the LPP (Hajcak & Nieuwenhuis, 2006; Moser, Most, & Simon, 2010). However, only attempts to decrease positive emotions have been shown to modulate the LPP (Krompinger, Moser, & Simons, 2008). Krompinger and colleagues found that attempts to increase positive emotion in response to pleasant picture stimuli were unsuccessful in modulating the magnitude of the LPP. In light of this, one explanation for the Valence x Social Information interaction observed in the current study is that the effect of social influence on emotion was driven by $Social_{High}$ trials. Because an increase in subjective positive emotion in response to pleasant picture stimuli is not necessarily associated with an increased LPP, whereas an increase in subjective negative emotion in response to unpleasant picture stimuli is associated with an increased LPP, we would expect to see the observed pattern of results if others' high emotion intensity ratings upregulated participants' emotional responses. Further support for this explanation is the statistically significant difference in LPP magnitude between pleasant and unpleasant pictures in the $Social_{High}$ condition only. This suggests that the $Social_{High}$ stimuli enhanced the LPP in response to unpleasant pictures, driving the LPP difference between unpleasant and pleasant pictures. Future studies should include a control condition in which no social information is presented to test this explanation. If $Social_{High}$ trials are indeed driving the results, there should be little or no difference between the $Social_{Low}$ and control conditions.

An alternative explanation is that a modulated encoding mechanism of social influence on emotion is indeed selective for negative emotions. If this is the case, future studies should seek to replicate the current findings using alternative measures of modulated encoding. Because the LPP is not necessarily responsive to the upregulation of positive emotions in response to pleasant picture stimuli, fMRI could provide an alternative measure of whether social information is modulating brain activity in response to pleasant stimuli. In addition to more rigorous tests of a modulated encoding mechanism of social influence on positive emotions, future research should investigate other neurocognitive mechanisms that could explain the observed relationship between others' emotion ratings and subjective emotion experience in response to pleasant picture stimuli. Our next step will be to test whether a social reinforcement learning mechanism can explain the observed relationship. Social reinforcement learning would affect the decision-making component of making an emotion rating, rather than the encoding of the emotional stimuli. This could explain the observed differences in the subjective ratings of, but not electrocortical response to, pleasant pictures.

A secondary finding of the current study was a main effect of picture valence on both self-reported emotion intensity ratings and LPP amplitude. Unpleasant pictures elicited higher self-reported emotion intensity ratings and increased LPP amplitudes compared to pleasant pictures. Although the LPP is responsive to both negative and positive emotions, it is also influenced by arousal (Hajcak & Macnamara, 2010). The mean normative arousal rating of our unpleasant stimuli set (M = 6.034, S.D. = .582) was significantly higher than the mean normative arousal rating of our pleasant stimuli set (M = 5.6596, S.D. = .658), $t\,(141) = 3.604$, $p < .001$. Due to the normative valence and arousal ratings of the IAPs stimuli set, this is an expected artifact of our selection procedure. The difference in arousal between our pleasant and unpleasant pictures likely explains the observed differences in emotion ratings and LPP magnitude.

Although the findings from the current study extend our understanding of how social information influences emotion experience, several important limitations should be considered. First, two important dimensions of emotion, arousal and valence, were collapsed into one measure of “emotion intensity” to increase participants’ understanding of the task. Future studies should distinguish between these separate dimensions both in the social information presented to participants and in the subjective emotion ratings obtained from participants in order to better understand which dimension of emotion experience is affected. The nature of the social information in the current study was also limited to emotion ratings said to come from ten other participants. Future studies should test whether emotion experience can be altered by just one other person's emotion rating, as research on IET typically involves participants' emotional response to one other person. The relationship of the "others" should also be manipulated to investigate whether in-group membership is necessary for influence to occur. Finally, the sample used in the current study was limited to mostly White, mostly female undergraduate students. Future studies should seek to extend these findings to more diverse populations.

Taken together, the findings from the current study suggest that social influence on subjective emotion experience does not rely on witnessing others' emotional responses, and its underlying mechanisms can be tested in a simple social influence paradigm. Thus, recent developments in neurocognitive research on social influence should inform future investigations of the neural mechanisms that underlie IET. The current study also provides support for a modulated encoding mechanism of social influence on emotion in response to unpleasant picture stimuli. Information about others' emotional responses to unpleasant stimuli influenced the encoding of unpleasant pictures, resulting in subjective and physiological changes in emotion experience. This result was likely driven by an increase in negative emotions in response to emotion ratings from others indicating high emotion intensity.

Elucidating the mechanisms that underlie social influence on emotion has important implications for our understanding of the emotion generative process in a social context. Emotion experience and expression frequently occur in social settings and a growing body of literature has begun to direct attention to the need to consider influences of other people in research on emotion (Fischer & van

Kleef, 2010; Manstead, 2005). In addition to influencing the emotion generative process, other people can impact emotion regulatory processes. Research on interpersonal emotion regulation has only recently been organized into a conceptual framework (see Zaki & Williams, 2013), and investigations of the mechanisms underlying specific interpersonal regulatory strategies are limited. Many forms of interpersonal emotion regulation, such as coregulation and sharing of affective states (Zaki & Williams, 2013) rely on or result in IET, making investigations into the neurocognitive mechanisms that underlie IET particularly useful in understanding the neural basis of interpersonal emotion regulation.

Although we discuss the benefits of investigating interpersonal emotion regulation and IET from the lens of social influence research, we do not suggest that these methods should replace the existing approaches of emotional contagion, social appraisal, and interpersonal emotion regulation researchers. Social influence paradigms offer unique opportunities to study the neurocognitive mechanisms that underlie general forms of IET, however distinct mechanisms might also underlie specific forms of IET such as emotional contagion and social appraisal.

5. Conclusion

The results of the current study suggest that subjective emotion experience can be influenced by others' emotion ratings. Social information also modulated the magnitude of the LPP in response to unpleasant pictures, providing support for a modulated encoding mechanism of social influence on emotion. These findings suggest that directly observing others' emotion expression is not necessary for IET to occur. This affords investigations of IET from the perspective of social influence research. The field of social influence provides an expansive literature to inform research on IET, and its simple paradigms are ideal for employing neurocognitive methods to elucidate the mechanisms that underlie IET.

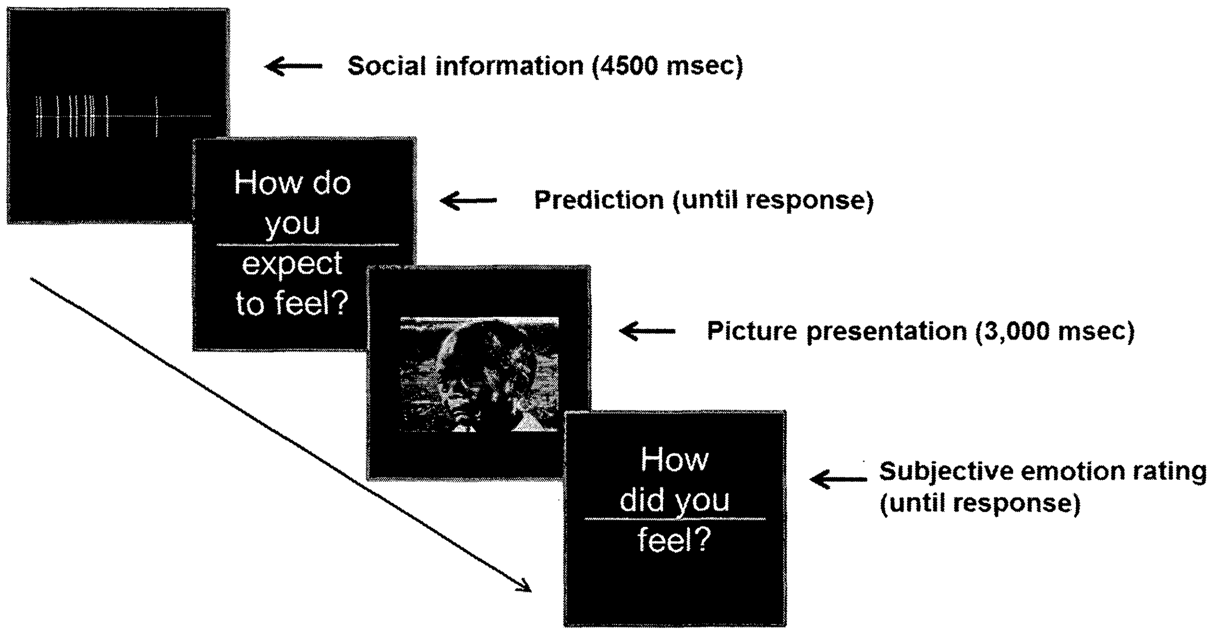

Figure 1. Illustration of the sequence a trial.

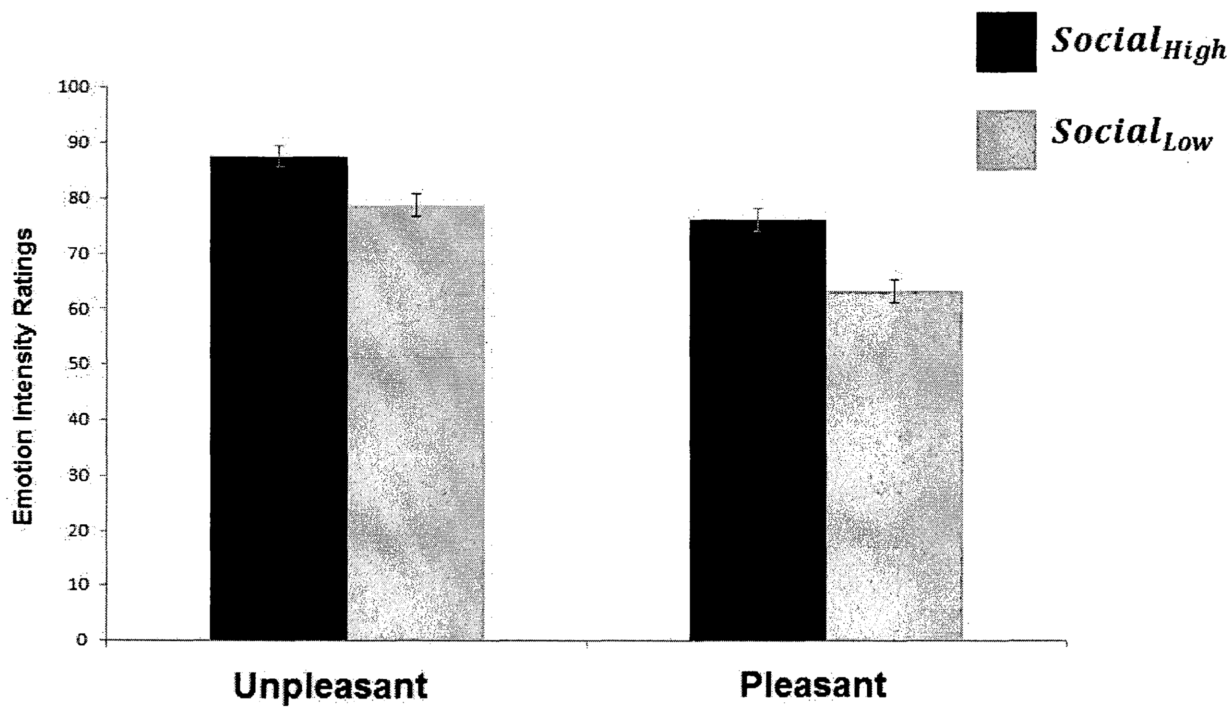

Figure 2. Mean self-reported emotion intensity ratings as a function of Valence and Social Information. Unpleasant pictures resulted in higher emotion intensity ratings than unpleasant pictures. $Social_{High}$ trials resulted in higher emotion intensity ratings than $Social_{Low}$ trials. Note that error bars are standard error.

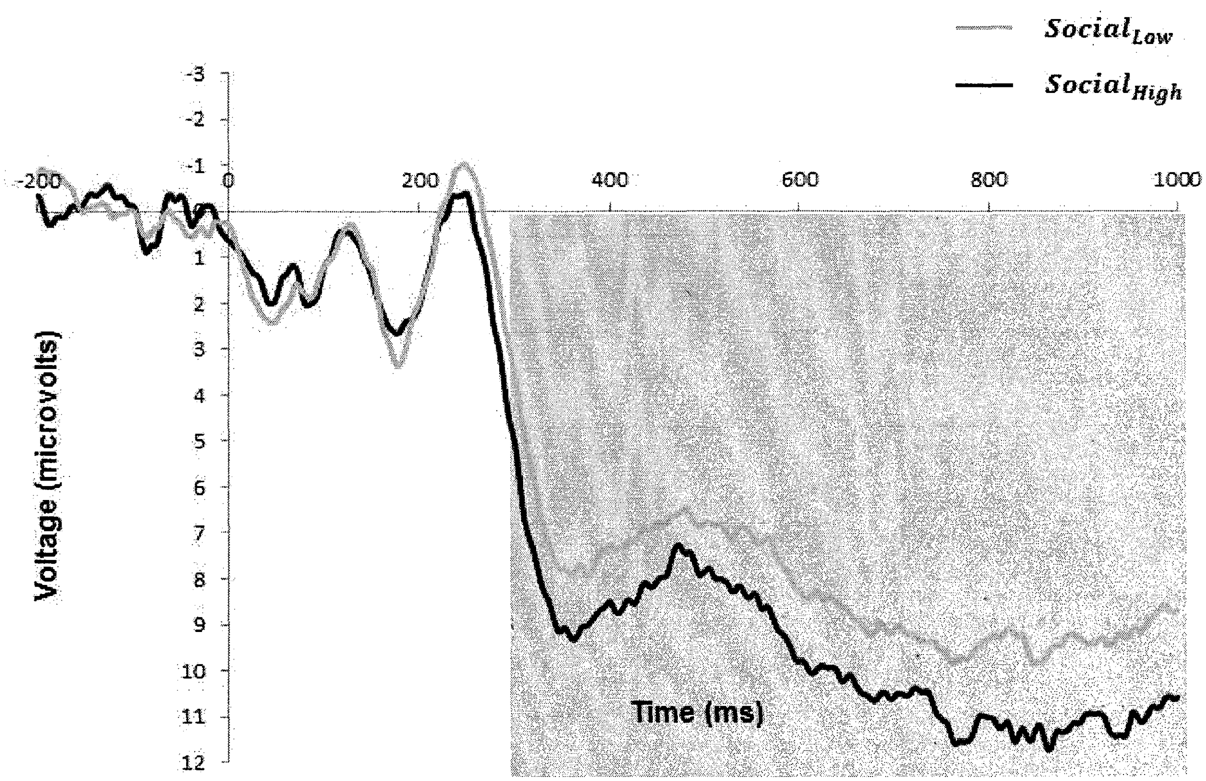

Figure 3. Mean late positive potential (LPP) amplitude measured at CPz as a function of social information for unpleasant pictures. The LPP is reliably enhanced in response to unpleasant pictures for $Social_{High}$, trials compared to $Social_{Low}$ trials.

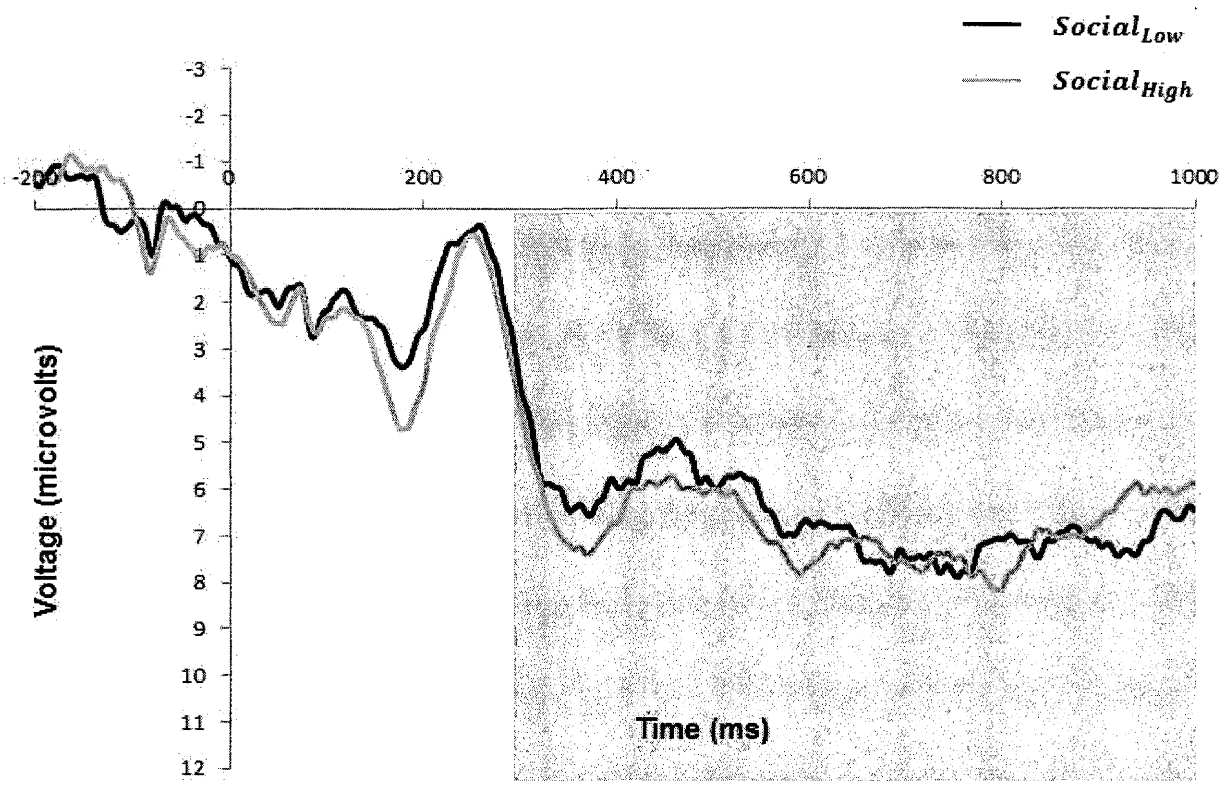

Figure 4. Mean late positive potential (LPP) amplitude measured at CPz as a function of social information for pleasant pictures. There is no significant difference in LPP amplitude between $Social_{High}$ and $Social_{Low}$ conditions.

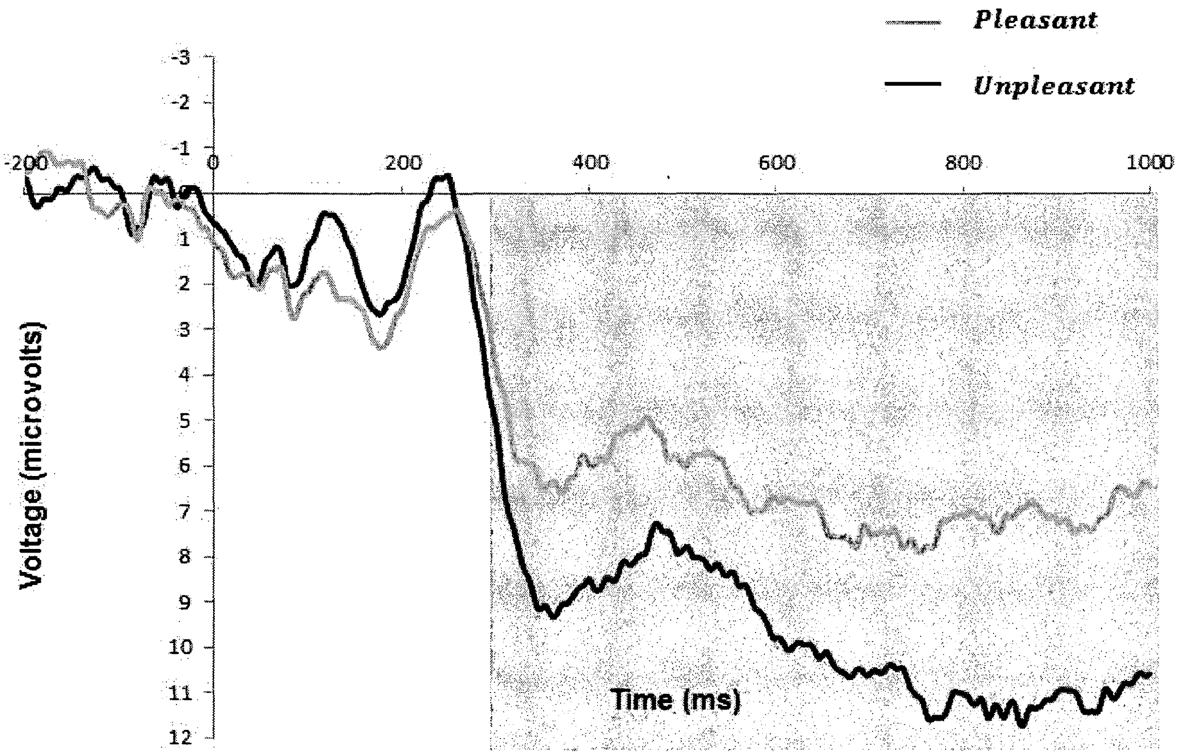

Figure 5. Mean late positive potential (LPP) amplitude measured at CPz as a function of picture valence for the $Social_{High}$ condition. The LPP is reliably enhanced in response to unpleasant pictures in the $Social_{High}$ condition only.

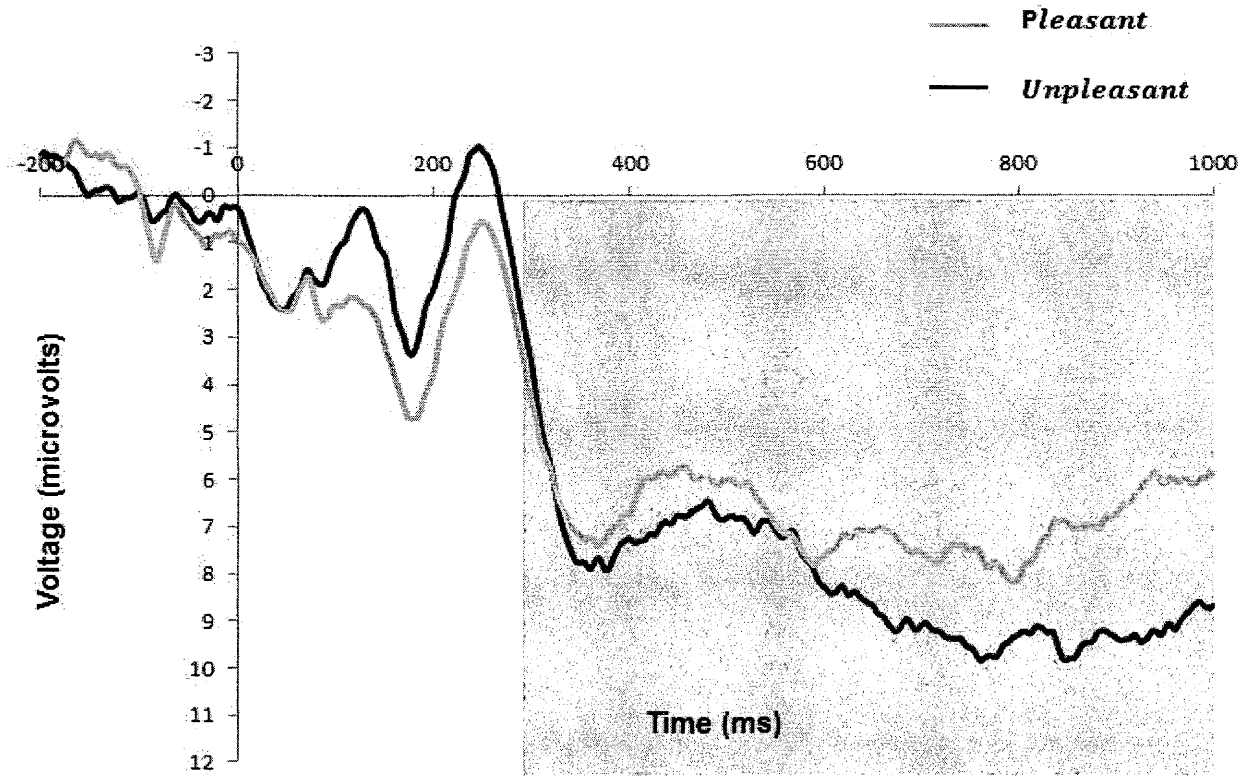

Figure 6. Mean late positive potential (LPP) amplitude measured at CPz as a function of picture valence for the $Social_{Low}$ condition. There is no significant difference in LPP amplitude between pleasant and unpleasant pictures in the $Social_{Low}$ condition.

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