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Implicit Conditioning of Faces via the Social Regulation of Emotion: ERP Evidence of Early
Attentional Biases for Security Conditioned Faces

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Abstract

Not much is known about the neural and psychological processes that promote the initial conditions necessary for positive social bonding. This study explores one method of conditioned bonding utilizing dynamics related to the social regulation of emotion and attachment theory. This form of conditioning involves repeated presentations of negative stimuli followed by images of warm, smiling faces. Beckes and colleagues (2010) found that this conditioning procedure results in positive associations with the faces measured via a lexical decision task, suggesting they are perceived as comforting. This study found that the P1 ERP was similarly modified by this conditioning procedure and the P1 amplitude predicted lexical decision times to insecure words primed by the faces. The findings have implications for understanding how the brain detects supportive people, the flexibility and modifiability of early ERP components, and social bonding more broadly.

Implicit Conditioning of Faces via the Social Regulation of Emotion: ERP Evidence of Early Attentional Biases for Security Conditioned Faces

Social connectedness is now recognized as crucial to human health and well-being (e.g., Baumeister & Leary, 1995; Uchino, Cacioppo, & Kiecolt-Glaser, 1996; House, Landis, & Umberson, 1988; Holt-Lunstad, Smith, & Layton, 2010). One pathway through which social relationships are thought to benefit health is through the regulation of emotional responses to stressful events (e.g., Beckes & Coan, 2011; Bowlby, 1969/1982; Coan, 2008, 2010; Hofer, 1995, 2006; Mikulincer & Shaver, 2003; Cohen & Wills, 1985). Bowlby's (1969/1982) seminal attachment theory was the first to propose that a vital role of "secure" attachment relationships was to regulate negative emotion. Secure attachments emerge out of relationships that provide a sense of "felt security" (Sroufe & Waters, 1977), which grows when the relationship partner is available and responsive to the distress of the other (Mikulincer & Shaver, 2003); relieving distress and regulating negative emotion. According to social baseline theory (SBT; Coan, 2010; Beckes & Coan, 2011) social relationships are perceived as *resources* that offset the risks and efforts associated with daily life. But the effectiveness of a social resource is contingent upon its reliability, raising the question of how that reliability is assessed. The answer rests on social experience.

According to SBT, people reflexively use any available information to predict the likelihood that another person will be a reliable resource. In general, reliable, familiar, and predictable social resources are the most valuable in times of need. If an individual has been both needed and responsive in the past—even the very recent past—then it is wise to affiliate more with that individual. This experiment examines the role of non-verbal signals of responsiveness in the presence of potential threats. Specifically it extends previous research by

Beckes, Simpson, and Erickson (2010) by exploring the neural timing of conditioned learning related to the social regulation of emotion, and the degree to which these processes promote approach relevant attentional biases in early social perception.

Social Regulatory Conditioning

Beckes and colleagues (2010) hypothesized that the experimental combination of threat and responsiveness would foster felt security in their participants. Specifically they tested whether people would be more likely to develop positive, attachment-related associations with the faces of people who display genuine smiles *if* those faces have been implicitly paired with distressing stimuli (e.g., snake or mutilation photos). Results from these studies indicated that smiling faces paired with negative stimuli did indeed decrease lexical decision response times for security related words (e.g., “belong”) while increasing lexical decision response times to insecurity related words (e.g., “betray”). Importantly, the learning process did not have this effect when neutral, unresponsive faces were used. Thus, responsive (smiling) faces preceded by potential threats promote implicit associations between those responsive faces and security constructs.

The hypothesis that this sequence of events could lead to secure associations emerged out of an integration of neurobiological models of attachment and contemporary adult attachment theory. According to Mikulincer and Shaver (2003) attachment security should emerge through repeated iterations of a sequence of threat, followed by support seeking, followed by responsiveness from a supportive other. This theoretical sequence has much in common with basic animal models of attachment behavior. For example, Nelson and Panksepp (1998) argue that social bonding is supported by two basic affective/motivational neural subsystems that form a larger integrated social emotion system. The first subsystem, governing separation distress, is

involved in support seeking motivation. Evidence for the neural mechanisms involved in separation distress come from animal studies using electrical stimulation of the brain. Stimulation of a circuit including regions of the dorsomedial thalamus, ventral septal area, preoptic area, basal nucleus of the stria terminalis, anterior cingulate cortex, amygdala and hypothalamus increases distress calls in mammals (see Nelson & Panksepp, 1998). Further these regions appear to be down regulated by endogenous opioids and oxytocin (see Panksepp, Siviy, & Normansell, 1985), which separately are critical components of what Panksepp and Nelson term a social reward subsystem.

Importantly, neuro-chemicals involved in the stress response such as corticotrophin releasing hormone (see Panksepp et al., 1985) increase activity in the separation distress circuit and promote distress vocalizations in most social species. Alternatively, opioids and oxytocin are not only associated with down-regulation of separation distress, but they tend to be released via social stimuli such as soft touch (e.g., Blass & Fitzgerald, 1988). Taken together, these literatures and theoretical traditions both seem to argue that stressors can produce a motivation to seek support, and if that support is given in appropriate ways (e.g., soft physical touch, responsiveness) it diminishes the stress response, and conditions an association between the supporter and feelings of security and comfort.

This begs the question, what is meant by responsiveness? Why does a smiling face signal responsiveness? Responsiveness is an admittedly vague and broad concept, which makes it difficult to operationalize in a specific and grounded manner. Despite this Reis, Clark, and Holmes (2004) note that perceived responsiveness is an important organizing construct in the relationship domain and therefore may be thought of a part and parcel of myriad operationalizations of interaction quality within dyads. For example, they suggest that measures

of verbal and nonverbal behaviors in interactions, behavioral mimicry, perceived validation, and several other measures frequently capture aspects of responsiveness. We take a more explicitly behavioral approach in this research using concrete non-verbal cues such as direct eye-gaze and Duchenne smiles as an alternate construct for responsiveness. The degree to which this can be termed responsiveness per se is debatable, however, such non-verbal behavior is likely foundational to the perception that another is being responsive. Moreover, there is now considerable evidence that facial expressions, eye contact, physical touch, and similar behaviors have powerful effects on emotional and physiological systems of social mammals (e.g., Harlow, 1958; Hofer, 2006; Whalen, Rauch, Etcoff, McInerney, Lee, & Jenike, 1998), a phenomenon which Hofer termed “*hidden regulators*”. More specifically, Whalen and colleagues (1998) note that even at an implicit level, masked happy faces appear to signal safety. Thus, although warm, smiling faces may not embody responsiveness, they are an excellent behavioral operationalization of the social signal of safety, the primary signal of interest, in that they are acutely observable, controllable, and easily replicable.

In practice this conditioning method is most similar to that employed by Olson and Fazio (e.g., 2001), which they have dubbed *evaluative conditioning*. This approach usually takes conditioned stimuli such as faces and repeatedly pairs them with negative, neutral, or positive unconditioned stimuli in order to transfer the valence of the unconditioned stimuli onto the conditioned stimuli. This procedure follows the traditional classical conditioning sequence in which the conditioned stimuli are presented prior to (or alternatively simultaneously with) the unconditioned stimuli. This sequence leads the learner to associate the conditioned stimuli with the subsequent presentation of the unconditioned stimuli, as if it were a signal of the positive or negative stimulus that is about to be presented. Our method flips the event sequence such that the

conditioned stimuli (faces) always follow the unconditioned stimuli (negative or neutral images). In this sense, the faces become cues that the unconditioned stimulus is being removed. In this way the faces become negatively reinforced (in a novel classical manner) if presented after the negative stimulus, and signal a return to baseline safety. As found by Beckes and colleagues (2010), however, the face appears to require signals of safety to function as a negative reinforcer. It is possible that the unconditioned properties of warm, smiling faces are necessary for this type of negative reinforcement to take hold and truly neutral objects cannot be conditioned in this manner.

Early Stage Social Perception and the Social Regulation of Emotion

Social baseline theory argues that early stage or “bottom-up” perceptual processes make important contributions to the social regulation of emotion (Beckes & Coan, 2011). If true, it is likely that cues indicating the reliability, familiarity, and predictability of individuals are encoded in early perceptual circuits, and that the social regulatory conditioning identified by Beckes et al. should be evident in early perception. Indeed, signs from others of warmth and safety have their greatest signal value when one is in dire straits. If another person reliably and predictably shows up for a poker game or night out for fun this type of information bears far less predictive value than if they respond appropriately during times of duress or when asked for help. Thus, helping when the chips are down defines what it means to be reliable and predictable social resource for the purposes of affect regulation. This is intimately related to what Simpson (2007) terms *trust diagnostic situations*. According to Simpson, people often look to “strain-tests” to determine the trustworthiness of a given relationship partner. Strain-tests refer to situations in which the other person has power to benefit the individual, but could choose to not help. Thus, one critical factor in learning a sense of security with another person is having them be reliably helpful or calming

in challenging situations. But why should this manifest in early perception? This hypothesis emerges out of continued findings that typical top-down regulatory mechanisms (e.g., the ventromedial prefrontal cortex) do not appear to be acting to down regulate threat response during social contact (e.g., Coan, Scharfer, & Davidson, 2006; Coan, Beckes, & Allen, in press), despite repeated findings that social contact does diminish threat responding. Thus, social baseline theory has argued that the diminished threat experienced under social contact may be due to bottom up perceptual processes changing the perception of the motivational landscape (Beckes & Coan, 2011). In effect the perceptual characteristics get automatically linked to a sense of safety and security in memory, increasing motivated approach, and diminishing vigilance and anxiety over potential environmental threats.

Event related potentials (ERPs) provide an ideal method for determining the timing of such processes. ERP captures electrical potentials on the scalp. In face perception, these potentials usually include an early positive going potential over posterior electrodes that peaks shortly after 100ms, commonly referred to as the P1 component (Cunningham, VanBavel, Arbuckle, Packer, & Waggoner, 2012), and an early negative going potential over posterior regions usually peaking around 170 ms, called the N170 component (Ito & Bartholow, 2009).

A growing body of research suggests that social categorization processes are visible in these early components (Ito & Bartholow, 2009). For example, the N170 component has been shown to be larger in amplitude to other race faces (Walker, Silvert, Hewstone, & Nobre, 2008; Hermann, Schreppel, Jager, Koehler, Ehli, & Fallgatter, 2007; Stahl, Wiese, & Schweinberger, 2008; Ito & Urland, 2005) and to novel rather than familiar faces (Jaques & Rossion, 2006). More recently, Cunningham and colleagues (2012) found evidence for smaller P1 and larger N170 amplitudes to other race faces. Intriguingly, the N170 components in this study appeared to

be a function of the P1 difference—with N170 effects disappearing after statistically adjusting for the P1. Further, these differences were attenuated when participants were in an approach motivational frame, suggesting that the P1 component is sensitive to motivational states. This implies that the P1 component is tapping attentional biases toward approach relevant social stimuli and could be used to gauge the degree to which faces are perceived as approach relevant, ingroup stimuli relative to other faces.

The Current Experiment

This experiment was designed to test whether social regulatory conditioning (Beckes et al., 2010) would result in larger P1 amplitudes to smiling faces that had been previously paired with threatening-negative stimuli (i.e., striking snakes) relative to faces previously paired with neutral stimuli (i.e., rolling pins). We focused on the P1 effect because it appears to tap into motivational components of ingroup perception, whereas the N170 appears to be more sensitive to task features that modify structural encoding (Senholzi & Ito, 2012). The procedure involved a learning phase in which a set of two faces displaying genuine Duchenne smiles (Freitas-Magalhaes & Castro, 2009) was repeatedly preceded by a negative stimulus and another set of faces was preceded by a neutral stimulus. The “test” phase of the experiment involved measuring ERP components to the face stimuli and response times (RTs) to words primed by the face stimuli. We predicted (1) that when primed by snake-paired faces (relative to rolling pin-paired faces), RTs to secure words would decrease while RTs to insecure words would increase; (2) that snake-paired faces would result in larger P1 amplitudes relative to rolling pin-paired faces; and (3) that condition differences in lexical decision times would be correlated with condition differences in P1 amplitude. We used a 2 x 2 within-subjects design for the lexical decision task, including conditioning of face prime (snake- vs. rolling pin-paired) and attachment valence

(secure vs. insecure). For ERP measurements, we used a 2 x 2 within-subjects design, including conditioning of face stimulus (snake- vs. rolling pin-paired) and electrode site hemisphere (left vs. right)¹.

Method

Participants

Forty-six undergraduate students (16 men, 30 women) participated in exchange for course credit. They ranged in age from 16 to 23 ($M = 19.1$). Self-identified racial background indicated the sample consisted of 3 African American, 5 Asian, 1 Hispanic, 32 white, 4 “other race” and 1 mixed race participants. One subject was dropped due to technical problems during data collection.

Stimulus Materials

Face photos were originally selected from the NIMSTIM database (Tottenham, Borscheid, Ellertsen, Marcus, & Nelson, 2002) and included face shots of individuals with forward facing eyes and Duchenne smiles. Images were displayed in color with a resolution of 253 x 325 dpi. The images were separated into two sets counterbalanced on likability, warmth, and attractiveness (see Beckes et al., 2010). Each set included one image of a woman and one image of a man (01F, 07F, 28M, and 34M).

Images used as unconditioned stimuli included a negative US (a striking snake, IAPS slide 1050) and a neutral US (a rolling pin IAPS slide 7000), and were originally selected from the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 2005). A scrambled image of nature scenes was used as a mask stimulus. Each image was 512 x 384 dpi.

Stimulus words were presented in white font on a black background in order to minimize blink artifacts, and were composed of 5 different categories of words. The categories included

secure words, insecure words, sexual desire words (e.g., desire, lust), disgust words (e.g., decay, disease), and neutral words (e.g., tissue, foot). Each category included ten words equated on word length, and frequency in written language (Kucera & Francis, 1967), taken from the Affective Norms for English Words list (Bradley & Lang, 1999). In addition, 50 non-words were used as distracters, and were similar in length to the real words. Secure words included the following: *tender, warmth, secure, calm, sensitive, affection, belong, comfort, trust, nurture*. Insecure words included the following: *insecure, neglect, fear, hurt, distress, avoid, betray, rejection, lonely, anxiety*.

Procedure

Participants completed informed consent and self-report measures including demographic measures of race, age, and gender. Upon completion of consent, and prior to filling out self-reports, 32-electrodes were affixed to their face and scalp. Upon finishing self-reports and testing the electroencephalographic (EEG) signal, the participants were given instructions on the learning phase.

The *learning phase* (see Fig. 1) involved watching a series of images flash upon the screen and at the end of each trial indicating whether they saw a star (by pressing the “n” key) or a box (by pressing the “b” key). The monitor refresh rate was set at 75 Hz. Each trial lasted a total of 11 seconds and contained a fixation point displayed for 2 seconds, a brief 14ms implicit presentation of a snake or rolling pin (unconditioned stimuli; US), a mask image presented for 186ms to prevent explicit identification of the US, a blank screen for 800ms, a smiling face for 3 seconds, followed by a 14ms presentation of a white box or triangle, in that order. A blank screen filled in the inter-trial interval for the remainder of the 11 seconds. We used a black background for each image in both the learning and test phases to prevent blink artifacts. The sequence of

US-face presentation was such that the snake always preceded one set of face photos and the rolling pin always preceded the other set of face photos. This combination was switched via random assignment across participants so that some participants always had the snake paired with set 1 and the rolling pin paired with set 2 and vice versa for participants assigned to the other group. Each US-face pairing occurred 20 times in the learning phase for 80 total trials. Upon finishing the learning phase participants were given instructions on the test phase.

The *test phase* (see Fig. 1) required participants to make a lexical decision (word vs. non-word) by pressing the appropriate key (“b” and “n” respectively) as quickly as they could while still being accurate. Each word was primed by each of the faces in random order. In addition, 20 trials for each face (80 trials total) were collected without a lexical decision in order to get clean ERP measurement of the face stimuli both with and without words being presented immediately afterward. This phase included several trials with a fixation point presented for 250ms, a face presented for 250ms, a word/non-word presented until response, and a 1 second inter-trial interval. This led to 20 lexical decisions for each face condition/word category combination and 240 individual ERP epochs for each face condition or a total of 480 per subject.

Upon finishing the test phase participants were screened using a funneled debrief in which they are asked a) to recall all stimulus they saw, b) to guess any stimuli that may have been presented but that they did not consciously recognize or see, and c) to choose from set of forced choice options what stimuli they might have seen. Five participants either recalled or guessed without the forced-choice options that they saw the snake. Given that the implicit nature of the learning procedure is important, these subjects were removed from further analysis in order to make sure all learning was implicit in nature and to avoid potential confounds associated with explicit inference and participants guessing study hypotheses.

Physiological Data Collection and Reduction

ERP recordings were collected from 32 scalp electrodes using a Biosemi ActiveTwo EEG system. The 32 electrode headcap conformed to international 10/20 standards, and we measured activity from all electrode sites (Fp1, Fp2, AF3, AF4, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, CZ, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, PO3, PO4, O1, Oz, and O2). ActiveTwo is a battery powered system that uses two electrodes called “Common Mode Sense” and “Driven Right Leg” electrodes as a ground. The electrodes form a feedback loop which functions to place the subject’s average potential as close to amplifier zero as possible. The EEG system sampled the signal at 1024 Hz which were decimated to 256 HZ using Biosemi’s Decimater and processed in EEGLab (Delorme & Makeig, 2004) and ERPlab (Marley, Luck, & Lopez-Calderon, 2011). Data were filtered offline with a high-pass filter of .2 Hz and a low-pass filter of 19.8 Hz. An average reference was derived off-line by subtracting from each electrode site the average activity of all electrode sites. Electrodes placed at approximately 20% of the nasion–inion distance directly below FP1 and FP2, were used to monitor eye movements and blink artifacts. Epoch’s were defined as the window from 200ms pre- to 800ms post-stimulus presentation. Artifact detection was carried out using ERPlab’s moving window peak-to-peak artifact detection function using a voltage threshold of 80 μ v. Visual inspection was used to verify the effectiveness of this detection method. Data were corrected to the mean voltage of the pre-stimulus interval. Three participants failed to have at least 30 accepted trials for each face stimulus, and were thus removed from analysis.

Results

Response Time Results

Accuracy rates during the lexical decision task were excellent with mean hit rates over 96%. Incorrect trials were dropped from analysis, and trials with RTs more than 1500 ms (~ 3 standard deviations from the mean) were also dropped. It should also be noted that a log transformation on the RT data resulted in the same results (only small changes in summary statistics with no impact on interpretation), so all effects reported are on untransformed data. To test the effects of conditioning on response time, we conducted a repeated measures ANOVA with conditioning (snake-paired vs. rolling pin-paired faces), valence (secure vs. insecure), and word type (attachment vs. non-attachment) as the primary independent variables and gender as a between subjects effect. Results indicated a significant effect of conditioning $F(1, 38) = 7.3, p = .03$, partial $\eta^2 = .16$, indicating slower response times to words primed by snake-paired faces. There was an additional main effect of valence, $F(1, 38) = 7.8, p = .008$, partial $\eta^2 = .17$, indicating slower responses to negative words relative to positive words. No other significant effects emerged, all other p 's $> .2$.

To further interrogate these effects we conducted additional ANOVAs for attachment words and non-attachment words to determine if one of these groups was driving the effects of conditioning and valence. First we conducted a repeated measures 2×2 ANOVA with conditioning (snake-paired vs. rolling pin-paired faces) and valence (secure vs. insecure) as the primary independent variables and response time to words after a face prime as the primary dependent variable of interest. We predicted a significant interaction between conditioning and security such that RTs to secure words would be faster if primed by snake-paired faces and RTs to insecure words would be slower if primed by snake-paired faces relative to responses to words primed by rolling pin-paired faces. A significant main effect of conditioning emerged, $F(1, 39) = 4.1, p = .05$, partial $\eta^2 = .09$, indicating slower response times to words primed by snake-paired

faces (see Fig. 2). All other effects were non-significant, all p 's > .1. The effect found in Beckes and colleagues (2010) was not fully replicated as there was only a non-significant trend in the interaction in the expected direction, $F(1, 39) = 1.8$, $p = .19$, partial $\eta^2 = .04$. Additional paired t -tests revealed that there was a significant effect of conditioning on RTs to insecure words as predicted, $t(39) = 2.8$, $p = .007$, such that insecure words primed by snake-paired faces were significantly inhibited relative to insecure words primed by rolling pin-paired faces (see Table 1). There was no significant effect for the secure words, $t(39) = .6$, $p = .58$. This provides partial support for hypothesis 1 and partially replicates the Beckes and colleagues (2010) findings. The lack of full support is likely a function of statistical power and repeated word presentations, most likely the latter. It is possible that repetition priming (Tulving & Schacter, 1990) effectively washed out any effects of conditioning on the secure word priming. These design limitations were introduced to offset other demands and costs associated with ERP studies. Importantly, when the current data were concatenated with those of Beckes and colleagues (2010) and re-analyzed meta-analytically, we found that the interaction between condition (snake vs. rolling pin-paired faces) and valence (secure vs. insecure) remained significant despite using data from this sample, $p = .003$.

Analyses of RTs to non-attachment related words were conducted in the same manner with a 2 x 2 ANOVA using conditioning and valence as within-subjects factors. This analysis resulted in a significant main effect of valence, $F(1, 39) = 8.3$, $p = .007$, partial $\eta^2 = .18$, indicating that sexual desire words were responded to significantly faster than disgust words. No other effects were detected, all p 's > .25. Paired t -tests on all categories of words including neutral words revealed that conditioning of the prime faces only significantly changed RTs to insecure words as described above, all other p 's > .2 (see Table 1).

Overall these analyses indicate that the snake conditioning significantly inhibited response times to insecure words, but had no significant effect on other word categories. These results also indicate generally faster response times to positive words, driven in part by baseline differences in the non-attachment words, and partially by the inhibition of insecure attachment words by the snake-paired faces.

P1 Component Results

We focused on the P1 component peaking between 110-140ms post-stimulus presentation. As can be seen in figure 3B, the P1 positivity was greatest in occipito-parietal electrode sites, specifically O1, O2, PO3, and PO4, where expected. Data was analyzed for these four electrodes only, and data from all other electrodes was ignored. We conducted a 2 x 2 repeated-measures ANOVA with conditioning (snake-paired vs. rolling pin-paired faces) and hemisphere (PO3/O1 (left) vs. PO4/O2 (right)) as the primary independent variables and mean amplitude between 110-140ms post-stimulus presentation as the primary dependent variable. We also included gender as a between-subjects factor in all analyses. We predicted greater P1 amplitudes to snake-paired faces relative to rolling pin-paired faces. No effects emerged from this analysis, all p 's $> .1$, except a significant conditioning by hemisphere interaction $F(1, 35) = 6.9, p = .01$, partial $\eta^2 = .17$. Further interrogation of this effect identified a significant main effect of conditioning in the left hemisphere (PO3/O1) $F(1, 35) = 5.6, p = .02$, partial $\eta^2 = .14$, but not in the right hemisphere (PO4/O2) $p > .9$. As can be seen in figure 3A and 3C there were significantly larger P1 amplitudes to snake-paired faces ($M = 6.2, SE = .26$) relative to rolling pin-paired faces ($M = 5.8, SE = .26$). This result supports hypothesis 2.

A potential confound with race could emerge in these results if the race of the faces and participants was somehow unbalanced during randomization. Previous research has found

significant differences in the P1 to same vs. different race faces. Given that all the faces used in this study were of white individuals, we tested whether our effects obtained in only our white participants. The same test in this subsample revealed the same significant interaction between conditioning and hemisphere, $F(1, 24) = 7.2, p = .01$, partial $\eta^2 = .23$, all other p 's $> .10$. This eliminates the possibility that the conditioning effects were a function of race.

No peak N170 effects were detected, however, there was a trending effect in the left hemisphere electrodes (PO3/O1), $F(1, 35) = 3.3, p = .08$, partial $\eta^2 = .09$, indicating greater negativity to rolling pin-paired faces relative to snake-paired faces—an effect that is similar to the N170 ingroup/outgroup effects reported in Cunningham et al (2012).

P1 Correlation with Response Times

One potential problem with the interpretation that P1 components are due to social regulatory conditioning is that faces paired with snakes may get more early attention due to the arousing nature of the snake stimulus. If this is the case, however, P1 amplitude differences should be uncorrelated with lexical decision times or systematically correlated with arousing words regardless of word type if this is the case. To test this we took the difference in amplitude for each face condition (snake-paired minus rolling pin-paired faces) in the left hemisphere electrodes (PO3/O1) and the difference in response time for each face condition (snake-paired minus rolling pin-paired face primes) to each category of words and conducted a Pearson's product moment correlation test to see if these differences were significantly related. As hypothesized, for the insecure words these variables correlated positively, $r(37) = .36, p = .03$, meaning that the greater the P1 amplitude was to snake-paired faces relative to rolling pin-paired faces, the slower the RT to insecure words primed by snake-paired faces relative to rolling pin-paired faces (see Fig. 4). Moreover, these effects did not emerge in the correlations between P1

amplitude and RTs to other word categories, all p 's $> .10$. Moreover, the correlations with sexual desire ($r(37) = -.25, p = .14$) and disgust words ($r(37) = -.19, p = .26$), both of which are high arousal word categories, are not only non-significant, but also of opposite sign to that of the correlation with the insecure words. This finding makes it unlikely that the inhibition of insecure words associated with the conditioning procedure is simply a function of arousal. This finding strengthens the other results and the conditioning interpretation by providing evidence that the RT and P1 measures are functionally linked in a manner more specific than would be predicted from a simple arousal effect.

Discussion

Results reported here provide additional support for the original hypotheses of Beckes et al. (2010), who suggested—and observed—that the social regulatory conditioning procedure inhibits supportive faces from being associated with insecurity concepts. More importantly, the conditioning procedure also seems to amplify P1 responses to supportive faces paired with snakes relative to rolling pins. This supports hypothesis 2 that early attentional biases toward securely conditioned faces would mirror P1 biases toward putative ingroup faces. Such evidence implies that social regulatory conditioning increases early categorization of individuals as potential resources, and may lead to the encoding of familiarity and possibly ingroup membership. If true, it is likely via an increase in the approach relevance of the target individual. Together, these processes point to psychological pathways for building, maintaining, and strengthening secure social bonds by virtue of the combination of threat and responsiveness.

The ERP evidence suggests further that P1 generators are sensitive to implicit learning. This supports the general conclusions of Cunningham and colleagues (2012) that early attentional biases are flexible and modifiable by various factors. Specifically this experiment

suggests that one can increase approach relevant attentional biases toward novel individuals by using the principles laid out by the social regulatory conditioning approach. Such insights could lead to new ways to change implicit biases to promote less biased perceptual processes toward marginalized members of a community, or outgroup members more generally. Indeed, Mikulincer and Shaver (2007) note that boosting attachment security increases pro-social values and intergroup tolerance. It may be that the social regulatory conditioning method is tapping into similar psychological dynamics as security priming by enhancing approach motivation with respect to target individuals.

The significant correlation between P1 and insecure RT measures provides convergent evidence for the conclusion that social regulatory conditioning functions to facilitate the perception of target individuals as safe and supportive. Specifically, it indicates that early perceptual biases are functionally linked to implicit associations. Because the conditioning procedure both increases approach related attentional biases toward target individuals and decreases implicit associations between the target individual and insecurity—and because those changes correlate—these data provide persuasive evidence for our conceptual interpretation.

Despite this plausible alternative hypotheses may exist. Arousal has been associated with greater attraction to target individuals in investigations of links between arousal and affiliation (e.g., Allen, Kenrick, Linder, & McCall, 1989; Brehm, Gatz, Goethals, McCrimmon, & Ward, 1978; Dutton & Aron, 1974; Jacobs, Berscheid, & Walster, 1971; Kenrick & Johnson, 1979; Riordan & Tedeschi, 1983). These effects have alternatively been explained as misattribution of arousal, response facilitation effects, and negative reinforcement effects. Although, to our knowledge, none of these studies have looked at downstream learning as a function of pairing arousal with a social target, it is possible some associative learning does occur in these situations

even if the underlying mechanism is more closely related to misattribution or response facilitation explanations. Here we have interpreted our findings with a negative reinforcement explanation, which easily explains the downstream learning found in our data, but similar learning cannot be ruled out for the other possible mechanisms. These results, regardless of the underlying psychological mechanism, should still be of keen interest to those curious about how human bonding occurs and how it affects perceptual processes related to social targets. Debates over the foundational mechanisms that link fear and arousal with social affiliation have continued since Schacter's (1959) experiment, with only temporary gaps in which no new data was brought to bear. More recently with the burgeoning development of neurobiological models, Shelley Taylor (2006) has suggested a link between stress responses and affiliation mediated by oxytocin mechanisms, a process she pits against fight or flight with "tending and befriending". Here we do not make any grand claims related to resolving these debates, but rather offer novel evidence for how this process may unfold and how that process relates to perceptual learning.

This experiment suggests a readiness of the human mind to implicitly interpret the sequence of threat followed by responsiveness with safety and security in such a way as to bias very early social perception processes. Further it highlights links between broader social ingroup-outgroup perception and interpersonal bonding and attachment. Much more needs to be explored regarding this unique conditioning phenomenon and its underlying mechanisms. Despite the need for more investigation, however, this research is beginning to shed light on important ways in which trust and comfort in others is developed and may lead to important therapeutic and applied insights to help solve a number of social and relational problems faced by people in day to day life.

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Footnotes

1 – The decision to split the analysis by hemisphere was based on recommendations by Luck (2005) and following the methods used by Cunningham et al. (2012). An additional, more conservative analysis was done including electrode site as a factor (PO3 vs. O1 vs. PO4 vs. O2) in the analysis in order to verify reported findings. This analysis resulted in the same interpretation as the hemispheric analysis, indicating a significant conditioning by electrode interaction ($p = .04$ multivariate test and $p = .007$ within-subjects effect with Greenhouse-Geisser correction).

2 – Subsequent analysis indicated that in the meta-analysis a paired-t-test of the hypothesis that snake paired face primes lead to faster reaction times to secure words than rolling-pin paired face primes was significant, $p = .05$. Further, a paired-t-test of the hypothesis that snake paired face primes lead to slower reaction times to insecure words than rolling-pin paired face primes was significant, $p = .005$.

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Tables

Table 1 – Table 1 depicts the means, standard errors, and paired comparison t-test statistics between words primed by snake-paired faces and words primed by rolling pin-paired faces for lexical decisions on each word category.

	Snake-Paired Face Prime	Rolling Pin- Paired Face Prime	Paired Comparison		
Word Category	Mean (ms)	Mean (ms)	SE (ms)	t-statistic	<i>p</i> -value
Secure	659	654	9	.6	.58
Insecure	674	655	7	2.8	.007
Disgust	676	665	9	1.2	.23
Sexual Desire	653	651	7	.3	.79
Neutral	680	680	8	.1	.91

Figures

Figure 1. Figure 1 depicts a schematic of the method and timing involved in the learning and test phases of the experiment.

Figure 2. Figure 2 depicts the mean response times to secure and insecure words as a function of face prime condition. As can be seen, participants were slower to respond to insecure words when those words were primed by snake-paired faces relative to when they were primed by rolling pin-paired faces. Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Figure 3. Figure 3 panel a) depicts the ERP waveform for snake-paired faces (in black) and rolling pin-paired faces (in red) at the PO3 electrode site; Panel b) depicts a scalp map of the distribution of potentials during the 110-140ms time frame, with the distribution for snake-paired faces above and rolling-pin paired faces below; Panel C) depicts a bar graphs of the mean amplitude of the P1 component measured between 110-140ms in left hemisphere electrode sites (O1 and PO3), with within-subjects 95% confidence intervals (Cousineau, 2005) for error bars.

4. Figure 4 depicts a scatterplot of the relationship between the difference in P1 amplitude by condition (snake-paired faces minus rolling-pin paired faces) and the difference in response time to insecure words by condition (snake-paired faces minus rolling-pin paired faces). P1 amplitude difference is plotted on the y-axis and insecure word response time difference is plotted on the x-axis.

Appendix A – Table of words used by category

Secure	Insecure	Sexual Desire	Disgust	Neutral
tender	insecure	romance	sewage	stove
warmth	neglect	romantic	wounds	steam
secure	fear	desire	illness	tissue

calm	hurt	arouse	sick	foot
sensitive	distress	lust	rot	cabinet
affection	avoid	erotic	decay	contents
belong	betray	intercourse	disease	concentrate
comfort	rejection	passion	sickness	gallon
trust	lonely	excite	accident	belly
nurture	anxiety	sex	infection	metal