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Perceived parental support predicts enhanced late positive event-related brain potentials to parent faces

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ABSTRACT

This study examined event-related brain potentials in college students viewing facial pictures of their parents, celebrities, and strangers in the context of a guessing task. A temporal principal component analysis of data obtained from midline electrode sites was used to extract a component reflecting the mid- to late-positive deflection observed between 200 and 500 ms following stimulus onset. Parent faces elicited enhanced positivity compared to celebrity and stranger faces suggesting greater attention allocation to parent faces. In addition, greater perceived parental support predicted larger factor scores to parent faces relative to non-parent faces. Greater perceived negative interaction with parent, however, attenuated this relationship.

1. Introduction

A growing interest in delineating neural mechanisms of human affiliation has led to a rise in neuroimaging and electrophysiological studies reporting differences in brain activity when individuals process information related to significant others compared to unfamiliar or less significant others. These include fMRI studies reporting increased activity in areas of the brain associated with reward and empathy when mothers view facial pictures of their children compared to familiar and unfamiliar children (i.e., amygdala, insula, anterior paracingulate cortex, posterior temporal sulcus; Leibenluft et al., 2004), when mothers listen to infant cries (i.e., medial thalamus, medial prefrontal and right orbitofrontal cortices, midbrain hypothalamus, dorsal and ventral striatum; Lorberbaum et al., 2002), and when individuals view facial pictures of their romantic partners compared to familiar faces (i.e., right ventral tegmental area, right postero-dorsal body, medial caudate nucleus; Aron et al., 2005; Fisher et al., 2005), as well as compared to pictures of non-romantic friends (i.e., striatum, middle insula, anterior cingulate cortex, dentate gyrus/hippocampus, hypothalamus, ventral tegmental area; Bartels and Zeki, 2000). Studies examining event-related brain potentials (ERPs) complement imaging research by enabling a finer examination of the time course of emotional processing of personally relevant stimuli. These include ERP studies reporting enhanced P3 responses (i.e., early P3a), associated with attention allocation, when individuals view facial pictures of acquaintances compared to unfamiliar faces (Bobes et al., 2007), increased late positive potential (LPP) components when individuals view facial pictures of their romantic partners compared to unfamiliar faces (Langeslag et al., 2007), and enhanced positivity at frontal (i.e., P2) and parietal sites (i.e., P3) when mothers view facial pictures of their infants compared to familiar and unfamiliar infants and adults (Grasso et al., 2009).

Research suggests that the processing of faces, versus other types of visual stimuli, may possess ethological importance related to human social behavior (Depue and Morrone-Strupinsky, 2005; Zebrowitz, 2006). Facial features provide the means to garner important characteristics such as age, race, gender, and emotional state, as well as to determine familiarity and personal significance of individuals. In addition, facial stimuli have the potential to elicit emotionally laden, affiliative memories and facilitate the formation and maintenance of human relationships—tapping brain processes that elicit appetitive or approach behavior (Depue and Morrone-Strupinsky, 2005). This suggests that processing the face of a personally relevant individual, like a romantic partner, parent, or child, may lead to greater activation of appetitive brain regions compared to viewing the face of a stranger or less significant other. It also suggests that brain activity associated with social behavior may correlate with measures of relational qualities or characteristics (e.g., intimacy, support, companionship). We began to explore this possibility in an earlier study of mothers viewing a facial picture of their infant child versus pictures of other faces, in which we used an observational coding scheme[1] (i.e., This is My Baby Interview [TIMB]; Bates and Dozier, 2002) to measure characteristics of

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[1] The TIMB is a semi-structured interview that is recorded and then coded for three dimensions reflecting a mother's relationship with her child. Each dimension is quantified using a five-point Likert scale.

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the mother–child relationship (Grasso et al., 2009). We found that mothers who were rated higher on Acceptance (i.e., perceiving her relationship with the child as positive and rewarding) and Awareness of Influence (i.e., perceiving the relationship as instrumental to her child's emotional wellbeing and development) exhibited ERPs with enhanced late positivity, associated with greater attention allocation, while viewing facial pictures of their child (Grasso et al., 2009). Given that the TIMB measures positive relational constructs, however, we could not examine whether high scores on a negative relational construct (e.g., negative parent–child interaction) also relate to ERP patterns. It seems plausible that a measure of negative interaction, which need not necessarily share a negative relationship with positive support, might also be reflected in the LPP.

In the current study, we aimed to replicate and extend findings from our mother–infant study in the context of the parent/young–adult relationship by exploring the potential associations between late positive ERP responses and both positive and negative aspects of this relationship. Undergraduate college students rated a parent on a measure with two scales, positive support and negative interaction, and engaged in a task in which they were instructed to choose one of three doors to reveal a hidden facial picture, either their parent, a celebrity, or a stranger. We expected to find enhanced late positivity to parent faces compared to stranger faces and celebrity faces, which were used to control for familiarity. We also predicted a positive association between ratings of positive support and late positivity. Our examination of the potential association between negative interaction and the LPP was exploratory.

2. Methods

2.1. Participants

The sample included 27 undergraduate college students (60.7% female) enrolled in an Introductory Psychology class and receiving course credit for participating in the study. Subjects were between the ages of 18.06 and 20.56 years (M = 18.96, SD = .98) and all were classified as Non-Hispanic and European American.

2.2. Stimuli and measures

2.2.1. Face stimuli

Digital pictures were obtained from subjects' parents electronically and uploaded into Adobe Photoshop CS Version 8.0. Pictures were cropped to 800 × 800 pixels (8 × 8 in.) so that the head, neck, and shoulders occupied the majority (i.e., about 60%) of the frame. Pictures were adjusted for visual clarity using the Auto Levels command. The space surrounding the head, neck, and shoulders was filled in with the color black. The edges of the figure touching the black background were softened with the blur tool. Pictures were then de-saturated to a gray scale. Pictures of celebrities were obtained from Internet sites posting royalty free downloadable stock photographs. Pictures of strangers were taken from a database of facial pictures we have established for research purposes and used in previous studies. Celebrity and stranger pictures were treated the same as parent pictures.

2.2.2. The network of relationships inventory (NRI) short form

The NRI short form (Furman, 1996) yields two dimensions, support and negative interaction, derived from seven items assessing support (e.g., *How much does this person treat you like you're admired and respected?*) and six items assessing negative interaction (e.g., *How much do you and this person get upset and mad at each other?*), respectively. Items are rated on five-point Likert-type scales ranging from 1 (*Little or None*) to 5 (*The Most*). The short form is based on the full NRI, which is comprised of ten relational dimensions. The NRI has demonstrated good psychometric properties (Furman, 1996). Internal consistency (Cronbach's alpha) in the current sample was .90 for support and .85 for negative interaction.

2.3. Procedures

Initial contact with students occurred during an introductory meeting in which students learned the requirements of the study and received 30-min worth of course credit. Students interested in the study agreed to obtain verbal permission from a parent of their choice (58.3% mothers) to provide a digital facial picture of him or herself to be used in the research study and to send parents' contact information to research staff. All parents of students interested in the study agreed to provide pictures. These parents were mailed a release form and instructed to return the form and to electronically mail the picture to research staff. Upon receipt of the form and picture, students were individually scheduled for a 1.5-h laboratory session. After providing written consent and completing the NRI short form, subjects were shown a facial picture of a celebrity, gender-matched to their parent, and asked to identify the celebrity by name. If subjects were unable to identify the celebrity, the picture of an alternate celebrity, also gender-matched, was presented for identification. All subjects were able to identify either the first or second celebrity, and it was the picture of the identified celebrity that was used in the computer task. A gender-matched facial picture of a total stranger completed the three-picture stimulus set.

After a brief orientation to the electrophysiology equipment, sensors were attached and subjects were introduced to the computer task. Subjects were shown three faces (i.e., their parent, a celebrity, and a stranger) and told that three doors, each hiding one of the faces, would appear on screen. For each trial, subjects were instructed to think of the facial picture they wanted to see the most and to select the door thought to hide the chosen picture by pressing the 1–3 buttons on the keyboard. Subjects were told that the face behind the chosen door would appear for several seconds, followed by another set of three doors. Subjects were instructed to repeat this process a number of times until the computer task ended. Each picture type was randomly presented 40 times and appeared on-screen for 6000 ms using Presentation software (Neurobehavioral Systems Inc.). When later asked which face they were looking for most of the time, all subjects reported always selecting doors that they thought would reveal their parent's face. Thus, the parent face became the target stimulus. This task was chosen to facilitate subjects' engagement throughout the experiment and to maximize their attention to the stimuli.

2.3.1. Psychophysiological recording and data reduction

Two tin 9 mm cup disk electrodes (ECI) were attached on the left and right mastoids (M1 and M2, respectively). Two Ag/AgCl miniature electrodes (Med-Associates) were attached 1 cm above and below subjects' left eye to record the vertical electrooculogram (EOG). A clip electrode functioning as a ground was attached to subjects' left ear. EEG recordings were taken from frontal (Fz), fronto-central (FCz), central (Cz), and parietal (Pz) areas along the midline using an ECI electrocap. All electrode impedances were below 10 kΩ and the data from all channels were recorded using a Grass Model 78D polygraph with Grass Model 7P511J preamplifiers (bandpass = 0.1–100 Hz). During the recording, all EEG activity was referenced to Cz.

All bioelectric signals were digitized on a laboratory microcomputer using VPM software (Cook, 1999). The EEG was sampled at 200 Hz. Data collection began 500 ms prior to picture presentation and continued 1000 ms after picture onset. EEG data reduction was performed using EEGLAB 6.01 (Delorme and Makeig, 2004; http://www.sccn.ucsd.edu/eeglab) running under Matlab 7.6 (The Mathworks). All data were rereferenced from Cz to the average-mastoid reference. All trials were inspected visually, and only trials without artifact were retained. The EEG data for each trial was corrected for vertical EOG artifact by employing Independent Component Analysis (ICA). ICA decomposed each trial's data into five components. Components representing EOG artifact were identified and rejected by calculating Pearson-Product Moment correlations between each component and the EOG channel, then determining the highest correlation. These determinations were also corroborated by visual inspection. Finally, using EEGLAB 6.01 (Delorme and Makeig, 2004), artifact-free EEG data were regenerated by back-projecting the remaining ICA components, which was accomplished by multiplying the selected component activities with the reduced component-mixing matrix. Single trial EEG data were lowpass filtered at 20 Hz with a 51-weight FIR digital filter. Stimulus-locked ERPs were averaged separately for each type of face stimulus. A baseline equal to the average activity in a 200 ms window prior to picture onset was subtracted from each data point after picture onset.

Because in our earlier study (i.e., Grasso et al., 2009) we had observed late positive responses to facial stimuli at all midline sites, though largest at Pz, and reflected in several components (e.g., P2, N2, P3, LPP), we conducted a temporal principal component analysis (PCA; Chapman and McCrary, 1995) on the current data to extract a finer measure of the underlying component. The temporal PCA was based on a covariance matrix of the averaged waveforms represented by 200 time points (from 0 to 1000 ms). The pre-analyzed database was comprised of 27 subjects, three stimulus categories, and four electrode sites yielding 324 averaged waveforms. A Varimax rotation was performed on four factors, which explained 87.9% of the cumulative variance.

2.4. Statistical analyses

Data were analyzed using SAS JMP Version 8 (www.jmp.com). A Repeated-Measures Analysis of Variance (RM ANOVA) with face type (parent vs. celebrity vs. stranger) as the within-subject factor, and factor scores as the dependent variable was used to examine potential differences among face stimuli. To further examine significant main effects of face type, three pairwise post hoc comparisons were conducted using Hochberg's (1988) modified Step-Up Bonferonni procedure. Partial eta squared ($\eta_p{}^2$) values are reported to demonstrate the size of effects, where .05 represents a small effect, .1 represents a medium effect, and .2 represents a large effect (Cohen, 1988).