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Electrocortical reactivity to social feedback in youth: A pilot study of the Island Getaway task

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ABSTRACT

Peer relationships become a major concern in adolescence, yet event-related potential (ERP) measures of reactivity to social feedback in adolescence are limited. In this pilot study, we tested a novel task to elicit reactivity to social feedback in youth. Participants (10–15 years old; 57.9% male; $N = 19$) played a game that involved exchanging personal information with peers, voting to remove players from the game, and receiving rejection and acceptance feedback from peers. Results indicated that participants modified their voting behavior in response to peer feedback, and rejection feedback was associated with a negativity in the ERP wave compared to acceptance (i.e., the feedback negativity, FN). The FN predicted behavioral patterns, such that participants who showed greater neural reactivity to social feedback were less likely to reject co-players. Preliminary analyses suggest that the task may be a useful measure of individual differences: adolescents higher in social anxiety symptoms were less likely to reject peers and showed an enhanced FN to rejection vs. acceptance feedback, and higher depressive symptoms predicted an increased FN to rejection specifically. Results suggest that the FN elicited by social feedback may be a useful, economical neural measure of social processing across development and in clinical research.

1. Introduction

1.1. Reactivity to social feedback in adolescence

Peer relationships assume increasing importance in adolescence and shape adolescent behavior in both positive and negative ways (Allen et al., 2005; Brown, 2004; Steinberg and Morris, 2001). There has been growing interest in evaluating the neural correlates underlying the response to social feedback in order to understand normative developmental changes, as well as mechanisms underlying internalizing disorders (Bolling et al., 2011; Crowley et al., 2010; Gunther et al., 2010; Guyer et al., 2012; Sebastian et al., 2010, 2011; Silk et al., 2013; Somerville, 2013). A major challenge in this work is developing realistic computerized social interaction tasks. Though several paradigms have been created to evaluate the development of neural reactivity to social feedback using functional magnetic resonance imaging (fMRI), very little work has focused on event-related potential (ERP) measures of reactivity to social feedback across development.

1.2. fMRI paradigms for measuring reactivity to social feedback

Previous fMRI work in youth has evaluated reactivity to social exclusion as well as peer feedback indicating rejection and acceptance. For example, Cyberball, a virtual

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ball-tossing paradigm in which participants are eventually excluded from a game (Williams et al., 2000), is a task used to measure reactivity to social *exclusion* in youth. In adolescents, activation in the subgenual anterior cingulate cortex (subACC) and insula related to greater distress during exclusion, while activation in the ventrolateral prefrontal cortex (vlPFC) negatively related to distress (Masten et al., 2009). In addition, there is evidence of developmental changes in these networks, with exclusion associated with increasing activation in the vlPFC from childhood to adulthood, and greater reactivity in the ventral anterior cingulate cortex (ACC) in adolescence compared to childhood (Bolling et al., 2011; Sebastian et al., 2011).

Although social exclusion implies rejection, it is likely that ostracism in Cyberball elicits complex negative emotional responses that may include frustration, anger, and jealousy (Harmon-Jones et al., 2009; Peterson et al., 2011). In order to more directly examine neural activity linked to explicit feedback regarding peer acceptance and rejection, there has been growing interest in the development of social paradigms that include the pretense of more direct and mutual communication with peers. For example, in the Chat Room task, participants rate how interested they are in participating in an online chat with other youth based on their photographs, and then receive feedback regarding how interested the other people are in chatting with them (Guyer et al., 2008). Compared to rejection, receipt of acceptance feedback activated social affiliation and reward regions, including the ACC, striatum, superior temporal gyrus, insula, and thalamus, and increasing age across late childhood and adolescence was associated with greater neural responses to social acceptance feedback, particularly for females (Guyer et al., 2012). Relatedly, Silk et al. (2012) developed a Chat Room Interact task, in which participants and computerized co-players make decisions regarding with whom to discuss specific topics, and participants receive rigged acceptance and rejection feedback. This task is among the first to include biographical profiles of the confederates and to measure reactivity to simulated live interaction using both eye tracking (Silk et al., 2012) and fMRI (Silk et al., 2013). In one fMRI study, pubertal maturation in adolescence predicted greater neural reactivity to rejection feedback in the amygdala, parahippocampal gyrus, caudate, and subACC (Silk et al., 2013).

Taken together, previous fMRI work has begun to identify neural networks involved in social feedback processing (Guyer et al., 2012; Sebastian et al., 2011; Silk et al., 2013), and provide evidence that adolescents may be particularly emotionally reactive to peer feedback, with systems to regulate these emotional responses continuing to develop into adulthood (Bolling et al., 2011; Guyer et al., 2012; Sebastian et al., 2011; Silk et al., 2013).

1.3. Utility of event-related potential measures

Compared to fMRI research, little work has evaluated event-related potential (ERP) measures of reactivity to social feedback across development. ERPs have excellent temporal resolution, providing neural measures of very early stages of processing that can be applied across a range of development and may be particularly useful for clinical applications, given their relative cost-effectiveness compared to other neural measures (Banaschewski and Brandeis, 2007; Luck, 2005; Nelson and McCleery, 2008).

The feedback negativity (FN) is an ERP component that could be used to measure reactivity to social feedback. The FN is a *relative* negativity in the ERP wave following receipt of negative feedback compared to positive feedback that peaks approximately 250–300 ms after feedback over frontocentral recording sites (Foti et al., 2011; Gehring and Willoughby, 2002). That is, negative feedback (e.g., monetary loss or negative performance feedback) appears as a more negative deflection in the FN wave, whereas positive feedback (e.g., monetary reward or positive performance feedback) appears as a relative positivity (Gehring and Willoughby, 2002; Hajcak et al., 2006; Luu et al., 2003; Nieuwenhuis et al., 2004). It is plausible that the FN would also be modulated by social rejection and acceptance feedback; however, additional work is needed to evaluate this possibility.

The FN is thought to be generated as part of a reinforcement learning signal used to modify behaviors with negative outcomes and reinforce behaviors with positive outcomes (Holroyd and Coles, 2002). In monetary reward tasks, the FN correlates with activation in reward-related brain regions, including ventral striatum and medial prefrontal cortex (Becker et al., 2014; Carlson et al., 2011). Importantly, the FN has also demonstrated excellent psychometric properties across development (Bress et al., in press) and contributed to understanding of developmental changes in the processing of feedback. For example, compared to adults and adolescents, children show enhanced ERPs to feedback overall but less differentiation in the FN response to positive vs. negative feedback (Ferdinand and Kray, 2014; Hämmerer et al., 2011). That is, although children may react more strongly to external feedback, they appear to be less efficient in discriminating between positive and negative outcomes. As the FN provides a very early measure of reactivity to feedback and can be easily assessed across development, it has the potential to provide insight into developmental changes in social processing and may be particularly useful given the importance of peer relationships in adolescence (Allen et al., 2005; Brown, 2004; Steinberg and Morris, 2001).

Despite the potential contributions of ERP measures of social processing to research on neural development, to our knowledge no previous study has evaluated the FN to social feedback in youth. In one Cyberball study, Crowley et al. (2010) found some evidence that social exclusion modulates a component similar to the FN; however, the effect did not reach significance, which could be attributed to the lack of explicit acceptance and rejection feedback in the Cyberball task. Given the potential utility of the FN to studying social feedback in developmental research, additional work is needed to create a paradigm with direct, personally relevant feedback that may modulate the FN.

1.4. Implications for the development of internalizing symptoms

Recent fMRI work has also begun to evaluate associations between internalizing disorders and neural reactivity