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Three-year-olds' rapid facial electromyographic responses to emotional facial expressions and body postures

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ABSTRACT

Rapid facial reactions (RFRs) to observed emotional expressions are proposed to be involved in a wide array of socioemotional skills, from empathy to social communication. Two of the most persuasive theoretical accounts propose RFRs to rely either on motor resonance mechanisms or on more complex mechanisms involving affective processes. Previous studies demonstrated that presentation of facial and bodily expressions can generate rapid changes in adult and school-age children's muscle activity. However, to date there is little to no evidence to suggest the existence of emotional RFRs from infancy to preschool age. To investigate whether RFRs are driven by motor mimicry or could also be a result of emotional appraisal processes, we recorded facial electromyographic (EMG) activation from the zygomaticus major and frontalis medialis muscles to presentation of static facial and bodily expressions of emotions (i.e., happiness, anger, fear, and neutral) in 3-year-old children. Results showed no specific EMG activation in response to bodily emotion expressions. However, observing others' happy faces led to increased activation of the zygomaticus major and decreased activation of the frontalis medialis, whereas observing others' angry faces elicited the opposite pattern of activation.

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This study suggests that RFRs are the result of complex mechanisms in which both affective processes and motor resonance may play an important role.

Introduction

Seeing the emotional expressions of the people we interact with most often elicits similar expressions in us as observers. One of the most common examples is when we smile in response to seeing other people smile. Our responses can vary from being overt, observable with the naked eye, to being covert and detectable only by using specific electrophysiological measurements (i.e., electromyographic [EMG] measurements) of the muscles involved in generating these expressions. The covert responses can themselves vary from being extended to long periods of activity to being very rapid and subtle, also called rapid facial responses (RFRs). Forms of emotional expression congruency can be recorded in humans from the first months of infancy (e.g., Haviland & Lelwica, 1987), throughout childhood (e.g., Beall, Moody, McIntosh, Hepburn, & Reed, 2008; Deschamps, Coppes, Kenemans, Schutter, & Matthys, 2015; de Wied, van Boxtel, Zaalberg, Goudena, & Matthys, 2006; Oberman, Winkielman, & Ramachandran, 2009), and throughout adulthood (e.g., Bavelas, Black, Lemery, & Mullett, 1986; Hess & Blairy, 2001; Magnée, Stekelenburg, Kemner, & de Gelder, 2007) and have been documented for facial, vocal, and postural modes of emotional expressivity (Hatfield & Cacioppo, 1994). Importantly, these expressivity matching responses have been attributed essential socioemotional functions with relevance for emotional contagion (Hatfield & Cacioppo, 1994), empathy (Decety & Jackson, 2004; De Vignemont & Singer, 2006), social communication (Hess & Bourgeois, 2010), and social coordination through affiliation (Lakin & Chartrand, 2003), to name just a few. Despite a large body of research investigating the mechanisms underlying the variety of these abilities and their functions in adults, we still have limited knowledge about their development (Beall et al., 2008; Jones, 2007). The current study aimed to address this limitation by investigating the development of RFRs to others' emotions in 3-year-old children.

Two main theoretical assumptions have been put forward with regard to the mechanisms underlying RFRs. On the one hand, several researchers regard RFRs as being simple motor responses, triggered by observing others' facial expression, without any direct affective underpinnings, usually labeled as mimicry (Bavelas et al., 1986; Chartrand & Bargh, 1999; Hoffman, 1984; Meltzoff & Moore, 1977). Mimicking others' emotional displays is presumed to rely on perception–action matching mechanisms, whereby perceiving the pattern of motor behavior specific for expressing different emotions activates the same motor response in the observer (De Waal, 2009; Hatfield & Cacioppo, 1994; Lipps, 1907; Meltzoff, 2007). At the neural level, the mirror neuron system is hypothesized to be involved in eliciting these motor resonance responses (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003). Analogous to the neurons first described in the ventral premotor cortex and the inferior parietal lobule of the macaque brain (Ferrari, Gallese, Rizzolatti, & Fogassi, 2003; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Umiltà et al., 2001), the human mirror neuron system (including the pars opercularis of the inferior frontal gyrus, the ventral premotor cortex, and the anterior inferior parietal lobule) has been found to be responsive when adults both perform and observe simple goal-directed motor acts (e.g., Buccino et al., 2001; Buccino, Binkofski, & Riggio, 2004; Iacoboni & Dapretto, 2006; Iacoboni et al., 1999; Rizzolatti & Craighero, 2004), including emotional facial expressions (Lee, Dolan, & Critchley, 2008; Lee, Josephs, Dolan, & Critchley, 2006; Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008). According to this theoretical account, once elicited, RFRs can lead to a change in the affective state of the observer through associations with previously experienced emotions, generating emotional contagion (Cappella, 1993; Hoffman, 1984; Laird, Alibozak, & Davainis, 1994; Lipps, 1907).

In support of this view, it has been shown that adults' vocal (Hatfield & Hsee, 1995), facial (Davis, Senghas, Brandt, & Ochsner, 2010; Manstead, 1988; Matsumoto, 1987), and postural (Duclos et al.,