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Brief Report

The developmental emergence of unconscious fear processing from eyes during infancy

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ABSTRACT

From early in life, emotion detection plays an important role during social interactions. Recently, 7-month-old infants have been shown to process facial signs of fear in others without conscious perception and solely on the basis of their eyes. However, it is not known whether unconscious fear processing from eyes is present before 7 months of age or only emerges at around 7 months. To investigate this question, we measured 5-month-old infants' event-related potentials (ERPs) in response to subliminally presented fearful and non-fearful eyes and compared these with 7-month-old infants' ERP responses from a previous study. Our ERP results revealed that only 7-month-olds, but not 5-month-olds, distinguished between fearful and non-fearful eyes. Specifically, 7-month-olds' processing of fearful eyes was reflected in early visual processes over occipital cortex and later attentional processes over frontal cortex. This suggests that, in line with prior work on the conscious detection of fearful faces, the brain processes associated with the unconscious processing of fearful eyes develop between 5 and 7 months of age. More generally, these findings support the notion that emotion perception and the underlying brain processes undergo critical change during the first year of life. Therefore, the current data provide further evidence for viewing infancy as a formative period in human socioemotional functioning.

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Introduction

Detecting emotional expressions in others provides a vital basis for coordinating and regulating behavior during social interactions in humans (Frith, 2009; Shariff & Tracy, 2011). The ability to perceive, process, and differentiate other people's emotions based on facial expressions undergoes rapid development during the first year of life (see Leppänen & Nelson, 2009). For example, by 7 months of age, infants begin to reliably discriminate between different emotional facial expressions, which they perceive consciously (Flom & Bahrick, 2007; Kobiella, Grossmann, Reid, & Striano, 2008; Peltola, Hietanen, Forssman, & Leppänen, 2013; Peltola, Leppänen, Mäki, & Hietanen, 2009). Specifically, at around this age, an increased sensitivity to fearful facial expressions emerges in infants, which is reflected in infants' allocation of increased attention to fearful expressions when compared with happy expressions (Peltola, Leppänen, Mäki, et al., 2009). The emergence of this increased sensitivity to fear can be traced in infants' behavioral responses (looking time) but also in infants' neural responses (event-related potentials, ERPs) (Peltola, Leppänen, Mäki, et al., 2009). This sensitivity emerges at a time in development when other important and potentially related developmental changes occur (Leppänen & Nelson, 2012). Namely, at around the same time, infants start to exhibit fear themselves as seen as an increasing fear of strangers (Braungart-Rieker, Hill-Soderlund, & Karrass, 2010) and also begin to locomote (crawl) and thereby encounter dangerous situations associated with the experience of fear and fearful expressions in their caregivers (Campos, Kermoian, & Zumbahlen, 1992).

In adults, it has been shown that the processing of fearful faces can occur without conscious perception of the face (Kiss & Eimer, 2008; Liddell, Williams, Rathjen, Shevrin, & Gordon, 2004; Smith, 2012). In particular, adults show differential ERP responses to emotional faces compared with neutral faces (Kiss & Eimer, 2008; Liddell et al., 2004; Smith, 2012) as well as between different emotional expressions (Smith, 2012). Typically, these unconscious (or subliminal) stimuli are presented for a very brief duration (< 20 ms), too short to be consciously perceived. On a behavioral level, therefore, adults perform at chance level when asked to classify the emotional expression just presented (Kiss & Eimer, 2008). Nevertheless, differences in brain activation can be observed.

A number of different adult ERP components have been investigated in relation to subliminal and supraliminal emotional face processing. One of the earliest stages at which emotion processing can be observed is the occipital cortex (P1), for which the amplitude tends to be larger for threatening facial expressions (Nomi, Frances, Nguyen, Bastidas, & Troup, 2013). The P1 is typically followed by an N2, which has been linked to orienting to a salient stimulus such as an emotional face. Typically, fearful facial expressions elicit a larger amplitude compared with neutral or positive facial expressions (Liddell et al., 2004). This effect can also be observed in the absence of conscious awareness.

Evidence regarding emotion differences at the level of the N170, a component involved in face processing (see Rossion, 2014), are mixed; whereas some adult studies show emotion effects at the N170, others do not (Vuilleumier & Pourtois, 2007). Findings are also mixed for subliminal processing, with some work reporting an emotion effect on the N170 (Pegna, Landis, & Khateb, 2008) and other work observing no difference for the N170 (Kiss & Eimer, 2008).

Finally, emotional information also affects later stages of processing, especially when information is perceived consciously. One component of particular importance here is the P3, which has been linked to a higher order processing of emotional information (Kiss & Eimer, 2008).

In direct comparison between subliminal and supraliminal emotion processing, some ERP components appear to be specific to subliminal stimuli (e.g., an enhanced N2; Kiss & Eimer, 2008; Liddell et al., 2004), whereas others can be observed for both subliminal and supraliminal emotion processing (e.g., an enhanced frontal positivity; Smith, 2012). Therefore, subliminal emotion processing appears to rely on distinct mechanisms but also on mechanisms shared in common with supraliminal emotion processing.

Interestingly, the unconscious processing of fear can be seen not only in response to faces but even in response to minimal information from the eye whites (sclerae) (e.g., Whalen et al., 2004). Whalen and colleagues (2004) presented adults subliminally with only the sclerae of happy and fearful facial expression, and they observed an increased amygdala activation to fearful eyes, which is comparable to what had been reported previously for fearful faces (Morris et al., 1996). This is particularly