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Children's neural response to contrast-negated faces is species specific

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ABSTRACT

Face recognition abilities develop dramatically during the first year of life, but comparatively little is known about the nature of face-specific perceptual development during early childhood. Face-specific effects of image appearance on recognition, including face inversion and contrast negation, are a useful means of understanding the functional properties of face perception developmentally. Here, we examined the generality of the impact of contrast negation on face perception during early childhood using event-related potentials (ERPs). Specifically, we recorded continuous electroencephalography (EEG) while adult participants and children between 4 and 6 years of age viewed human and non-human primate faces presented in either positive or negative contrast. We examined both the P100 and N170 components to determine whether or not sensitivity to contrast polarity was evident in face-sensitive components during early childhood and also whether or not that sensitivity was specific to species category. We found evidence of a species-specific effect of contrast negation at the N170, suggesting that by early childhood some aspects of face-specific processing have been restricted to a relatively narrow class of face stimuli. However, this effect is of the opposite sign relative to adults, suggesting that there is continued maturation of face-specific processing during childhood.

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Introduction

Face processing, besides being functionally distinct from object processing, is also affected by the category membership of face stimuli. The most well-known examples of how face recognition and face discrimination differ as a function of experience-defined categories are the effects of race (Meissner & Brigham, 2001) and species (Dufour, Coleman, Campbell, Petit, & Pascalis, 2004) on performance. Briefly, faces belonging to groups that observers have infrequent contact with tend to be remembered poorly, to be difficult to distinguish, and to look more homogeneous than faces that resemble those that observers have more frequent contact with. A lack of experience with a particular category of faces not only compromises raw recognition and discrimination performance but also appears to compromise the extent to which face-specific mechanisms are applied. There are, for example, several behavioral indexes of expert-level face processing that distinguish face processing from object processing: The well-known inversion effect (Yin, 1969) obtains more robustly for faces than other objects and is also less evident for faces belonging to other-race categories (Balas & Nelson, 2010). Holistic processing of faces, as revealed by the "composite face effect" (Young, Hellawell, & Hay, 1987), also does not obtain as robustly for other-race faces as for own-race faces (Michel, Rossion, Han, Chung, & Caldara, 2006). The "part–whole effect," another index of holistic processing that does not obtain robustly for non-face objects (Tanaka & Farah, 1993), also exhibits selectivity for experience-defined face categories (Tanaka, Kiefer, & Bukach, 2004). These behavioral results suggest that the underlying mechanisms that drive face-specific processing might not be applied as readily to faces belonging to "other" categories.

The emergence of experience-dependent face processing takes place during the first year of life. Specifically, infants follow a developmental trajectory that has been termed "perceptual narrowing" to reflect the fact that young infants are better able to discriminate between exemplars of multiple face categories than older infants (Nelson, 2001). This is evident for categories defined by race (Kelly et al., 2007) and species (Pascalis et al., 2005) and is taken to imply that the representation of face appearance has "narrowed" or converged to a state that is optimal for the subset of faces that infants see most frequently but is potentially suboptimal for other types of faces. The effects of perceptual narrowing are evident both behaviorally and in electrophysiological data; event-related potential (ERP) components, including the N290 and the P400, are sensitive to face category membership in a manner that is broadly consistent with perceptual narrowing (Balas, Westerlund, Hung, & Nelson, 2011; de Haan, Pascalis, & Johnson, 2002), suggesting that neural representations of face appearance are being substantially modulated by experience during the first year of life.

Whereas the emergence of category effects on face recognition begins during infancy, many of the behavioral effects described above that distinguish face processing from object processing are evident during early childhood. The inversion effect, for example, is evident in children at 3 or 4 years of age (Sangrigoli & de Schonen, 2004), as is the part–whole effect (Pellicano & Rhodes, 2003). Holistic processing as indexed by the composite face effect is adult-like by 6 years of age (Mondloch, Pathman, Maurer, Le Grand, & de Schonen, 2007) and has been observed in children as young as 4 years (de Heering, Houthuys, & Rossion, 2007). Thus, many so-called qualitative markers of expert face processing appear to be mature during early childhood and may even be mature during infancy (McKone, Crookes, & Kanwisher, 2009). Selectivity within the category of faces also appears to begin developing relatively early in childhood as well and influences the impact of stimulus manipulations that selectively disrupt face recognition. For example, by 3 years of age, children not only show better processing of own-race faces compared with other-race faces but also show a larger inversion effect (Sangrigoli & de Schonen, 2004). This suggests that by early childhood at least some of the mechanisms underlying the differential processing of faces and objects may be mature and that some categories of faces may also be processed by different mechanisms than the faces that children are developing expertise for.

Our goal in the current study was to examine whether or not stimulus manipulations that affect face recognition performance manifest during early childhood in a category-dependent way. Does greater experience with one category of faces versus another affect the extent to which neural responses to those faces are modulated by appearance manipulations that are known to affect faces