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Brief Report

Eye contrast polarity is critical for face recognition by infants

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ABSTRACT

Just as faces share the same basic arrangement of features, with two eyes above a nose above a mouth, human eyes all share the same basic contrast polarity relations, with a sclera lighter than an iris and a pupil, and this is unique among primates. The current study examined whether this bright–dark relationship of sclera to iris plays a critical role in face recognition from early in development. Specifically, we tested face discrimination in 7- and 8-month-old infants while independently manipulating the contrast polarity of the eye region and of the rest of the face. This gave four face contrast polarity conditions: fully positive condition, fully negative condition, positive face with negated eyes ("negative eyes") condition, and negated face with positive eyes ("positive eyes") condition. In a familiarization and novelty preference procedure, we found that 7- and 8-month-olds could discriminate between faces only when the contrast polarity of the eyes was preserved (positive) and that this did not depend on the contrast polarity of the rest of the face. This demonstrates the critical role of eye contrast polarity for face recognition in 7- and 8-month-olds and is consistent with previous findings for adults.

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Introduction

Humans are the only primates that have a white sclera that contrasts with a darker colored iris and pupil (Kobayashi & Kohshima, 1997, 2001). Whereas color and darkness of skin, hair, and iris vary widely among humans, the color of the sclera is near white and universally lighter than the iris and pupil. In this sense, the contrast polarity relationship between the sclera and iris is potentially as fundamental in human faces as the first-order spatial relationships between features—two eyes above a nose above a mouth (Diamond & Carey, 1986). Here we explicitly tested whether the contrast polarity relationship between the sclera and iris is critical for face discrimination by infants.

Previous studies have shown that reversing the contrast polarity of an image severely impairs face perception in adults (e.g., Anstis, 2005; Bruce & Langton, 1994; Johnston, Hill, & Carman, 1992; Kemp, McManus, & Pigott, 1990; Lewis & Johnston, 1997). This effect has been attributed to the unusual pigmentation (Bruce & Langton, 1994; Russell, Sinha, Biederman, & Nederhouser, 2006) and/or the unnatural pattern of shading interfering with three-dimensional face perception (Johnston et al., 1992; Liu, Collin, Burton, & Chaudhuri, 1999).

Using "contrast chimera" images incorporating both positive and negative contrast within a face, Gilad, Meng, and Sinha (2009) reported that the contrast polarity around eyes is particularly important for face recognition in adults. Whereas familiar faces were poorly recognized in fully negated images (54.35%), performance improved dramatically when the contrast polarity around eyes (eye to eyebrow region inclusive) was made positive (contrast chimeras, 92.32%). In addition, although activation of the right fusiform facial area was reduced considerably for fully negative faces, it was as high for the contrast chimeras (negative face with positive eye region) as for fully positive faces. The results of Gilad and colleagues demonstrate the critical role of the eye region in the effect of contrast polarity on adult face recognition.

The importance of contrast polarity around the eyes was also reported previously in a developmental study investigating face preference in infants. Farroni and colleagues (2005) examined preference for upright over inverted schematic faces (consisting of three dark blobs on a white surface) and for facial photographs in newborn infants. They found that newborns' preference for upright images disappeared when the contrast polarity was reversed. Adding a small dark blob to each of the white blobs, consistent with a dark iris contrasting with a lighter sclera, reinstated the upright face preference for negative schematic faces.

The development of face perception and recognition during infancy has been studied extensively, including both the role of experience (Kelly et al., 2007, 2009; Pascalis, de Haan, & Nelson, 2002) and the aspects of visual information that infants use (Bhatt, Bertin, Hayden, & Reed, 2005; Cohen & Cashon, 2001; Hayden, Bhatt, Reed, Corbly, & Joseph, 2007; Quinn & Tanaka, 2009). However, there are relatively few studies testing the effect of contrast polarity of faces in infants.

Other studies examining preferential looking behavior are consistent in showing that infants perceive positive and negative contrast polarity faces differently even though this manipulation preserves the geometrical structure and spatial frequency content of the image. Dannemiller and Stephens (1988) and Mondloch and colleagues (1999) consistently reported that 12-week-olds, but not 6-week-olds or newborns, preferred schematic faces with positive contrast polarity over contrast-reversed versions of the same stimuli. In addition, and again consistent with Farroni and colleagues (2005), Otsuka, Hill, Kanazawa, Yamaguchi, and Spehar (2012) reported that a preference for upright over upside-down two-tone facial images disappeared when the contrast polarity of the stimuli was reversed. The disappearance of an upright face preference for contrast-reversed stimuli suggests that the "faceness" of the facial images may be lost when contrast polarity is reversed.

As far as we are aware, there is only one published article on the effect of the contrast polarity on face discrimination in infants. Using the habituation method, Layton and Rochat (2007) examined 4- and 8-month-olds' ability to discriminate between unfamiliar faces and between unfamiliar faces and their mother's face under positive and negative image conditions with either static or dynamic presentation. In the positive contrast image condition, both age groups discriminated between faces in all of the conditions examined. With negative contrast images, however, only the 8-month-olds discriminated between faces, and this was limited to the discrimination of the maternal face from unfamiliar