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Category-specific face prototypes are emerging, but not yet mature, in 5-year-old children

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A B S T R A C T

Adults' expertise in face recognition has been attributed to norm-based coding. Moreover, adults possess separable norms for a variety of face categories (e.g., race, sex, age) that appear to enhance recognition by reducing redundancy in the information shared by faces and ensuring that only relevant dimensions are used to encode faces from a given category. Although 5-year-old children process own-race faces using norm-based coding, little is known about the organization and refinement of their face space. The current study investigated whether 5-year-olds rely on category-specific norms and whether experience facilitates the development of dissociable face prototypes. In Experiment 1, we examined whether Chinese 5-year-olds show race-contingent opposing aftereffects and the extent to which aftereffects transfer across face race among Caucasian and Chinese 5-year-olds. Both participant races showed partial transfer of aftereffects across face race; however, there was no evidence for race-contingent opposing aftereffects. To examine whether experience facilitates the development of category-specific prototypes, we investigated whether race-contingent aftereffects are present among Caucasian 5-year-olds with abundant exposure to Chinese faces (Experiment 2) and then tested separate groups of 5-year-olds with two other categories with which they have considerable experience: sex (male/female faces) and age (adult/child faces) (Experiment 3). Across all three categories, 5-year-olds showed no category-contingent opposing aftereffects. These results demonstrate that 5 years of age is a stage characterized by minimal separation in the norms and associated

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coding dimensions used for faces from different categories and suggest that refinement of the mechanisms that underlie expert face processing occurs throughout childhood.

Introduction

Young children demonstrate several characteristics of adult-like face processing. They process faces holistically (e.g., de Heering, Houthuys, & Rossion, 2007), are more accurate in recognizing upright versus inverted faces (e.g., Mondloch, Le Grand, & Maurer, 2002) and own-race versus other-race faces (e.g., Sangrigoli & de Schonen, 2004), and show sensitivity to featural and relational (i.e., feature spacing) cues to identity (e.g., McKone & Boyer, 2006; Mondloch et al., 2002). Despite these abilities, children continue to make more errors on a variety of face perception tasks until mid-adolescence (e.g., Baudouin, Gallay, Durand, & Robichon, 2010; de Heering, Rossion, & Maurer, 2012; Freire & Lee, 2001; Mondloch, Dobson, Parsons, & Maurer, 2004; Schwarzer, 2000). There is debate as to whether these age-related improvements in face processing can be attributed to face-specific perceptual development or to more general cognitive and perceptual development (reviewed in McKone, Crookes, Jeffery, & Dilks, 2012). For example, Weigelt and colleagues (2014) reported improved performance in both face perception and face memory tasks between 5 and 10 years of age. However, whereas improvements in face memory were domain specific, improvements in face perception were not; similar improvements in perception were observed for cars, bodies, and scenes.

Regardless of the extent to which improvements in face perception during childhood reflect domain-specific versus domain-general development, two statements appear to be accurate. First, many of the mechanisms underlying adult-like face processing are present early in life (McKone et al., 2012). Second, face perception (e.g., the ability to discriminate faces) continues to improve throughout childhood (e.g., Baudouin et al., 2010; Mondloch et al., 2004). Thus, childhood may be characterized as a period of refinement. For example, although even infants are sensitive to differences among faces in feature spacing (Hayden, Bhatt, Reed, Corbly, & Joseph, 2007), adult-like sensitivity develops after 10 years of age (Mondloch et al., 2002) even when memory demands are eliminated (Mondloch et al., 2004). In the current study, we examined the extent to which refinements in norm-based face coding may contribute to children's tendency to make more errors than adults on face perception tasks. In particular, we examined whether 5-year-olds' face space is less well refined than that of adults with regard to the dimensions of faces from different categories.

Norm-based coding

Adult expertise in face processing has traditionally been attributed to the use of norm-based coding. According to Valentine (1991), individual faces are encoded relative to a face prototype (i.e., average face) extracted from all faces previously encountered. Individual faces differ on a variety of dimensions (e.g., distance between the eyes), and each dimension is represented as a unique vector in a multidimensional face space. Within this face space, individual faces are represented as distinct points; the farther a face is from the prototype, the more distinctive and less attractive it appears (Rhodes & Tremewan, 1996).

The face prototype is continuously updated by experience. Adaptation is an experimental method commonly employed to examine the malleability of the prototype. For example, repeated exposure to faces distorted in a similar direction (e.g., features compressed inward) produces a temporary shift in the prototype that results in unaltered faces appearing distorted in the opposite direction while similarly distorted faces appear more attractive, referred to as figural aftereffects (Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003; Webster & MacLin, 1999). Thus, judgments of attractiveness require participants to reference a norm that is temporarily altered by exposure to distorted faces. Aftereffects