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Three studies on configural face processing by chimpanzees

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Abstract

Previous studies have demonstrated the sensitivity of chimpanzees to facial configurations. Three studies further these findings by showing this sensitivity to be specific to second-order relational properties. In humans, this type of configural processing requires prolonged experience and enables subordinate-level discriminations of many individuals. Chimpanzees showed evidence of a composite-like effect for conspecific but not human faces despite extensive experience with humans. Chimpanzee face recognition was impaired only when manipulations targeted second-order properties. Finally, face processing was impaired when individual features were blurred through pixelation. Results confirm that chimpanzee face discrimination, like humans, depends on the integrity of second-order relational properties.

Keywords: Face processing; Configuration; Expertise; Chimpanzee; Composite effect

1. Introduction

Numerous studies have demonstrated that human faces are recognized primarily using the configurational arrangement of facial features. In their seminal article, Diamond and Carey (1986) differentiated two types of configural information present in faces. First-order relational properties refer to the relative arrangement of facial features which is similar in every face, i.e., the eyes are laterally displaced above the nose, which is above the mouth, etc. This type of configural information provides the means for recognizing faces from other categories of visual stimuli. Newborn babies, for example, are more attracted to face-like patterns than nonface like patterns, suggesting that attraction to and/or the ability to use first-order relational information might be present from birth (Goren, Sarty, & Wu, 1975; Mondloch et al., 1999; Valenza, Simion, Cassia, & Umilta, 1996). Second-order relational properties reflect the prototypical arrangement of facial features into a standard template, i.e., the spacing between the eyes and mouth, which is more or less unique to every face. This prototypical configuration of facial features establishes the formation of individual representations, enabling specific individuals to be distinguished from one another through the use of facial information alone. Thus, while first-order relational properties enable the identification of faces at a basic categorical level, second-order relational properties facilitate the subordinate-level classification of faces, i.e. the ability to distinguish Mary from Jane.

One of the most robust methods for investigating configural vs. feature-based face processing is the inversion effect. Inverting faces by rotating them 180° from their typical upright orientation results in impaired recognition response times and accuracy (Valentine, 1988; Valentine & Bruce, 1988; Yin, 1969). This is because inverting faces impairs the ability to extract various aspects of configural information, including both first-order relational features, second-order relational features and holistic information (Maurer, Le Grand, & Mondloch, 2002). Studies of the inversion effect in nonhuman primates are limited but there is strong evidence for the inversion effect in chimpanzees. Parr and colleagues, for example, demonstrated significant

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inversion effects for unfamiliar chimpanzee and human faces, the categories that the chimpanzee subjects were familiar with, but not for discriminations involving the faces of an unfamiliar species of monkey, the capuchin, automobiles, or abstract shapes (Parr, Dove, & Hopkins, 1998). In these studies, subjects used a joystick-controlled cursor to select one of two inverted stimuli that matched the sample, i.e., the same stimulus presented in its upright orientation. Tomonaga (1999) also found the inversion effect in chimpanzees when discriminating human faces. Moreover, a recent study found that chimpanzee's performance matching unfamiliar faces compared to houses was significantly affected by their angle of orientation: as faces were rotated away from their veridical angle (0°) towards their inverted orientation (180°), performance declined linearly (Parr & Heintz, in press). This is interpreted as evidence against a dual-processing strategy for upright and inverted face, with upright faces being processed configurally and inverted faces being processed using feature-based cues. If the dual-process account were correct, performance would not show a linear decline with angle of rotation but would be expected to return to typical upright levels with inverted images once the processing shift has occurred. This suggests that upright and inverted faces are not processed using separate perceptual mechanisms, one configural and the other feature based, but rather Hominoids must preprocess inverted faces into their typically viewed upright orientation to make use of configural features (Collishaw & Hole, 2002).

Rhesus monkeys were also tested using the same computerized matching-to-sample tasks as the chimpanzees and they showed no evidence of familiarity-dependent inversion effects for faces. These monkeys showed significant impairments discriminating inverted compared to upright faces of unfamiliar humans, the capuchin monkey faces and automobiles, but not their own species' faces (Parr, Winslow, & Hopkins, 1999). Published studies on the inversion effect in monkeys, however, are conflicting. Some have reported evidence of the inversion effect in macaques and chimpanzees (Tomonaga, 1994; Vermeire & Hamilton, 1998), while others have failed to find evidence of orientation-specific processing for faces in monkeys (Bruce, 1982; Parr et al., 1999) or chimpanzees (Tomonaga, Itakura, & Matsuzawa, 1993). Some authors have suggested that the inversion effect occurs only with low-spatial frequency homogeneous stimuli which bias processing towards the use of configurational cues regardless of expertise (Phelps & Roberts, 1994; Wright & Roberts, 1996). These authors suggest that human faces are more homogeneous than nonhuman primate faces making the inversion effect a phenomenon specific to human faces. There is little empirical evidence, however, to support such a view in nonhuman primates. Therefore, studies of the inversion effect have consistently shown that chimpanzees are sensitive to the configurational arrangement of facial features when processing familiar categories of faces like conspecifics and humans, while data from monkeys suggest that they may use a different perceptual strategy. More comparative research is needed before any similarities and differences in the face processing strategies between apes and monkeys can be fully understood.

A second widely recognized test of configural face processing, particularly holistic, second-order relational processing, is the face composite effect (Young, Hellawell, & Hay, 1987). In this task, the top half of one individual's face is either aligned or misaligned with the bottom half of another individual's face. In the seminal study, subjects were first familiarized to the individuals (most of the individuals were already famous for subjects) and then were presented with either the aligned or misaligned composite and asked to name either the top or bottom half individuals as quickly as possible. Because faces are processed using second-order relational features, our configural face processing system fuses the identity of the individuals in the aligned condition, making it very difficult to detect that the aligned composite is actually composed of two different individuals. In this case, subjects were impaired at naming the individuals from their face parts, regardless of whether they were asked to name the top or bottom half individual. When the face parts were misaligned, however, humans had little difficulty in recognizing that the face consisted of parts from two different individuals and were especially good at naming the individual represented by their top face half (Young et al., 1987; experiment 1). The composite effect was found for faces of both famous, highly recognizable individuals and unfamiliar individuals (Young et al., 1987; experiment 3). The reaction time advantages for misaligned composites were eliminated by inverting the composite faces, as configurational cues are not readily available in inverted faces (Collishaw & Hole, 2000; Young et al., 1987).

The human developmental literature has historically reported a strong relationship between age and face processing skills, with the critical period falling between 6 and 10 years of age (Diamond & Carey, 1977; Goldstein & Chance, 1964; Mondloch, Geldart, Maurer, & Le Grand, 2003). Young children, for example, were more distracted when required to match faces that contained paraphernalia, such as hats, glasses and other external features, compared to children over 10 years of age. This was interpreted as evidence of a shift from piecemeal, or feature based processing, to configural face processing that requires attention to inner facial details (Diamond & Carey, 1977). Some studies have continued to support a general shift in face processing skills in children over 10 years of age. When presented with the task of recognizing classmates from inner compared to outer facial features, children under 7 years of age showed the best performance when the whole face was presented but were significantly better on the external compared to internal feature manipulations. After 9 years of age (9–11 years age group), performance was better for discriminations involving inner compared to external features (Campbell, Walker, & Baron-Cohen, 1995). Sensitivity to second-order relational features was supported in a recent study by Mondloch, Le Grand, and Maurer (2002) who found children between 6 and 8 years of age to be more impaired