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ASSESSING THE PERCEPTION OF FACE PAREIDOLIA IN CHILDREN AND
NONHUMAN PRIMATES

by

MOLLY FLESSERT

Under the Direction of Michael J. Beran, PhD

ABSTRACT

Face pareidolia is the misperception of a face in an inanimate object and is a common error of the face detection system in humans. Whereas there are many similarities in how humans and nonhuman animals such as monkeys perceive and respond to faces, it is still unknown as to whether other species also perceive this illusion. I presented a novel computerized task to capuchin monkeys (*Cebus apella*), rhesus monkeys (*Macaca mulatta*) and pre-school aged children (*Homo sapiens*). This task trained subjects to choose faces over nonface images, and then presented pareidolia images with nonface images. All species selected faces most often on trials that included face images. However, only children selected pareidolia images at levels above chance. These results suggest that while children do perceive face pareidolia, monkeys do not. These species differences could be due to human-unique experiences that result in a sensitivity to extracting face-like patterns in objects.

INDEX WORDS: Visual perception, Perceptual processing, Face perception, Illusory perception

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NONHUMAN PRIMATES

by

MOLLY FLESSERT

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Arts

in the College of Arts and Sciences

Georgia State University

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2020

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MOLLY FLESSERT

Committee Chair: Michael J. Beran

Committee: David Washburn

Şeyda Özçalışkan

Jessica Taubert

Electronic Version Approved:

Office of Graduate Services

College of Arts and Sciences

Georgia State University

August 2020

DEDICATION

I would like to dedicate this work to my family. Without their love, support, and guidance I would not be where I am today.

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I would like to acknowledge my committee members, David, Seyda, and Jess, for all their advice and guidance throughout the duration of this project. I would also like to thank all the members of the Comparative Intelligence and Cognition (COMIC) lab for their support and help with data collection. Thank you to the hardworking animal care and veterinarian staff of the Language Research Center who work tirelessly to keep the monkeys happy and healthy. Finally, a special thanks to my graduate advisor and committee chair, Mike Beran, for the incredible amount of support and advice that has ultimately gotten me to this point.

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1 INTRODUCTION

1.1 Purpose of the Study

Face perception is a fundamental cognitive process that underlies social interactions and provides information such as an individual's identity, sex, age, and emotional state. Humans can detect faces rapidly and without effort, an ability demonstrated by rapid saccade speed (Crouzet et al., 2010; Rousselet et al., 2003), captured attention (Langton et al., 2008; Theeuwes & Van der Stigchel, 2006), and search efficiency (Hershler et al., 2010; Hershler & Hochstein, 2005). Even from infancy, humans spend more time looking at face-like than nonface like patterns (Crouzet et al., 2010; Farroni et al., 2005; Goren et al., 1975). The importance in being able rapidly to detect and recognize faces is also apparent by the specialized cortical regions responsible for processing facial stimuli (Haxby et al., 1999; Kanwisher et al., 1997; Kanwisher & Yovel, 2006; Tsao & Livingstone, 2008). Despite their proficiency in detecting and recognizing faces, humans are still prone to perceptual disruptions during face processing. For example, when faces are inverted, the ability to recognize and discriminate faces from each other is greatly hindered (Yin, 1969). So, despite being an integral and essential human behavior, organizing and processing facial information is not an infallible process. It is in these errors, however, that we can better understand what it is about faces that causes us to respond so strongly to them. For example, does the basic configuration of eyes and mouth warrant these behaviors across species, or must there be relevant social and featural information as well?



Figure 1. Examples of face pareidolia

An example of a face processing error that is not well understood is the phenomenon of recognizing a face when one is not present – an illusion known as face pareidolia (Kato & Mugitani, 2015; Mamiya et al., 2016; Proverbio & Galli, 2016). Even in the most non-living of stimuli such as collections of objects, or in other highly recognizable stimuli, such as foods, the organization of certain features still leads to a sense that one is looking at a face (Figure 1). Perhaps one of the reasons humans are so susceptible to this illusion is due to their exceptional ability to detect and recognize faces, resulting in a sensitivity to the configural pattern of a face. Alternatively, humans may experience this illusion due to an increased tendency to anthropomorphize objects, especially in media. Face pareidolia is a common human phenomenon, with notable examples including the perception of Jesus’s face on a piece of toast or seeing a face in the clouds (Liu et al., 2014). Currently, much of the research investigating this illusion employs neurological measures including event-related potentials (ERPs), functional magnetic resonance imaging (fMRI), or magnetoencephalography (MEG) to assess whether areas typically activated by viewing faces are also activated by the perception of face pareidolia (Hadjikhani et al., 2009; Liu et al., 2014; Proverbio & Galli, 2016; Wardle et al., 2017). For example, illusory faces have been found to activate the fusiform face area (FFA) – an area typically associated with face processing (Liu et al., 2014; Wardle et al., 2017). A handful of studies have used behavioral measures to assess this illusion. For example, Takahashi and Watanabe (2013) found that examples of face pareidolia elicited a gaze shift, indicating that humans allocate attentional resources to the perception of illusory faces similarly to how we allocate attentional resources to real faces. In another experiment, humans used a 200-point slider scale and consistently rated the pareidolia images as more “face-like” than control images (Taubert et al., 2017). A few experiments, described in more detail later, have studied whether

this illusion is present in young children or infants, using looking-time measures and categorization tasks (Beran et al., 2017; Kato & Mugitani, 2015; Kobayashi et al., 2012).

Overall, this phenomenon appears to be well-established in humans and has added to a better understanding of the human visual processing system. However, very little is known about whether, or to what extent, nonhuman animals, such as monkeys, perceive this illusion – despite an established shared sensitivity to faces (for a review see Parr, 2011a).

Studying face pareidolia in nonhuman primates presents a unique opportunity to understand better the perceptual processing of these images and whether these images elicit the prioritization of certain processing strategies across species. For instance, face pareidolia could represent an error of preferential processing strategies pertinent to looking at faces rooted in many primate species' sensitivities to seeing faces frequently. Therefore, studying this illusion in multiple species will provide a more complete understanding of face processing and elucidate whether the misperception of illusory faces is unique to humans or an error of a shared face-processing strategy common across multiple species of primates.

1.1.1 Global versus local processing in humans

A critical part of early perceptual processing of visual stimuli that underlies face and object recognition involves the integration of individual features. Adult humans tend to discriminate environmental stimuli by attending to the global features, rather than the individual, or local, features (Broadbent, 1977; Kimchi, 1992; Lamb & Robertson, 1988; Navon, 1977, 1981; Neiworth et al., 2006). For example, Navon (1977) used stimuli made up of small letters arranged in the shape of a larger letter. Adults responded faster to the global form (the larger letter) rather than the local properties (the small letters that formed the large letter). This is described today as having a global precedence. This processing strategy is aligned with Gestalt

Theory, which states that a stimulus is perceived as a ‘sum of its parts’ and often in its “best form” (for a review, see Melnick, 1997). In fact, our tendency to group stimulus elements in this way has resulted in several perceptual errors, including various visual illusions. For example, in the Solitaire illusion, same-colored items on the periphery of an array appear less numerous because they lack the cluster-grouping of the other-colored inner items, despite these items being equal in number (Frith & Frith, 1972; Wertheimer, 1938). Misperceptions in size occur in the Delboeuf and Ebbinghaus-Titchener illusions, when identical central circles appear to be different in size due to our grouping of all the stimulus elements (Aglioti et al., 1995; Bondarko & Semenov, 2004; Cooper & Weintraub, 1970; Coren & Enns, 1993; Delboeuf, 1892; Ebbinghaus, 1902; Jaeger et al., 2014; McClain et al., 2014; Nicolas, 1995; Van Ittersum & Wansink, 2012; Weintraub, 1979; Weintraub & Schneck, 1986). Our tendency to process stimuli globally has led to decades of research on human face processing and the intricacies of how our perceptual system organizes faces into a coherent, whole form – also known as holistic face processing (for reviews see Maurer et al., 2002; Richler & Gauthier, 2014). In line with global and Gestalt processing, humans group individual facial features (the eyes, nose, and mouth) into what we effortlessly recognize as a holistic face (Tanaka & Farah, 1993; Tanaka & Simonyi, 2016; Taubert et al., 2011; Wagemans et al., 2012).

Global perceptual processing is largely the outcome of a developmental progression. As they grow older, children become more efficient at processing stimuli globally than by their individual parts. Whereas several studies suggest that local perceptual processing is the dominant mode of processing in young children, other studies suggest that young children equally discriminate and replicate by hand-drawing hierarchical stimuli based on their global *and* local properties, and that by the age of 8 years an adult-like global-dominant processing strategy

emerges (Carey & Diamond, 1977; De Lillo et al., 2005; Dukette & Stiles, 1996, 2001; Elkind et al., 1964; Nayar et al., 2015; Poirel et al., 2008). For example, four-year-old children had more difficulty than six-year old children in integrating individual parts of a spatial array into a coherent whole, but they still demonstrated an ability to do so, and this ability improved with age (Dukette & Stiles, 1996). Proximity of local elements within a perceived stimulus plays a large role in one's ability to group those elements into a whole, and this is also seen in the developmental literature. In one study, children (ages four and five) showed a global bias only when the local elements of the stimuli were densely spaced, but equivalent discrimination was seen for global and local properties in sparsely spaced stimuli (Neiworth et al., 2006). When distance between elements was increased, 4- and 5-year-old children experienced larger deficits than 6- and 8- year-olds in integrating the remaining parts into a coherent whole, whereas older children and adults did not (Dukette & Stiles, 2001). Despite this age difference, the younger children were still competent in reproducing the global form from memory. Therefore, while the efficiency of global processing increases with age, younger children are still proficient processing the global features of images. In terms of the perception of face pareidolia, children, especially children under five years of age, may be more susceptible than older children and adults to interference by local elements and less efficiency in grouping elements together to recognize the face-like configuration characteristic of face pareidolia.

1.1.2 Face perception in humans

As with hierarchical/compound stimuli discussed earlier, human adults process more complex stimuli, such as faces, globally. This is often referred to as holistic face processing (Farah et al., 1998; Richler et al., 2011). Maurer and colleagues (2002) described three ways in which faces are processed: the detection of a face by the recognition of its first-order features

(eyes, nose, mouth, etc.), the integration of these features into a ‘whole,’ and finally the discrimination of one face from another based on second-order information (how these features are arranged relative to each other and thus, the variance between faces).

Holistic face processing has been studied with various testing paradigms in the human literature. One of the most common is the face inversion effect (Diamond & Carey, 1986; Tanaka & Farah, 1993; Yin, 1969). Humans are impaired in their ability to discriminate and recognize faces when the faces are inverted or rotated 180 degrees. In other words, the faces’ typical second-order properties are altered, and this causes issues in recognition and discrimination. Whereas it is still debated as to whether the face inversion effect relies completely on second order relational information and how we integrate features into a whole or also on individual feature processing as well (Civile et al., 2014, 2016; Diamond & Carey, 1986; Rakover & Teucher, 1997; Rhodes et al., 1993), research suggests that the inversion effect is largely a result of a holistic face processing strategy for upright faces (Freire et al., 2000; Leder & Bruce, 2000; Leder & Carbon, 2006; Rosenthal et al., 2018; Rossion, 2008; Sergent, 1984; Van Belle et al., 2010). Further, research on this effect suggests that inversion is specific to faces because of our level of expertise and experience attending to faces in our day-to-day lives (Diamond & Carey, 1986; Leder & Carbon, 2006; Robbins & McKone, 2007) and because faces are “special” to us (Farah et al., 1998; McKone et al., 2007; Yin, 1969). This specialness is reflected in our rapid ability to recognize faces holistically and configurationally, so much so that they are set apart from other objects (Watson, 2013). Some research suggests that our rapid holistic processing of faces is partially contingent on our experience, and thus expertise, with specific face categories. For example, the ‘other race effect’ describes an ability to discriminate faces of an observer’s own race better than faces of people of other races (e.g., Michel et al.,

2006). Therefore, face processing is influenced both by the grouping of features into a holistic form but also from experience.

Another way of testing holistic face processing through face inversion is through the Thatcher Illusion. This illusion was first demonstrated using pictures of Margaret Thatcher's face, with just the eyes and the mouth inverted – making the face appear 'grotesque' (Thompson, 1980). However, when this 'Thatcherized' image was inverted, the unusual orientation of local features relative to the whole face is no longer easily detectable. As in the typical face inversion effect, holistic processing is impaired when the image is turned upside down, making changes in the local features less noticeable compared to when it is presented right side up. Evidence for the Thatcher illusion has been shown in humans ranging from infants to adults (Bartlett & Searcy, 1993; Bertin & Bhatt, 2004; Leder & Carbon, 2006; Utz & Carbon, 2016).

The composite face effect has also been used to assess holistic face processing. In the composite face effect, it is more difficult to identify top halves of a face when they are aligned with different bottom halves (Murphy et al., 2017; Young et al., 1987). Holistic processing strategies cause us to group these two different halves into a whole, unique face. This creates the illusion of a novel face and makes it more difficult to identify the top halves of these composite faces. On the other hand, misaligning the halves of the faces disrupts configural/holistic processing of the face, making it easier to identify identical top halves of faces in this condition. Overall, the composite face effect demonstrates how our tendency to process faces holistically can interfere with how we recognize faces. This effect has been well documented in several studies with adults (Goffaux & Rossion, 2006; Le Grand et al., 2004; Maurer et al., 2002; McKone, 2008; Mondloch et al., 2002; Murphy et al., 2017; Young et al., 1987).

For young children, whose efficiency in global processing seem to mature with age, there is conflicting evidence as to whether faces conform to this rule. Some research suggests that younger children seemed to process faces more by local features rather than the holistic method seen in older children and adults (Carey et al., 1980; Carey & Diamond, 1977; Schwarzer, 2000). For example, Carey et al. found a face inversion effect in older children, but not in younger children, suggesting that holistic face processing, like global processing, is a product of development. However, studies that provide evidence for predominantly local processing of faces in young children also tended to use larger stimuli (Lundy, 2001; Nakabayashi & Liu, 2014). As mentioned earlier, children are more likely to respond to the local feature changes when stimuli have larger inter-element distances, so larger stimuli might explain some of these patterns. However, studies that have used smaller (more densely spaced) stimuli tend to report holistic face processing in children as young as three (Baenninger, 1994; Flin, 1985; Lundy, 2001). Therefore, results indicating developmental differences in face processing may be the result of insufficient stimulus sets.

Many studies have reported that young children are, in fact, sensitive and responsive to the configurational properties of faces and, thus, are processing faces holistically (Hayden et al., 2007; McKone & Boyer, 2006; Mondloch et al., 2003; Pascalis et al., 2011; Petrakova et al., 2018; Quinn & Tanaka, 2009). Schwarzer and colleagues (2007) posited that between 4 and 10 months of age, infants shift from a featural processing strategy towards a configural face processing strategy. Additionally, newborns and infants as young as a few months old have been shown to prefer faces that are configurally accurate and upright (Bhatt et al., 2005; Cohen & Cashon, 2001; Rose et al., 2008; Slater et al., 2000; Turati et al., 2004). Although it is generally weaker than in adults, multiple studies report the face inversion effect in infants and young

children (Brace et al., 2001; Joseph et al., 2015; Joseph et al., 2006; McKone & Boyer, 2006; Meinhardt-Injac et al., 2014; Rose et al., 2009; Schwarzer, 2000; Tanaka et al., 1998).

Additionally, the composite face effect appears to be present in children ranging from just a few months old to 13 years old (Carey, 1996; Carey & Diamond, 1994; Cassia et al., 2009; de Heering et al., 2007; Pellicano & Rhodes, 2003; Susilo et al., 2009; Tanaka et al., 1998; although, see Mondloch et al., 2007; Turati et al., 2010 for evidence for developmental differences in the inversion effect). Overall, like with nonface stimuli, children are likely able to process faces in a global – or holistic – manner. In fact, the special role that faces play and our abundant experience with faces may explain why many of these studies find holistic processing in children as young as a few months old. However, these studies also suggest that holistic face-processing in young children may not be fully developed into its adult like form – also consistent with what is seen in nonface hierarchical stimuli. Studying face pareidolia in children will provide interesting insights into how well they can prioritize a global/holistic processing strategy in images that lack the correct facial features over images that contain real facial features but lack the correct facial configuration. If children readily perceive and judge pareidolia images as face-like, this would indicate that just the configuration of features is enough to trigger a response similar to the one elicited by real faces.

Children, even in infancy, are sensitive to face-like configurations, but few researchers have investigated the perception of face pareidolia in children. Kato and Mugitani (2015) used looking time to measure whether infants recognized illusory faces made up of ‘blobs.’ Results showed that 10 and 12 month old infants looked at the ‘blob’ representing the mouth region more often when presented upright than inverted whereas 8-month old infants did not, suggesting that older infants perceive the blobs as illusory faces and look to the mouth blob due to an existing

sound-mouth association (Kato & Mugitani, 2015). In another study, researchers presented Arcimboldo images (portraits of people that are made up of various fruits, vegetables, and plants) to infants and found a viewing preference for upright, but not inverted, exemplars (Kobayashi et al., 2012). However, it remains unclear whether these responses represent explicit recognition of a pattern being “face-like” or an implicit attraction to this particular configuration (without the adult-like recognition of it being similar to that of a real face). Alternatively, three- to five-year-old children were given a categorization task in which they categorized Arcimboldo images as faces significantly more often than they did scattered images with no face-like configuration (Beran et al., 2017). Therefore, by the age of three children’s holistic processing of faces is sophisticated enough to elicit explicit recognition of illusory faces. Despite these promising results, it remains unclear the extent to which children can explicitly judge illusory faces as more or less face-like, especially with a wider variety of pareidolia images that differ from the Arcimboldo portraits.

1.1.3 Global versus local processing in nonhuman primates

Studying how nonhuman animals perceive the world has greatly aided our understanding of what perceptual mechanisms and phenomenon are common across species or unique to humans. Therefore, our knowledge of the developmental progression and perception of face pareidolia in humans could be bolstered by studying this illusion in nonhuman animals such as monkeys. Comparing how monkeys and humans perceive the world around us can help us to understand how perceptual processing strategies differ across the primate phylogeny. For example, differences in how monkeys and apes perceive the global and local properties of stimuli has provided evidence that a more global-processing strategy has likely developed before the emergence of modern humans and helps explain some differences in perceptual errors across

species. Alternatively, understanding how primates process some stimuli similarly (like faces), can provide useful insight into how experience with stimuli and the importance of certain characteristics result in similar phenomena (see the sections below in the face inversion and composite effect). Therefore, we can benefit by expanding our study of perception from a development perspective and including a comparative approach. Doing so can help disentangle the roles of certain perceptual processing strategies as well as how experience may influence the perception of visual illusions. In other words, only studying face pareidolia in children does not provide a sufficient explanation or understanding of the underlying perceptual processing strategies that play a role in illusory face perception. The differences in how children and adults perceive hierarchical stimuli are confounded with factors such as experience, development, and so on, and those confounds can blur our understanding of how this illusion is truly being perceived. Studying face pareidolia in nonhuman primates will serve to clarify inconsistencies that remain in the developmental literature and how species differ in the processing of different stimulus characteristics.

Nonhuman primates, like humans, have cortical areas that are made up of face-selective neurons responsible for processing information extracted from faces (Ku, Tolia, Logothetis, & Goense, 2011; Leopold & Rhodes, 2010; Piskunov et al., 2005; Tsao et al., 2003; Tsao et al., 2008a, 2008b; Yovel & Freiwald, 2013; see Parr, 2011, for a review). Some of these areas are sensitive to face-like patterns as well (Nguyen et al., 2014). Additionally, nonhuman primates demonstrate specialized behavioral responses to faces, such as fast and efficient search and a proficiency in discriminating faces based on features such as identity, familiarity, expression, and more (Parr, 2003; Parr et al., 2000; Pokorný & de Waal, 2009a; Talbot et al., 2016). Efficient search for faces and captured attention towards faces have also been demonstrated in chimpanzees

(Tomonaga & Imura, 2009, 2015). Nonhuman primates and other animals, like humans, also demonstrate strong preferences for viewing faces and facial features in the correct configuration (Dupierrix et al., 2014; Farroni et al., 2005; Goren et al., 1975; Gothard et al., 2004; Kuwahata et al., 2004; Myowa-Yamakoshi & Tomonaga, 2001; Rosa-Salva et al., 2010; Rosa Salva et al., 2011; Sugita, 2008). Given their closely related biological and psychological systems, nonhuman primate species have long been studied to understand our hypersensitivity to faces and the evolutionary origins for our behavioral response towards faces.

Despite the multitude of shared, specialized responses to faces, there also appear to be some highly relevant differences among primate species in other aspects of cognitive and perceptual abilities. For example, comparative work suggests that ape and monkey species differ in their precedence of global versus local stimulus properties during discrimination tasks. Like humans, chimpanzees discriminate hierarchical stimuli based on their global properties (Fujita & Matsuzawa, 1990; Hopkins & Washburn, 2002; Tomonaga & Matsuzawa, 1992; but see Fagot & Tomonaga, 1999, for a study in which chimpanzees did not show a global bias). Hopkins and Washburn (2002) used a sequential matching-to-sample task in which subjects had to match a hierarchically compound stimulus (like in Navon's studies; e.g., a large 'F' made up of smaller 'E's) to an identical sample while ignoring a foil stimulus that differed either at the global, local, or both levels. Chimpanzees performed better when the difference between the two stimuli was global in nature.

Monkeys, unlike humans and other great apes, rely more on local features when discriminating hierarchical stimuli (De Lillo et al., 2005, 2012; Deruelle & Fagot, 1998; Fagot & Deruelle, 1997; Hopkins & Washburn, 2002; Neiworth et al., 2006; Spinozzi et al., 2003, 2006, 2009). However, the local precedence observed in monkey species has varying degrees of

strength in its actual perceptual bias. For example, rhesus monkeys performed similarly when discriminating stimuli that differed on either local or global information in the study by Hopkins and Washburn (2002). Therefore, this “local bias” might be better described as a lack of global bias. Capuchin monkeys were biased towards local features in a matching-to-sample task, but this bias weakened when inter-element distance was decreased and the stimuli appeared denser (Spinozzi et al., 2003). Similarly, Neiworth et al. (2006) found that tamarins, after being trained to select a circle made up of smaller circles, were just as likely to select a global circle made up of local squares as a global square made up of local circles when inter-element distance was larger. However, when the interelement distance was reduced and the same stimuli appeared more densely arranged, monkeys showed a global bias. Baboons also initially showed a local bias towards the same stimuli in which humans showed a global bias (Fagot & Deruelle, 1997). However, when this was tested with reduced inter-element distance the local bias in baboons was also reduced (Fagot et al., 2001). Therefore, monkeys may rely equally on local features and global configurations when discriminating stimuli whereas apes rely more on the global configuration. This is similar to the literature on children’s ability to discriminate and reproduce hierarchical stimuli. For example, cotton top tamarins and capuchin monkeys discriminated these arrays similarly to how young children performed (De Lillo et al., 2005; Neiworth et al., 2006). Several studies have reported that monkeys, apes, and young children can perceive stimuli at both the local and global levels effectively (Deruelle & Fagot, 1998; Dukette & Stiles, 1996; Fagot & Deruelle, 1997; Fagot & Tomonaga, 1999; Feeney & Stiles, 1996; Hopkins & Washburn, 2002; Prather & Bacon, 1986; Stiles et al., 1991; Stiles & Tada, 1996; Tada & Stiles-Davis, 1989). Therefore, it is important to understand whether monkeys and children perceive face pareidolia to similar degrees – doing so could reveal important species similarities related to

how stimulus characteristics are grouped and perceived. Alternatively, it could lend crucial insight into the role that human experience plays in perceiving faces from a young age.

Building on studies of global and local processing, research has also investigated whether nonhuman animals are susceptible to the same misperceptions as humans (see Feng et al., 2017, and Wasserman, 2012, for reviews). For example, chimpanzees do not perceive the Solitaire illusion, but rhesus monkeys and capuchin monkeys sometimes do (Agrillo et al., 2014). This is surprising because we might expect that because chimpanzees, like humans, tend to process stimuli globally, they should also experience the Gestalt grouping principles that cause humans to perceive the “grouped” arrays as more numerous in the Solitaire illusion. However, rhesus and capuchin monkeys do not readily perceive the Delboeuf illusion (Parrish et al., 2015), but chimpanzees, like humans, do (Parrish & Beran, 2014). These results are consistent with a more predominantly global processing strategy in apes. Additionally, baboons failed to perceive the Ebbinghaus-Titchener illusion (Parron & Fagot, 2007). Overall, these results are consistent with what we would expect given the differences in monkeys’ and apes’ local and global processing strategies. Further, these studies demonstrate the visual illusions are sometimes, but not always, common across species of primates.

1.1.4 Face perception in nonhuman primates

Given what we know about how monkeys and nonhuman apes process nonface hierarchical stimuli, we might not expect to find evidence for the face inversion effect of the composite face illusion in monkey species. However, research suggests that monkeys often display a global precedence when it comes to faces, and that, they too, process faces holistically (Taubert et al., 2012a; for a review see Parr, 2011a). As mentioned earlier, faces are salient and important stimuli, and they are the foundation of many social interactions. Therefore, a need to

recognize and distinguish one face from another quickly likely causes many species of primates to process faces holistically even from infancy, despite some species' tendencies to process other environmental stimuli locally (Kuwahata et al., 2004; Parr, 2011a; Parr et al., 2006; Paukner et al., 2014; Sugita, 2008). Evidence for holistic face processing has been shown in several studies investigating the face inversion effect in great apes and monkeys. Chimpanzees are better at discriminating faces when they are presented upright than when they are presented inverted (Parr, 2011a; Parr & Heintz, 2006; Parr et al., 1998; Tomonaga, 1999, 2007), indicating that they, like humans, are holistically processing faces. For example, one study found that as faces are rotated from an upright to an inverted position, chimpanzees' impairments in discriminating conspecific faces increased linearly (Parr & Heintz, 2006).

Face inversion effects have been found in cotton-topped tamarins, squirrel monkeys, capuchins, Japanese macaques, and Rhesus macaque monkeys (Dahl et al., 2009; Gothard et al., 2009; Neiworth et al., 2007; Overman & Doty, 1982; Parr et al., 1999; Parr, 2011b; Parr et al., 2000; Parr & Heintz, 2008; Phelps & Roberts, 1994; Pokorny & de Waal, 2009a, 2009b; Pokorny, Webb, & de Waal, 2011; Tomonaga, 1994; Vermeire & Hamilton, 1998; Wright & Roberts, 1996; see Parr, 2011a, for a review). On the other hand, several studies have failed to find conclusive evidence of an inversion effect (Bruce, 1982; Dittrich, 1990; Gothard et al., 2004; Rosenfeld & Van Hoesen, 1979; Weiss et al., 2001). Unlike chimpanzees, rhesus monkeys sometimes appear susceptible to the effect across several stimulus categories, including conspecific faces, chimpanzee faces, capuchin faces, and even sometimes for non-animal stimuli such as houses or automobiles (Parr et al., 1999; Parr, 2011b; Parr & Heintz, 2008). These mixed results in the monkey face inversion literature demonstrates that while monkeys process faces holistically, this tendency may not be as strong as in human and most great ape studies.

Evidence for the Thatcher illusion also demonstrates the inconsistencies apparent in the inversion effect. Studies using viewing preference as a measure of the illusion reported that rhesus macaques do perceive the Thatcher illusion. For example, monkeys' viewing patterns indicated that they perceived normal and Thatcherized conspecific faces as different when they were upright, but less so when they were inverted (Adachi et al., 2009; Dahl et al., 2011). Nakata and Osada (2012) reported evidence of a Thatcher effect in squirrel monkeys, but the monkeys in this experiment had to first undergo training to discriminate between normal and Thatcherized faces, whereas in previous experiments monkeys were not exposed to Thatcherized faces before testing. In a matching task, baboons were unable to discriminate between inverted Thatcherized and non-Thatcherized face (Parron & Fagot, 2008). In a matching-to-sample task paradigm, chimpanzees, but not rhesus monkeys, perceived the Thatcher illusion, indicating a more distinct difference between monkeys' and apes' dependence on configural facial information (Weldon et al., 2013).

Inconsistencies in the composite face effect have also been reported in great apes and monkeys (Taubert, 2010; Taubert & Parr, 2009). Evidence for this effect has been shown in chimpanzees viewing conspecific face images (Taubert et al., 2012b; Parr et al., 2006). In an eye-tracking study, rhesus monkeys showed the composite face effect for chimpanzees and conspecific faces (Dahl et al., 2007). However, Taubert and Parr (2009) reported that rhesus monkeys experienced the composite face effect for chimpanzee but not human faces. Overall, research on the composite face effect indicates that monkeys and apes are processing faces holistically, but perhaps to varying degrees.

1.1.5 A comparative approach to studying face pareidolia

Several of the difficulties with comparative research, especially pertaining to studying face processing, include the variability in which nonhuman subjects are raised and kept and the level of experience the animals have with human experimenters (including whether they see their faces due to differences in personal protective equipment across facilities). Also, comparative research employs a wide spectrum of methodologies and types of stimuli to measure an animal's perceptual experience. There is no benefit of verbal instruction or feedback, so researchers must be especially stringent on task design to ensure that behavioral tasks are, in fact, measuring the intended phenomenon. Still, different types of tasks are often used to measure the same behavior or phenomenon. In the studies summarized above, many only tested one or two species, used tasks ranging from passive eye viewing to active matching paradigms, and the stimuli varied in color, size, angle, or including of various features. Several did not use control stimuli to compare effects of faces against nonface stimuli. Overall, the inconsistencies apparent in comparative findings, especially with research focusing on inversion or composite face effects, could reflect the inconsistencies in methodology. The wide variety of tasks, stimuli, and generally small number of individuals and species included can make it difficult to integrate results into a clear and cohesive conclusion as to one species' overarching perceptual experience, much less a broader claim about primates in general. Because of this, the present study uses two species of nonhuman primates, including both Old World and New World monkeys. The methodology is based upon previous tasks used to measure this phenomenon in hopes of clarifying and/or building on already existing yet seemingly conflicting results.

Currently, there are very few studies of how primates process faces when their local features are not features of a face but contain a facial configuration, such as face pareidolia.

There is some work in which facial information has been degraded, such as when chimpanzees were presented with Mooney faces (in which second-order relational information is limited and discrimination is based on first order properties; Taubert & Parr, 2012). Despite the shared neural and behavioral responses to faces across numerous species of nonhuman primates outlined above, pareidolia has not been well-studied in the comparative literature. A recent eye-tracking study showed a viewing preference for illusory faces over nonface objects as well as higher fixation frequency for illusory “eye” and “mouth” regions (Taubert et al., 2017), consistent with typical primate gaze behavior when viewing a real face (Dal Monte et al., 2014; Guastella et al., 2008; Leonard et al., 2012). This work suggests that monkeys do indeed perceive a face-like configuration in illusory faces. However, an experiment investigating face pareidolia in capuchin monkeys, rhesus monkeys, and children (3 to 5 years old) found that only children, and not monkeys, categorized Arcimboldo images as faces more often than they categorized scattered Arcimboldo images as faces (Beran et al., 2017). This result instead suggests that monkeys do not readily recognize illusory faces, or rather, categorize them as such. However, the apparent inconsistency across these two studies may reflect a difference in the dependent measures generated by differing methodologies, as well as what stage in perceptual processing is being measured. As outlined above, looking-time experiments clearly indicate that primates are sensitive and prefer to look at faces and face-like patterns. It is likely that these studies are measuring an implicit behavior rooted in early perceptual processing. For example, when we walk through a busy hall or take part in a conversation, we are not necessarily aware that we primarily fixate on people’s faces. If this is true for nonhuman primates as well, a preference for looking at an illusory face may not necessarily indicate an explicit recognition of a face-like pattern, but an implicit attraction to that configuration. Holistic processing is described as a

relatively automatic process (Richler et al, 2009; Tanaka & Farah, 1993), so it is possible that the sensitivity towards configural information happens before the explicit recognition of a face is possible.

A task in which subjects are required to make an active response as to whether a stimulus is a face requires more active decision, rooted in later perceptual processing that takes into account previous experiences (such as those that have taught us what is a face and what is not). For example, we may see a “natural” example of face pareidolia (a face in the clouds) or view an Arcimboldo portrait, but we employ our knowledge of the world in order to recognize that, despite its face-like appearance, it is not a true face. In other words, we make an explicit and conscious decision as to the contents of the image. If this is also true for monkeys, they may recognize the face-like pattern of Arcimboldo images (a behavior that could be identified using eye-tracking measures) but make an explicit decision about whether it is truly a ‘face’ or a ‘food’ based on later cognitive processing (a behavior measured by a categorization task). The local features are made up of foods, and therefore it could be categorized as ‘food.’ However, the global configuration appears face-like and could be categorized as ‘face.’ Both categories are simultaneously represented within each Arcimboldo image. So, if a monkey is explicitly recognizing both properties, it may be difficult to identify these images consistently as one or the other. The salience of the local elements (various types of foods) in Arcimboldo images could also play a role in this decision-making process. In fact, Beran and colleagues (2017) found that the monkeys performed at chance levels on this particular discrimination.

Studying face pareidolia in nonhuman primates will elucidate how face processing is involved in early (implicit/passive viewing behavior) and late (explicit/active choice) perceptual processes. It will further our understanding as to what facial characteristics (featural vs

configural) are necessary or prioritized in recognizing and/or categorizing stimuli as a face or as face-like, and, it will increase our knowledge of how different species employ different perceptual processing strategies for a stimulus that lies somewhere between an object and a face. This study will lend insight into how experience (whether it be with faces in general or experience with illusory faces) plays a role in the perception of face pareidolia. Overall, studying face pareidolia in multiple species using consistent methods will clarify true differences or similarities in visual perception across primates. For instance, a difference in how monkeys and children perceive illusory faces (i.e., children perform better at identifying the face-like nature of illusory faces) would indicate that, despite their similarities in processing some stimuli, there are species differences in what stimulus characteristics elicits the recognition and judgment of a face-like pattern. If there is no difference in how monkeys and children recognize illusory faces, and they both respond to such stimuli similarly to real faces, this would suggest that the characteristics that trigger the judgement of an image as “face-like” are shared across multiple primate species, and that this illusion is not unique to just humans.

2 METHODS

2.1 Participants

A total of 21 brown-tufted capuchin monkeys (*Cebus apella*: 14 females and 7 males; 7 to 40 years old) were tested on a computerized task. All capuchin monkeys were group-housed (ranging from 2 to 9 individuals per group) with daily indoor and outdoor access at Georgia State University’s Language Research Center where they had continuous access to water and were fed a diet of primate chow, fruits, nuts, and vegetables by trained animal care staff. During testing, monkeys voluntarily separated into individual testing spaces. Additionally, 7 rhesus macaque monkeys (*Macaca mulatta*: all males between 16 and 36 years old) were tested. All rhesus

macaque monkeys were housed individually with continuous visual and auditory access to nearby conspecifics. Compatible partners were given access to each other multiple times per week in an indoor-outdoor enclosure. Rhesus monkeys had continuous access to water and were fed a diet of primate chow, fruits, nuts, and vegetables by trained animal care staff. Because of the likelihood of failing to engage with or pass through all phases of the task, all monkeys that were available at the time of data collection were tested. Additionally, due to unforeseen circumstances related to the COVID-19 pandemic, data collection concluded earlier and, thus, limited the possible sample size. Overall, 14 of the 21 capuchins that were tested successfully completed all phases of the experiment. Three capuchins completed the pre-test but failed to pass the training and generalization phases (described below) and four capuchins failed to complete the pre-test phase. Therefore, only the 14 capuchins that completed the experiment were included in the analyses. All seven rhesus macaques completed all phases of the experiment.

A total of 46 preschool-aged children (26 female) were tested on the pre-test phase, to ensure no prior preference for choosing faces existed. After pre-test data collection, a total of 60 children (including those tested on the pre-test) participated in the training and test phases of the experiment. Children ranged in age from 37 to 61 months and were tested at local preschools in the Atlanta, Georgia area. According to the literature summarized above, this age range included children for whom global processing typically was not yet the dominant form of perceptual processing, but holistic face processing was commonly reported. Therefore, this age group was an ideal study sample to investigate whether children will employ global processing strategies on a face-like object. Prior to testing, parents read and signed consent forms allowing their children to participate in the study. On the day of testing, children provided verbal assent

and agreed to work with the experimenters. At any time during testing, if children indicated that they wanted to stop working, the experimenters escorted the children back to their classrooms.

2.2 Materials

Testing for the capuchin and rhesus monkeys was conducted using the Language Research Center's Computerized Test System (LRC-CTS; Evans et al., 2008; Richardson et al., 1990). The LRC-CTS includes a testing computer, joystick, color monitor, and pellet reward system per individual. Individual testing spaces were equipped to connect to the LRC-CTS to allow subjects continuous access to the testing system while in those spaces. Monkeys manipulated the joystick to produce movements of a cursor displayed on the monitor. For a 'correct' response, monkeys received a food reward in the form of a banana flavored pellet as well as a positive melodic tone. For an 'incorrect' response, there was no food reward, a negative buzz tone, and a timeout of 20 seconds before the next trial began.

Experimenters brought children from their classroom to a testing room where they worked on touchscreen laptop computers. If children were tested in pairs, they were seated on opposite sides of a table from each other to prevent either child from seeing their partner's screen and/or choices. Children started each trial and made responses by tapping their finger on the image that they selected. Children received audio feedback that corresponded to their response (a buzz if incorrect and a 'woo-hoo!' if correct).

Stimuli consisted of five categories: real faces (F; composed of all three species being tested), pareidolia images/exemplars (P), nonfaces (N; composed of inanimate objects and animate plants and animals that do not contain a face; hereafter referred to as 'objects'), scattered real faces (S) and scattered pareidolia faces (X; see Figure 2 for an example of all stimulus categories). The real face stimuli were from the Labeled Faces in the Wild online free database

(Huang et al., 2007). Rhesus and capuchin face stimuli were gathered from various collaborators' libraries (Rhesus: Dr. Jessica Taubert; Capuchin: Dr. Kate Talbot & Dr. Sarah Brosnan). Illusory face images were collected from the public domain using the Google image search engine.

Object images were gathered from the public domain using the Google image search engine as well as various online databases. Only images under creative commons license and/or labeled for noncommercial reuse with modification were used as stimuli. The pareidolia face images contained a variety of background content, so using the Labeled Faces in the Wild and other online sources to acquire object images ensured that background information was variable for all image categories. The scattered images were created from the F and P stimuli, using a Visual

Basic 6.0 program that divided each image into a 16 X 16 grid and randomized the location of each square in the grid. Only scattered images that did not contain any face-like configuration (no two consecutive squares were aligned horizontally or vertically) were used as S or X stimuli. All stimuli were cropped and resized to square dimensions. Additionally, images were cropped in a manner so that they fully contained the face, face-like configuration, or object. Figure 2 presents examples of all these image types.

All three species viewed face stimuli of capuchin monkeys, rhesus monkeys, and humans. In doing so, all three species encountered the same exact trials and images throughout their respective testing phases. Further, using multiple species' faces as

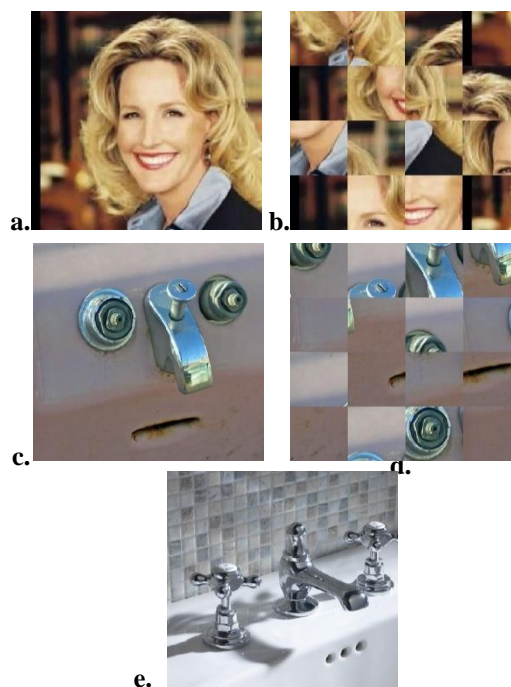


Figure 2. All stimulus categories for the computerized task. a. real face (F). b. scattered real face (S). c. pareidolia (P). d. scattered pareidolia (X). e. nonface (N).

‘face’ exemplars ensured that a general ‘face’ concept was being used during the rule learning in the training phase, rather than any specific features unique to a certain species’ face. Object images contained inanimate objects and animate objects such as plants and animal images in which the face was cropped out or turned away. By including animate objects, this prevented subjects from learning to select an image that was ‘animate’ rather than learning a face-selective rule.

2.3 Design and Procedure

2.3.1 Pretests

The 28 monkeys (21 capuchins, 7 rhesus) were tested on a forced-choice simultaneous matching-to-sample task. Monkeys used a joystick to move a cursor until it came into contact with the sample image, presented at the center of the screen. Then two choices – the target (identical to the sample) and a distractor (of any stimulus category described above) were presented until the monkey moved the cursor to select one of the images. Correct choices (selecting the target) resulted in positive reinforcement in the form of a positive tone and a single 45mg food pellet reward. All stimulus categories were included in this test and target and distractor images were presented randomly in two or four randomly selected positions on the screen. Because all stimulus categories were included, this pre-test served to give the monkeys a positive reinforcement history with each type of stimulus category and avoid biasing their behavior in the training and test phases. For instance, this pre-test was implemented to prevent subjects from avoiding certain stimulus classes that were present in the test phase but not the training and generalization phase and to deter them from using a strategy based on the reinforcement history of the training and generalization phases. The task was made up of blocks of 600 trials. A total of 120 stimuli (30 F, 30 N, 30 S, 30 scattered N) were presented and

repeated throughout these 600 trials. Scattered objects were used in place of scattered pareidolia (X) images to acclimate monkeys to the scattered image appearance but to prevent using the same stimuli in the test phase. Criterion for the completion of the pre-test was a 75% correct on a block of 600 trials, or the completion of five blocks.

The children also completed a pre-test. Thirty pairs of images, each made up of an F and N image were presented on laminated sheets in front of each child. These images were the same images that were later included in the training phase of the computer program. The experimenter instructed the child to point to and/or touch one picture in each pair that they preferred or considered their 'favorite.' Choices were coded on a separate sheet of paper by the experimenter. At the conclusion of this test, children were asked to state why they chose some of the images as their favorite and/or why they preferred certain images over the others. This pre-test determined whether children had a pre-existing bias for selecting face images over nonface images before the training phase. Given the evidence provided by the literature summarized above, if faces are already inherently special to children in a way that causes them to choose these images preferentially, children should already show this pattern even before any training for this rule is done.

2.3.2 Training Phase

All monkeys completed a training and a generalization phase before the test phase of the experiment. In the training phase, monkeys initiated trials by moving the cursor on the screen towards a 'Start' button displayed on the monitor at screen center. Contacting this button resulted in the presentation of two stimuli simultaneously displayed at two of four randomly selected positions on the screen, to eliminate any potential biases for selecting images in certain spatial locations. Each trial presented one F and one N image, and subjects were required to select one

of these images using a joystick to move the on-screen cursor. Choosing the image that contained a real face (F) resulted in positive auditory feedback and a food reward. After a 1 second inter-trial interval (ITI), the 'Start' button indicating the next trial appeared. Choosing the N image resulted in negative auditory feedback and a 20-second time-out. In the training phase, subjects were required to meet a criterion of 80%, or 32 out of the most recent 40 trials completed. After the initial 40 trials, stimuli were repeated. Once this criterion was met, the program automatically progressed the monkey to the generalization phase.

The generalization phase also consisted of 40 trials of F and N stimuli. However, subjects were required to meet criterion of 32/40 correct within these 40 trials. Further, stimuli were novel faces and objects and were not repeated. The purpose of this training phase was to ensure that monkeys could generalize the rule (faces are correct) to new stimuli. Meeting this criterion resulted in the program automatically moving the monkey to the test phase. Failure to reach 32/40 correct resulted in the monkey being placed back into the training phase, viewing the same stimuli as before. Each monkey was given up to five attempts at unique versions of the generalization phase. If they failed to reach criterion after five attempts, they were removed from the study. The 80% training criterion was created to ensure that monkeys were performing at levels of chance or both the training and generalization phase, since we could not give them the rule like we could with children. Further, this criterion level was chosen because it allowed monkeys to maintain interest in the task. For example, if criterion was too strict, animals may have begun to lose motivation to engage with the task because it was more difficult to obtain the food reward.

Testing with the children took place in approximately 15-minute sessions. Because of this, only a brief training phase was completed before the test phase. The training and test phase

were completed within a single session. Each child participated in a minimum of two sessions and a maximum of three. The training phase consisted of a maximum of 40 trials. The child tapped a “Start” button displayed on the laptop screen, then two stimuli appeared at two of four random positions on the screen, to eliminate any potential biases for selecting images in certain spatial locations. Each trial in the training phase presented one F and one N image and the child would make a selection by tapping an image on the screen with their finger. Selecting an F image was followed by a 1 second ITI and positive auditory feedback. Selecting an N image was followed by a 3 second time-out and negative auditory feedback. In order to pass the training phase, children were required to respond correctly to 9 out of the 10 most recent trials completed. Therefore, some children could move on to the test phase in as few as 10 trials. However, if the child failed to meet this criterion within 40 trials, their session was ended. If the child passed the training phase they were prompted with a brief question (“Can you tell me what the rule was for choosing the correct picture?”). The experimenter manually entered the child’s response and then had the child continue to the test phase.

For the children who failed to meet criterion on their first session, they were given an opportunity to repeat that session on a later date where the experimenter told them the rule “Pick the image that looks most like a face.” Regardless of whether children passed or failed training (and ultimately repeated) their first session, all children were told the rule by the experimenter when they participated in the second session. This allowed me to examine whether children were able to comprehend and state the rule on their own without the experimenter’s prompt. Because all children completed a second session having had the rule explicitly stated to them, it was possible to determine whether knowing having the rule impacted performance. Overall, the

children who failed training and repeated the first session before completing the second session were tested on three separate days.

2.3.3 Test Phase

The test phase continued to present F vs. N trials, but now pareidolia (P), scattered real faces (S), and scattered pareidolia (X) were also presented. Scattered pareidolia images were used instead of scattered N images because, like scattered N images, they lacked both face features and face configuration, but controlled for image content that was presented in pareidolia images. For the monkeys, the test phase consisted of 90% baseline trials, which were the same format as the trials from the training phases but presented novel images that were unique from those in the training and generalization phases. The remaining 10% of the trials were composed of five different types of probe trials (F vs. S, F vs. P, P vs. N, P vs. S, and P vs. X; see below for hypotheses and why these specific trial types have been selected). Monkeys completed a total of 2,000 trials in the test phase, collected over multiple sessions. Overall, 1,800 trials were baseline (F vs. N) and 40 trials of each probe trial type were collected. Because of the time limitations for children, test phases consisted of 50% baseline trials and 50% probe trials. Each session presented 100 trials in the test phase, 50 of which were baseline (F vs. N) and 10 each were of the probe trials. Across the sessions, children completed two test phases, totaling 200 trials.

Trial order was randomized, and all stimuli were unique from the training phases. Baseline trials continued to be reinforced with a 1 second ITI and positive auditory feedback. However, probe trials were non-differentially reinforced (resulting in positive feedback 50% of the time and no feedback 50% of the time), to prevent any learning effects or biases for selecting specific stimuli types.

2.4 Hypotheses

I predicted that children and both species of monkeys would select images that contained a face-like configuration over an image that contained no face-like configuration after being trained on a task in which the selection of a face was positively reinforced. Overall, I predicted to find no significant species differences any of the trial types and comparisons outlined below.

When two images that did not contain a real face were presented, subjects should have selected the one that appears more like a face, indicating perception of that image as “face-like.” More specifically, I predicted that in trials that contain a face (F), subjects should have selected the F image above chance levels (see Table 1a). This would confirm that all subjects learned the rule that the image that contains a face was correct. Then, in trials that presented a pareidolia face with a nonface or a scattered pareidolia image (i.e., image categories that did not contain facial features or facial configurations), they should select the pareidolia image more often than chance. This finding would confirm that, in the absence of a real face, an image with a face-like configuration was perceived as more like a face than a nonface/scattered pareidolia face. For trials that paired scattered real faces with pareidolia images, I predicted that subjects would select pareidolia faces significantly above chance levels. This finding would confirm that subjects perceived and relied on the accurate facial configuration of a pareidolia image as more face-like than an image that contained the correct facial features but lacked the correct facial configuration.

For the planned comparisons proposed in this project, I predicted that the proportion of choices for pareidolia faces in pareidolia versus nonface trials would not differ from the proportion choice for real faces in face versus nonface trials (see Table 2). This finding would provide evidence for a pareidolia effect, such that pareidolia faces were being selected at rates

similar to real faces. However, this would only provide strong evidence for a pareidolia effect given that faces were chosen more than scattered faces in F vs. S and that pareidolia images were chosen more than scattered pareidolia in P vs. X. However, if subjects performed at chance level on either of these trial types, it cannot be ruled out that the participants were using a ‘nonface avoidance’ strategy rather than a ‘face selective’ strategy. If monkeys or children relied on a nonface avoidance strategy to progress to the test phase, they should have performed at chance level on trials that only presented images containing face parts (F vs. S) and trials that only presented images containing object parts (P vs. X). For the next comparison, I predicted that the proportion of choices for real faces in F vs. S trials would not differ from the proportion of choices for pareidolia faces in P vs. S trials. Again, this would provide evidence for a pareidolia effect because faces and pareidolia images would be treated similarly when paired with scattered face stimuli. I also predicted that the proportion of choices for pareidolia faces in P vs. S trials would be significantly greater than the proportion choice for pareidolia images in P vs. F trials. If this hypothesis is supported, it would indicate that subjects perceived pareidolia faces as being more face like when paired with a scattered face rather than when paired with a real face. For the final comparison, I predicted that the proportion of choices for faces in F vs. P trials would be significantly lower than the proportion of choices for faces in F vs N trials. This finding would suggest that when real faces were paired with an image that also elicited a face-like reaction, participants would not select the true face as often as when faces were paired with nonface objects.

Table 1. Trial types of interest with respective hypothesized directionality of the proportion choices.

Trial Type	Hypothesis
F vs. N	$F > N$
F vs. P	$F > P$
F vs. S	$F > S$
P vs. N	$P > N$
P vs. S	$P > S$
P vs. X	$P > X$

Table 2. Planned comparisons of specific trial types and respective hypothesized directionality. Proportions used in all trial types above are reflected by the first letter of the trial type.

Comparison	Hypothesis
P vs. N & F vs. N	$P \text{ vs. } N = F \text{ vs. } N$
F vs. S & P vs. S	$F \text{ vs. } S = P \text{ vs. } S$
P vs. S & P vs. F	$P \text{ vs. } S > P \text{ vs. } F$
F vs. P & F vs. N	$F \text{ vs. } P < F \text{ vs. } N$

3 Results

3.1 Pretest and Training – Children

Overall, there was no initial preference for selecting faces over nonfaces. Instead, children chose nonface images significantly more often than chance level (one sample $t(45) = -4.83, p < 0.001$). An independent samples t-test showed no significant effect of sex ($t(44) = 0.91, p = 0.37$). There was also no relationship between age and the proportion of choices of face stimuli ($r(46) = -0.12, p = 0.44$). Children reported most often selecting the pictures they ‘liked’ (for example: “Because I like monkeys.” or “Because I like the beach.”). On an individual level, 23 out of 46 children (50%) significantly differed from chance on their selection. Of those, 19 chose nonface images significantly more than chance whereas five children chose faces significantly more than chance ($p < 0.05$, binomial test). Thus, there was no a priori bias to select face stimuli.

In total, 40 children completed the first session without the rule being given to them. Twelve children then completed a re-attempt at the first session with the rule. Then, 46 children completed second sessions in which they were given the rule. A total of 18 sessions, including both first and second sessions, were excluded from analysis because the child failed to pass the training phase. Three additional sessions were excluded from analysis because the child failed to complete all the test trials in the session. There were five test sessions that were excluded from analysis due to experimenter error: failure to give the child the rule in the second session or repeating a test session that had already been completed. Thus, the following analyses were based on a total of 98 sessions.

To compare the number of trials it took for children to reach the test phase as a function of whether they were told the rule, I compiled data from children who completed two sessions, one with the explicit rule, and one without the rule being stated explicitly ($N = 36$). Because the data were non-normally distributed (No Rule Sessions: $W(36) = 0.83$, $p < 0.001$; Session with Rule: $W(36) = 0.38$, $p < 0.001$), I used Wilcoxon Signed Rank tests to assess whether the number of trials to criterion differed between these groups. It took significantly fewer trials for children to reach criterion when the rule was given ($M = 11.81$, $SD = 5.53$) than when the rule was not given ($M = 19.00$, $SD = 9.84$; $T = 325.00$, $z = -3.80$, $p < 0.001$). Although this effect likely reflects a causal relation of rule condition on performance, one must also recognize the rule was always given at some point after a non-rule session, and so this might also reflect an experience effect.

3.2 Pretest and Training – Monkeys

A total of 21 capuchin monkeys (14 female) were tested on the simultaneous matching-to-sample pre-test. However, due to low interest in participating in the task, 2 males and 1 female

Table 3. Summary of monkey information, performance, and progression through training and generalization phases. "*" denotes significant difference in performance between the 40 trials of the successful generalization phase and the first 40 trials of test phase.

	Age	Sex	Number of Training Trials before Test	Number of Generalization Attempts	Performance in Passing Generalization Phase	Performance in first 40 F vs. N in Test Phase	Chi-square	p	Overall performance on F vs. N in Test Phase
Capuchins									
Logan	14	M	148	1	0.83	0.88	0.39	0.76	0.90
Ivory	21	F	1203	failed all 5	-	-	-	-	-
Irene	18	F	1119	4	0.83	0.78	0.31	0.78	0.83
Ira	8	F	961	3	0.90	0.65	7.17	0.014*	0.78
Ingrid	7	F	241	3	0.80	0.78	0.08	1.00	0.85
Paddy	9	F	566	3	0.85	0.83	0.09	1.00	0.82
Griffin	22	M	1595	2	0.80	0.58	4.71	0.05	0.68
Lily	22	F	809	3	0.80	0.83	0.08	1.00	0.87
Wren	17	F	1053	3	0.85	0.68	3.38	0.11	0.75
Nkima	12	M	121	1	0.88	0.88	< 0.001	1.00	0.93
Nala	17	F	487	failed all 5	-	-	-	-	-
Lychee	20	F	362	2	0.85	0.80	0.35	0.77	0.86
Gambit	23	F	905	4	0.83	0.80	0.08	1.00	0.82
Gretel	16	F	354	3	0.90	0.80	1.57	0.35	0.89
Bailey	20	F	340	1	0.70	0.83	0.39	0.76	0.81
Applesauce	15	F	1081	failed all 5	-	-	-	-	-
Albert	8	M	588	2	0.90	0.70	5.00	0.048*	0.92
Rhesus									
Han	17	M	1034	1	0.80	0.83	0.08	1.00	0.89
Obi	16	M	133	1	0.95	0.88	1.41	0.43	0.91
Hank	37	M	1651	5	0.83	0.78	0.31	0.78	0.74
Chewie	21	M	303	1	0.80	0.55	5.70	0.031*	0.89
Luke	20	M	527	4	0.88	0.85	0.11	1.00	0.83
Murphy	27	M	356	2	0.80	0.73	0.62	0.60	0.87
Lou	27	M	219	2	0.80	0.83	0.08	1.00	0.90

failed to complete five sessions before the conclusion of data collection. The remaining 18 capuchins completed the pre-test, although three of these monkeys (Lychee, Bailey, and Irene) never reached the 75% correct criterion but did complete five 600-trial blocks.

Of the 18 capuchin monkeys that moved on to the training phase, three females (Nala, Ivory, and Applesauce) ultimately passed the training phase but failed all five generalization phases, and one male (Liam) failed to pass training or complete any generalization phase before data collection ended. Therefore, a total of 14 capuchin monkeys (4 males; 10 females) passed training, generalization, and completed the test phase (see Table 3).

A total of 7 rhesus monkeys were tested and passed the simultaneous matching-to-sample pre-test, reaching the 75% correct criterion in one or two 600-trial blocks. All seven rhesus

monkeys progressed to the training phase and passed their respective generalization phases and completed all test trials (See Table 3).

Before examining the test data, I compared the 40 trials in each monkey's successfully completed generalization phase to the first 40 F vs. N trials of their respective test phases to assess whether monkey's maintained similar levels of performance in selecting the face image. This would be conclusive evidence that they were using a rule to select stimuli that was not tied to specific stimuli. Because the rhesus data were non-normally distributed, I used a Wilcoxon signed rank test to compare the proportion of choices of face stimuli in the generalization phase to the proportions for choosing face in the first 40 F vs. N trials (baseline trials) of the test phase. Overall, rhesus monkeys selected faces at the same level in the generalization phase ($M = 0.84$, $SD = 0.06$) and in the first 40 F vs. N trials in the test phase ($M = 0.78$, $SD = 0.11$; $T = 4.00$, $z = -1.71$, $p = 0.09$). The capuchin data were normally distributed, so I examined these data with a paired-samples t-test. Capuchin monkeys selected faces more often in the generalization phase ($M = .84$, $SD = .05$) than in the first 40 F vs. N trials in the test phase ($M = 0.77$, $SD = 0.09$; $t(13) = 2.31$, $p = 0.038$). However, upon closer examination into individual performance, this effect seems to be driven largely by a small number of individuals. For example, only 2 of the 14 capuchins showed a significant difference between test phase and generalization phase (Albert: $\chi^2(1) = 5.00$, $p = 0.048$; Ira: $\chi^2(1) = 7.17$, $p = 0.014$). Overall, the majority of the monkeys maintained performance immediately upon entering the test phase, indicating that they successfully generalized their strategy to the new test stimuli. It is also important to note that only 3 of the 14 capuchin monkeys did not maintain 80% throughout the 1,800 baseline trials in the test phase. Of those three, all were between 68-78% correct in choosing faces in those trials. Further, only one rhesus monkey was below 80% overall on the F vs. N baseline trials in the test

phase. Therefore, most of the monkeys maintained or exceeded 80% correct on the baseline trials throughout the test phase, indicating that they successfully maintained the use of their respective strategies throughout the task. See Table 3 for a summary of individual performances from generalization and the first portion of the test phase.

3.3 Test – Overall Species Differences

To test for a difference in performance across species, I calculated the proportion of choices of the most ‘face-like’ stimulus in each trial type for each individual in each species group (children N = 40; capuchin N = 14; macaque N = 7). More specifically, I calculated the proportion of choosing the F stimulus in F vs. N, F vs. P, and F vs. S trials and the proportion of choosing the P stimulus in P vs. N, P vs. S, and P vs. X trials. For the sample of children, I used the first sessions that children completed

without having the rule given to them. By doing this, the children’s test sessions in this analysis were the closest comparison to the test sessions presented to the monkeys. Because of the small sample sizes in each group, and non-normal data distributions (see Table 4), I used nonparametric tests to assess whether there was an overall species difference in performance across each trial type. I ran a Kruskal-Wallis independent samples test with the proportions for each trial type as my dependent variables and species as the independent variable. There were no overall species differences for the F vs. N and F vs. P trial types ($H(2) = 5.04$, $p = 0.08$ and $H(2) = 0.409$, $p = 0.82$, respectively). However, there was a

Table 4. Summary of data distribution for each species and each trial type. In general, the children data are non-normally distributed for each trial type, whereas rhesus and capuchin monkeys have non-normally distributed data for one trial type each.

Tests of Normality				
Trial Type	Species	Shapiro-Wilk		
		W	df	p
FvN	Children	0.79	40	< 0.001*
	Capuchin	0.96	14	0.64
	Rhesus	0.79	7	0.035*
FvP	Children	0.86	40	< 0.001
	Capuchin	0.87	14	0.039*
	Rhesus	0.90	7	0.31
FvS	Children	0.83	40	< 0.001*
	Capuchin	0.88	14	0.06
	Rhesus	0.93	7	0.51
PvN	Children	0.93	40	0.017*
	Capuchin	0.93	14	0.34
	Rhesus	0.91	7	0.40
PvS	Children	0.91	40	0.004*
	Capuchin	0.98	14	0.95
	Rhesus	0.98	7	0.93
PvX	Children	0.91	40	0.003*
	Capuchin	0.91	14	0.17
	Rhesus	0.90	7	0.34

significant species difference for F vs. S ($H(2) = 11.74, p = 0.003$), P vs. N ($H(2) = 17.54, p < 0.001$), P vs. S ($H(2) = 13.45, p = 0.001$), and P vs. X ($H(2) = 15.79, p < 0.001$) trial types. To understand the nature of the species differences, I then conducted three Mann-Whitney tests to compare the pairwise performances of the capuchin monkeys, rhesus monkeys, and children, and I applied the Bonferroni correction to alpha to account for the effect of repeated testing of these data ($p = .0166$). First, the children and the capuchin monkeys differed significantly on the same four trial types that revealed the species differences. Children selected faces ($M = 0.83, SD = 0.19$) significantly more than capuchin monkeys ($M = 0.70, SD = 0.14$) in the F vs. S trials ($U = 134.00, z = -2.92, p = 0.003$). Similarly, children selected pareidolia images significantly more often than capuchin monkeys in P vs. N trials (Children: $M = 0.72, SD = 0.21$; Capuchin: $M = 0.50, SD = 0.07$; $U = 106.00, z = -3.46, p = 0.001$), P vs. S trials (Children: $M = 0.60, SD = 0.31$; Capuchin: $M = 0.30, SD = 0.08$; $U = 122.50, z = -3.12, p = 0.002$), and P vs. X trials (Children: $M = 0.74, SD = 0.21$; Capuchin: $M = 0.54, SD = 0.13$; $U = 112.00, z = -3.34, p = 0.001$). There was no statistical difference between capuchin monkeys and children on the F vs. N trials (Children: $M = 0.87, SD = 0.15$; Capuchin: $M = 0.84, SD = 0.07$; $U = 176.50, z = -2.05, p = 0.04$) or F vs. P trials (Children: $M = 0.73, SD = 0.28$; Capuchin: $M = 0.82, SD = 0.09$; $U = 273.50, z = -0.13, p = 0.90$) trial types. When comparing the performance of children and rhesus monkeys, three trial types differed significantly after Bonferroni correction: P vs. N, P vs. S, and P vs. X. Specifically, children selected pareidolia images significantly more often when compared to nonface images (Children: $M = 0.72, SD = 0.21$; Rhesus: $M = 0.49, SD = 0.06$; $U = 41.50, z = -2.97, p = 0.002$), when compared to scattered faces (Children: $M = 0.60, SD = 0.31$; Rhesus: $M = 0.28, SD = 0.08$; $U = 57.50, z = -2.48, p = 0.011$), and when compared to scattered pareidolia images (Children: $M = 0.74, SD = 0.21$; Rhesus: $M = 0.51, SD = 0.16$; $U = 49.00, z = -2.75, p =$

0.005). Children also selected faces more than rhesus monkeys in F vs. S trials (Children: $M = 0.83$, $SD = 0.19$; Rhesus: $M = 0.69$, $SD = 0.12$; $U = 62.50$, $z = -2.37$, $p = 0.02$), but this was not significant following Bonferroni correction. There was no significant difference between the proportions of choosing faces in either the F vs. N trials (Children: $M = 0.87$, $SD = 0.15$; Rhesus: $M = 0.86$, $SD = 0.06$; $U = 100.50$, $z = -1.19$, $p = 0.24$) or the F vs P trials (Children: $M = 0.73$, $SD = 0.28$; Rhesus: $M = 0.85$, $SD = 0.13$; $U = 123.00$, $z = -0.52$, $p = 0.63$) between children and rhesus monkeys. It is important to note that even though there were no significant differences between children and either of the monkey species in the F vs. P trial types, that monkeys selected faces more often than children, on average (Table 5). This also demonstrates that monkeys were successful at maintaining the rule of selecting faces and provides evidence that pareidolia images did not interfere with this to the extent they interfered with children's performance.

Finally, there was no statistical difference on any of the trial types between the two monkey species: F vs. N trials (Capuchin: $M = 0.84$, $SD = 0.07$; Rhesus: $M = 0.86$, $SD = 0.06$; $U = 36.50$, $z = -0.94$, $p = 0.35$), F vs. P trials (Capuchin: $M = 0.82$, $SD = 0.09$; Rhesus: $M = 0.85$, $SD = 0.13$; $U = 38.00$, $z = -0.83$, $p = 0.41$), F vs. S trials (Capuchin: $M = 0.70$, $SD = 0.14$; Rhesus: $M = 0.69$, $SD = 0.12$; $U = 49.00$, $z = 0.00$, $p = 1.00$), P vs. N trials (Capuchin: $M = 0.50$, $SD = 0.07$; Rhesus: $M = 0.49$, $SD = 0.06$; $U = 39.50$, $z = -0.72$, $p = 0.47$), P vs. S trials (Capuchin: $M = 0.30$, $SD = 0.08$; Rhesus: $M = 0.28$, $SD = 0.08$; $U = 40.00$, $z = -0.68$, $p = 0.50$), and P vs. X trials (Capuchin: $M = 0.54$, $SD = 0.13$; Rhesus: $M = 0.51$, $SD = 0.16$; $U = 38.50$, $z = -0.79$, $p = 0.43$). Because there were no differences between the two monkey species, these data were collapsed across those species for all subsequent analyses.

Table 5. Means and standard deviations for the proportion choice for each trial type, separated by species. The means reflect the proportion choice for the stimulus labeled first in each column (for example, means reflect the proportion choice for F in F vs. N or the proportion choice for P in P vs. N).

Species		FvN	FvP	FvS	PvN	PvS	PvX
Children (n = 40)	Mean	0.87	0.73	0.83	0.72	0.60	0.74
	SD	0.15	0.28	0.19	0.21	0.31	0.21
Capuchins (n = 14)	Mean	0.84	0.82	0.70	0.50	0.30	0.54
	SD	0.07	0.09	0.14	0.07	0.08	0.13
Rhesus (n = 7)	Mean	0.86	0.85	0.69	0.49	0.28	0.51
	SD	0.06	0.13	0.12	0.06	0.08	0.16

Table 5 shows that children selected pareidolia images more than monkeys in every trial type they were presented. It is also interesting to note that both species of monkeys were more affected when a scrambled face was paired with a face image, indicating that the local features of faces interfered with the baseline performance seen in F vs. N trials. In addition, the greatest difference in performance for the monkey species was between the P vs. N and P vs. S trials. The greater choice for scattered faces in P vs. S compared to the choice for nonface objects in P vs. N also demonstrates the monkeys' reliance on the local features of faces. Overall, the means for each trial type in Table 5 provide the beginning evidence that despite performing the same on baseline trials, monkeys and children performed differently on the test trials.

3.4 Test – Children

Because children who completed the first test session without the rule given to them differed significantly from the monkeys' test performance, I analyzed these data separately (Analysis 1). First, to see whether there was a bias towards a particular stimulus class for each trial type, I ran six one-sample Wilcoxon Signed Rank tests. Children in this group selected the more 'face-like' thing in each trial type except for P vs. S trials (see Figure 3, top left, and Table 6). Further, there was a significant correlation between age and the proportion of choices of faces in F vs. P trials ($r(39) = 0.32, p = 0.045$), indicating that older children chose greater proportions

of faces in F vs. P trials than younger children. However, no other trial types showed a relation to age. Further, Mann-Whitney tests revealed no significant differences for any trial type as a function of sex (see Table 6). A Friedman's test revealed a significant effect of trial type ($\chi^2(5) =$

Table 6. How the proportions for each trial type differed from chance levels, are related to age, and to sex for Analysis 1, 2, and 3 of the child data.

Analysis 1 - All Session 1, No Rule Given (N = 40)						
Trial Type	Avg. Proportion		Age		Sex	
	<i>T</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>U</i>	<i>p</i>
F vs. N	816.50	< 0.001*	0.24	0.15	199.0	0.99
F vs. P	674.50	< 0.001*	0.32	.045*	164.0	0.33
F vs. S	730.00	< 0.001*	-0.12	0.45	186.0	0.71
P vs. N	531.00	< 0.001*	-0.03	0.87	155.0	0.22
P vs. S	495.00	0.07	-0.18	0.26	190.5	0.81
P vs. X	694.00	< 0.001*	0.11	0.5	191.5	0.83
Analysis 2 - Session 1 Split by Rule, No Rule Group (N = 34)						
Trial Type	Avg. Proportion		Age		Sex	
	<i>T</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>U</i>	<i>p</i>
F vs. N	591.50	< 0.001*	0.29	0.10	131.50	0.70
F vs. P	514.00	< 0.001*	0.42	.014*	123.00	0.49
F vs. S	518.50	< 0.001*	-0.03	0.86	136.50	0.83
P vs. N	350.50	< 0.001*	-0.02	0.91	128.00	0.61
P vs. S	320.00	0.292	-0.17	0.35	131.00	0.69
P vs. X	483.00	< 0.001*	0.15	0.38	107.00	0.21
Analysis 2 - Session 1 Split By Rule, Rule Group (N = 16)						
Trial Type	Avg. Proportion		Age		Sex	
	<i>T</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>U</i>	<i>p</i>
F vs. N	135.00	< 0.001*	-0.20	0.47	29.50	0.96
F vs. P	77.50	0.11	-0.22	0.41	28.50	0.87
F vs. S	129.50	0.001*	-0.29	0.27	15.50	0.08
P vs. N	136.00	< 0.001*	-0.15	0.58	28.00	0.81
P vs. S	129.50	0.001*	-0.36	0.17	25.00	0.57
P vs. X	136.00	< 0.001*	-0.11	0.69	26.50	0.68
Analysis 3 - All Session 2, Rule Given (N = 46)						
Trial Type	Avg. Proportion		Age		Sex	
	<i>T</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>U</i>	<i>p</i>
F vs. N	1,035.00	< 0.001*	0.06	0.69	185.00	0.08
F vs. P	683.00	0.001*	-0.10	0.53	189.50	0.10
F vs. S	981.00	< 0.001*	0.04	0.79	211.00	0.21
P vs. N	990.00	< 0.001*	0.02	0.87	264.00	0.99
P vs. S	851.50	< 0.001*	0.02	0.88	251.50	0.77
P vs. X	1,037.50	< 0.001*	0.06	0.69	264.00	0.99

Table 7. How the proportion choices for face and pareidolia images were different or equivalent across trial types included in the planned comparisons.

Analysis 1 - All Session 1, No Rule Given (N = 40)		
Comparison	Outcome	<i>p</i>
FvN & PvN	FvN > PvN	< 0.001*
FvS & PvS	FvS > PvS	< 0.001*
PvS & PvF	PvS > PvF	< 0.001*
FvP & FvN	FvP < FvN	< 0.001*
Analysis 2 - Session 1 Split by Rule, No Rule Group (N = 34)		
Comparison	Outcome	<i>p</i>
FvN & PvN	FvN > FvP	< 0.001*
FvS & PvS	FvS > FvP	< 0.001*
PvS & PvF	PvS > PvF	< 0.001*
FvP & FvN	FvP < FvN	0.002*
Analysis 2 - Session 1 Split By Rule, Rule Group (N = 16)		
Comparison	Outcome	<i>p</i>
FvN & PvN	FvN = PvN	0.64
FvS & PvS	FvS = PvS	0.45
PvS & PvF	PvS > PvF	0.002*
FvP & FvN	FvP < FvN	0.001*
Analysis 3 - All Session 2, Rule Given (N = 46)		
Comparison	Outcome	<i>p</i>
FvN & PvN	FvN = PvN	0.06
FvS & PvS	FvS > FvP	0.004*
PvS & PvF	PvS > PvF	< 0.001*
FvP & FvN	FvP < FvN	< 0.001*

31.26, $p < 0.001$), indicating that the proportion of choices of the most-face like image in each trial type was not equivalent across trial types. The first planned comparison of interest revealed that children selected faces significantly more often in F vs. N trials ($M = 0.87$, $SD = 0.15$) than they selected pareidolia images in P vs. N trials ($M = 0.72$, $SD = 0.28$; $T = 614.50$, $z = -3.97$, $p < 0.001$; Table 7). Similarly, the second planned comparison indicated that children selected faces significantly more often in F vs. S trials ($M = 0.83$, $SD = 0.19$) than they selected pareidolia

images in P vs. S trials ($M = 0.60$, $SD = 0.31$; $T = 38.00$, $z = -4.13$, $p < 0.001$; Table 7), indicating that faces were selected more than pareidolia images and not selected as the most face-like image equivalently. However, children selected pareidolia images more often when they were paired with a scattered face than when they were paired with a real face (P vs. S: $M = 0.60$, $SD = 0.31$; P vs. F: $M = 0.28$, $SD = 0.28$; $T = 34.50$, $z = -4.61$, $p < 0.001$), suggesting that the real face interfered with the selection of pareidolia images more so than scattered faces with only featural information. Finally, children selected faces more often when paired with nonfaces ($M = 0.87$, $SD = 0.15$) than when paired with pareidolia images ($M = 0.73$, $SD = 0.28$; $T = 541.50$, $z = -3.71$, $p < 0.001$; Table 7). This demonstrates that the ability to select faces in these trial types was impacted more by pareidolia images than by nonface objects.

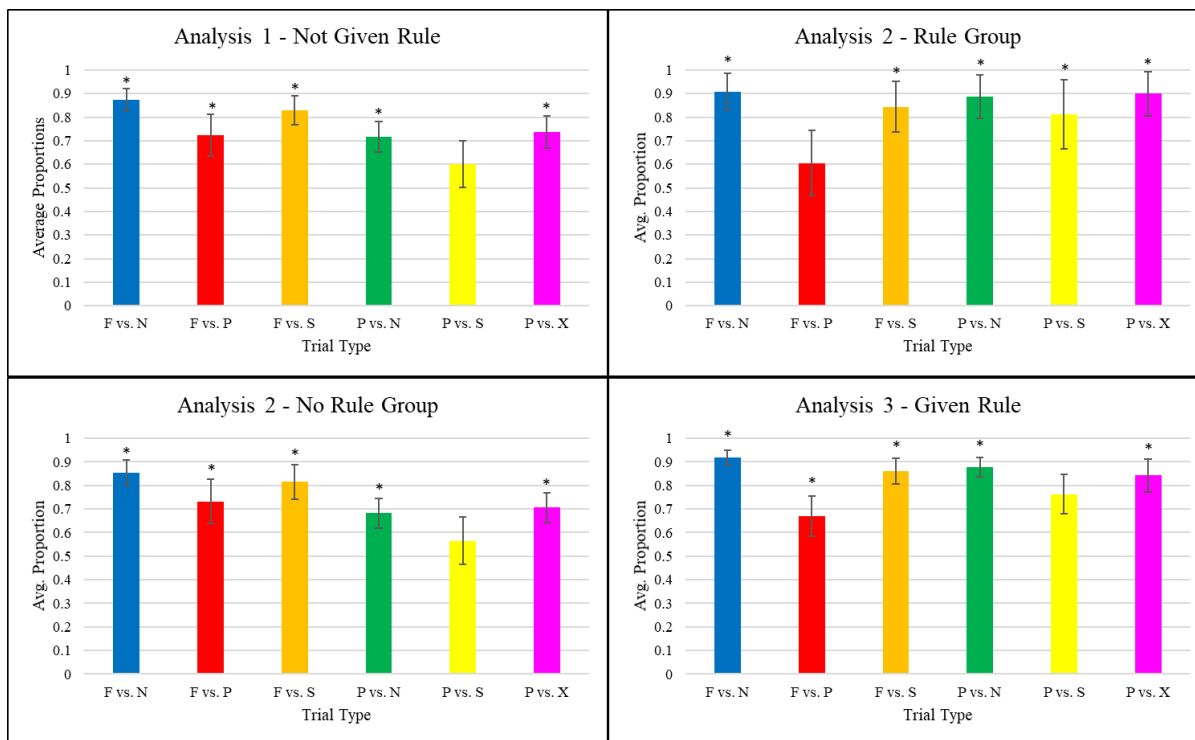


Figure 3. The average proportion choice for faces in F vs. N, F vs. P, and F vs. S trials and the average proportion choice for pareidolia images in P vs. N, P vs. S, and P vs. X trials for all children analyses. “*” denotes a trial type in which the proportion choice that differed from chance.

Because several children were unable to pass training without the aid of the rule, I then explicitly told children the rule on their re-attempt of session one, and I provided the rule for all children on their second session. When looking at the verbal responses from children after the training phases, a large percentage of responses from children who were not given the rule did

not indicate a clear comprehension of the ‘face’ rule (Figure 4, top). In fact, the majority of children responded that they selected monkeys and/or people when the experimenter did not tell them the rule. However, in all sessions where the rule was provided, the majority of children stated rules that included mentioning the selection of faces (Figure 4, bottom). Therefore, there was concern that the children in Analysis 1 were relying on a rule other than ‘faces’ to reach criterion in the training phase. If this is true, then children who comprehended the rule as

‘monkeys and/or people’ might bias them against selecting a face-like object over the scattered images or images that contain the local features of people and/or monkey faces and body parts.

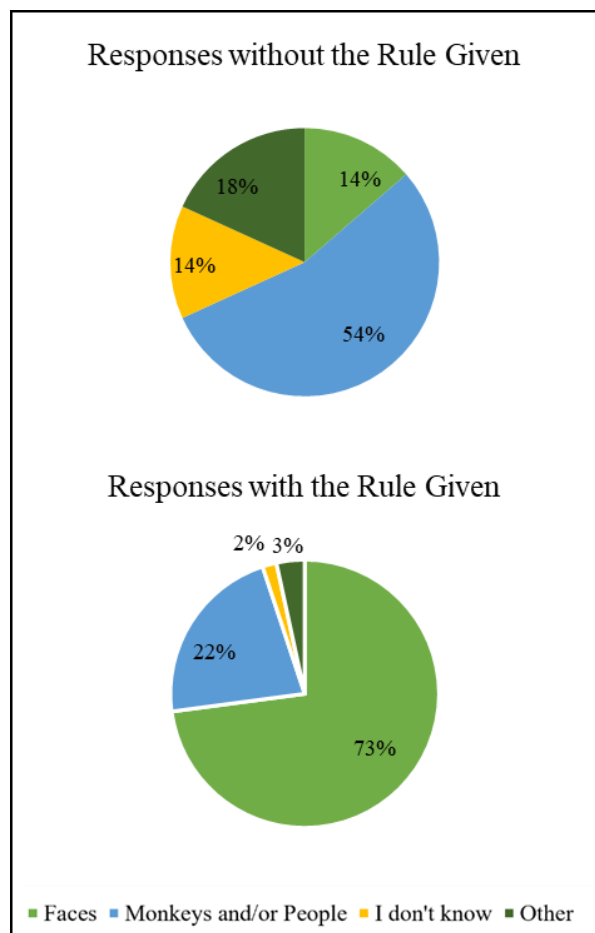


Figure 4. Verbal statements of rules/strategies by children with and without the rule explicitly told to them before training. Top: N = 44; Bottom: N = 59.

To see whether rule comprehension influenced performance with the images presented in the first test session (Analysis 2), I ran Mann-Whitney U tests for each trial type to examine whether groups that differed on rule comprehension influenced performance differently. The first group was composed of the children who passed into test without the rule but did not correctly state the rule ($N = 34$). The second group was made up of the children who were given the rule on their first session because they failed to meet criterion without the rule on their first attempt and the children who were not given the rule on their first attempt but correctly stated it (correct statement of the rule had to include a mention of choosing ‘faces’ or ‘heads’; $N = 16$). It is important to note that despite 17 sessions resulting in a failure to pass without the rule, only 10 of those children successfully completed a following session with the rule given. One child never completed a session following their first attempt. One case was an experimenter error in which a child was not told the rule for the second session and resulted in a failure to pass to test. Three children did not fully complete the first session where the rule was given and were thus removed from analysis. Two children failed the first session even when the rule was given on the second attempt. However, six children in total were able to state the rule correctly without it being explicitly given to them, which brought the sample size for this group to 16.

The Mann-Whitney tests revealed that there was no effect of rule on the proportion choice of faces for the trial types F vs. N (No Rule: $M = 0.86$, $SD = 0.15$; Rule: $M = 0.91$, $SD = 0.15$; $U = 201.50$, $z = -1.48$, $p = 0.14$), F vs. P (No Rule: $M = 0.73$, $SD = 0.28$; Rule: $M = 0.61$, $SD = 0.25$; $U = 187.50$, $z = -1.78$, $p = 0.08$) and F vs. S (No Rule: $M = 0.81$, $SD = 0.19$; Rule: $M = 0.84$, $SD = 0.25$; $U = 219.00$, $z = -1.14$, $p = 0.25$; see Figure 3, bottom left, and Figure 3, top right). This is to be expected since children who either comprehend the rule as “faces” or “monkeys and/or people” should perform similarly on these trials given that they all met the

training criterion. There was a significant effect of rule for the proportion choice of the pareidolia images in trial types P vs. N (No Rule: $M = 0.68$, $SD = 0.20$; Rule: $M = 0.89$, $SD = 0.15$; $U = 103.50$, $z = -3.55$, $p < 0.001$), P vs. S (No Rule: $M = 0.56$, $SD = 0.32$; Rule: $M = 0.81$, $SD = 0.26$; $U = 140.50$, $z = -2.76$, $p = 0.006$), and P vs. X (No Rule: $M = 0.71$, $SD = 0.21$; Rule: $M = 0.90$, $SD = 0.13$; $U = 107.50$, $z = -3.48$, $p = 0.001$; Figure 3, bottom left, and Figure 3, top right). Children who were not given the rule did not select pareidolia images as often in these trial types as children who were given the rule or correctly stated the rule.

I then ran one-sample Wilcoxon Signed Rank tests for each group to examine whether performance differed from chance on any given trial type. Children in the No Rule group selected the more ‘face-like’ thing in each trial type except for P vs. S trials (see Table 6). This tells us that despite not choosing pareidolia images as often as children who were given the rule on P vs. N or P vs. X trials, children still chose these images significantly more often than chance. Further, children in the No Rule group performed at chance levels on the P vs. S trial type – indicating that, despite the features of a face of the features of “monkeys and/or people” being present, these children were equally likely to select pareidolia images that lacked these features. Overall, these results indicate that children in the non-rule group were perceiving face pareidolia, but to a lesser extent than children who were given or stated the correct rule. It is also important to note that, similar to the first analysis, older children showed greater proportions of choice of faces in F vs. P trials ($r(33) = 0.42$, $p = 0.014$), but there was no relationship between age and proportion for any other trial type. There was also no effect of sex on performance for any of the trial types in this group (see Table 6). As expected, the planned comparisons revealed similar results as the analysis above of all children that were not given the rule (see Table 7). Children in the No Rule group selected faces significantly more often in F vs. N trials ($M = 0.86$,

$SD = 0.15$) than they selected pareidolia images in P vs. N trials ($M = 0.68$, $SD = 0.20$; $T = 468.00$, $z = -3.82$, $p < 0.001$). Similarly, the second planned comparison indicated that children in the No Rule group selected faces significantly more often in F vs. S trials ($M = 0.81$, $SD = 0.19$) than they selected pareidolia images in P vs. S trials ($M = 0.56$, $SD = 0.32$; $T = 20.50$, $z = -3.83$, $p < 0.001$). However, children selected pareidolia images more often when they were paired with a scattered face than when they were paired with a real face (P vs. S: $M = 0.56$, $SD = 0.32$; P vs. F: $M = 0.27$, $SD = 0.28$; $T = 34.50$, $z = -4.09$, $p < 0.001$). Finally, children in the No Rule group selected faces more often when paired with nonface objects ($M = 0.85$, $SD = 0.15$) than when paired with pareidolia images ($M = 0.73$, $SD = 0.28$; $T = 380.50$, $z = -3.05$, $p = 0.002$; Table 7). Overall, even when children failed to articulate the correct rule, they selected pareidolia images more often than chance when they were paired with either a nonface object or a scattered pareidolia image, revealing that the configurations of the pareidolia images were perceived as more face-like. Similarly, they chose faces more often when they were paired with nonface objects rather than the pareidolia images, indicating that the face-like configuration of pareidolia images interfered with their performance to always choose real faces. However, children did not show a bias for selecting pareidolia images when they were paired with scattered faces, indicating that the featural aspects of the face resulted in equivalent decisions to select those images. These results match those in Analysis 1, before children were separated into groups of rule comprehension.

However, for children who either correctly articulated the rule or were given the rule (Rule group), their selection for the more face-like image in each trial type was significant for all trial types except for F vs. P trials (see Table 6). There was no relationship between age and these choice proportions for any of the trial types, nor was there an effect of sex (Table 6).

Planned comparisons for this group revealed that children selected faces in F vs. N trials ($M = 0.91$, $SD = 0.15$) just as often as they selected pareidolia images in P vs. N trials ($M = 0.89$, $SD = 0.15$; $T = 60.00$, $z = -0.47$, $p = 0.64$), and they selected faces in F vs. S ($M = 0.84$, $SD = 0.25$) trials just as often as they selected pareidolia in P vs. S trials ($M = 0.81$, $SD = 0.22$; $T = 24.50$, $z = -0.76$, $p = 0.45$; Table 7). Children in the Rule group selected pareidolia images significantly more often in the P vs. S ($M = 0.81$, $SD = 0.22$) trials than in the P vs. F trials ($M = 0.39$, $SD = 0.25$; $T = 3.00$, $z = -3.12$, $p = 0.002$), and they selected faces more often in the F vs. N trials ($M = 0.91$, $SD = 0.15$) than in the F vs. P trials ($M = 0.61$, $SD = 0.25$; $T = 120.00$, $z = -3.41$, $p = 0.001$; Table 7). The key differences here are revealed in these first two comparisons. Children who were given or correctly stated the rule treated faces just like pareidolia images when those images were paired with either nonface objects or scattered faces. However, regardless of rule, children chose pareidolia images more often when paired with a scattered face than a real face and chose faces more often when they were paired with a nonface object rather than a pareidolia image (Table 7).

Taken together, children experienced pareidolia regardless of rule comprehension. However, children who were explicitly told to select images that look like faces showed an even stronger bias towards selecting pareidolia images in all trial types that those images appeared, reflecting that they were better at selecting images based on the configural information. However, even without the rule, pareidolia images were selected above chance levels when paired with nonface objects and scattered pareidolia images, but just as much as the scattered faces. Therefore, there was still a bias towards selecting these illusory faces without explicit rule comprehension.

These results were replicated by examining the second test sessions, in which the rule was given to all children (Analysis 3; $N = 46$). Because the data were non-normally distributed for each trial type, I used a Friedman Test to assess for an effect of trial type, and that test indicated that the proportions of each trial type differed significantly ($\chi^2(5) = 25.09, p < 0.001$; Figure 3, bottom right). To understand how the proportions of each trial type differed, I then conducted six one-sided Mann-Whitney U tests to assess for biases in each trial type. For children in their second test session, with the rule given, they chose the more ‘face-like’ image of each trial type significantly more often than chance (see Table 6). There was no effect of sex on the proportions chosen for any trial types, nor was there a relationship between age and performance for any trial type (see Table 6). This reflects a slight difference from the biases seen in the Rule group of session 1, in which children did not show a bias for selecting faces in F vs. P. However, when the proportions for the Rule group in the first test session were compared to the proportions in the second session, there were no significant differences between the groups for each trial type (see Figures 3, top right and 3, bottom right).

Next, six Wilcoxon signed ranks tests were run to assess the comparisons of interest, three of which were significant following a Bonferroni correction (Table 7). Children chose faces in F vs. S trials ($M = 0.86, SD = 0.19$) more often than they chose pareidolia images in P vs. S trials ($M = 0.76, SD = 0.28; T = 104.00, z = -2.86, p = 0.004$). However, the proportion of choices of faces in F vs. N trials ($M = 0.91, SD = 0.29$) was greater than the proportion of choices of pareidolia images in P vs. N trials ($M = 0.88, SD = 0.13$), although it was not significantly different ($T = 548.00, z = -1.86, p = 0.06$). The final two comparisons revealed that children chose pareidolia images more often in P vs. S trials than in P vs. F trials (P vs. S: $M = 0.76, SD = 0.28$; P vs. F: $M = 0.33, SD = 0.29; T = 14.00, z = -5.41, p < 0.001$) and that children

chose faces more often in F vs. N trials than in F vs. P trials (F vs. N: $M = 0.92$, $SD = 0.10$; F vs. P: $M = 0.67$, $SD = 0.29$; $T = 930.00$, $z = -5.08$, $p < 0.001$; Table 7). Overall, the results from session 2 closely resemble those from the children in the Rule group of session 1 – revealing a strong bias for selecting faces closely followed by a bias for selecting pareidolia images (Figures 3, top right and 3, bottom right).

3.5 Test – Monkeys

Because there were no significant differences between the monkey species for any trial types, I analyzed the rhesus and capuchin data together. Despite sufficient power ($N = 21$), I used non-parametric tests to analyze the monkey data to keep tests consistent with the kid data and because some of the outcome measures violated assumptions of normality. A Friedman test revealed a significant effect of trial type ($\chi^2(5) = 91.88$, $p < 0.001$; Figure 5). Using One-sample Wilcoxon signed rank tests to look at individual trial types, monkeys performed differently from

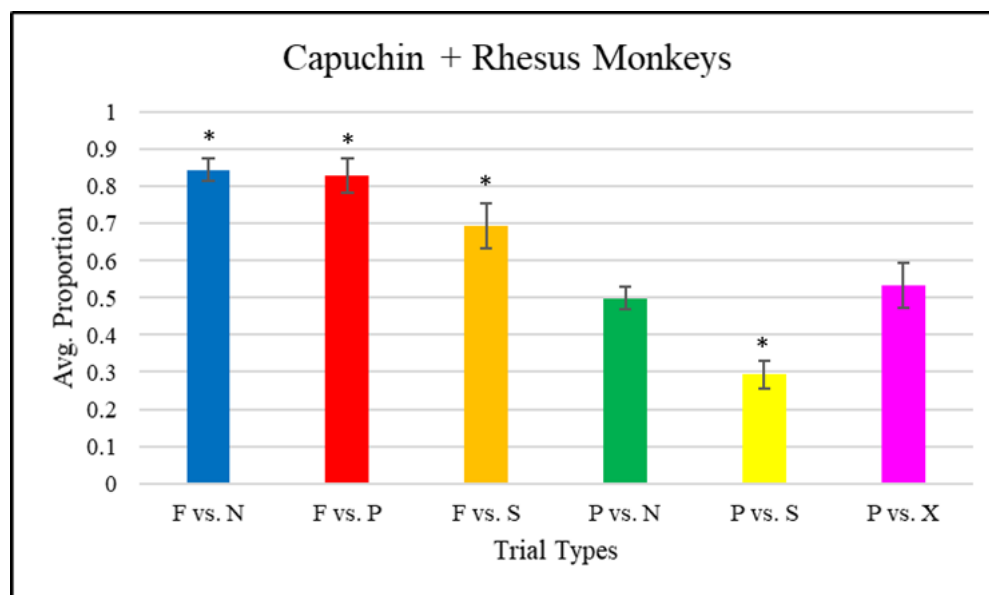


Figure 5. The average proportion choice for faces in F vs. N, F vs. P, and F vs. S trials and the average proportion choice for pareidolia images in P vs. N, P vs. S, and P vs. X trials for rhesus and capuchin monkey test trials, combined. “*” denotes a trial type in which the proportion choice differed from chance.

chance on four trial types. They selected faces more often than chance on F vs. N trials, F vs. P trials, and F vs. S trials. Additionally, monkeys selected pareidolia images significantly *less often* than chance on P vs. S trials. On P vs. N and P vs. X trials monkeys performed at chance levels, showing no bias to pick one stimulus over the other (see Table 8).

Table 8. How the proportions for each trial type differed from chance levels, are related to age, and to sex for all rhesus and capuchin test data. "" denotes a value that is statistically significant.*

Trial Type	Avg. Proportion		Capuchin Age		Capuchin Sex		Rhesus Age	
	<i>T</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>U</i>	<i>p</i>	<i>r</i>	<i>p</i>
F vs. N	231.00	< .001*	-0.33	0.25	10.00	0.16	-0.76	0.049*
F vs. P	231.00	< .001*	-0.06	0.84	14.00	0.39	-0.62	0.14
F vs. S	190.00	< .001*	-0.23	0.42	14.00	0.39	-0.63	0.13
P vs. N	70.00	0.756	-0.59	0.026*	12.00	0.25	-0.43	0.34
P vs. S	0.00	< .001*	-0.19	0.53	9.50	0.13	-0.13	0.77
P vs. X	113.00	0.468	-0.11	0.72	19.00	0.89	-0.49	0.27

Table 9. How the proportion choices for face and pareidolia images were different or equivalent across trial types included in the planned comparisons of the monkey data.

Comparison	Outcome	<i>p</i>
FvN & PvN	FvN > PvN	< 0.001*
FvS & PvS	FvS > PvS	< 0.001*
PvS & PvF	PvS > PvF	< 0.001*
FvP & FvN	FvP = FvN	0.285

When examining the planned comparisons, monkeys selected faces in F vs. N trials ($M = 0.84$, $SD = 0.07$) significantly more often than they selected pareidolia images in P vs. N trials ($M = 0.50$, $SD = 0.07$; $T = 231.00$, $z = -4.02$, $p < 0.001$; Table 9). They also selected faces in F vs. S trials ($M = 0.69$, $SD = 0.13$) significantly more often than they selected pareidolia images in P vs. S trials ($M = 0.29$, $SD = 0.08$; $T = 0.00$, $z = -4.02$, $p < 0.001$). Monkeys selected pareidolia images significantly more often when paired with a scattered face (P vs. S: $M = 0.29$, $SD = 0.08$) than when paired with a real face (P vs. F: $M = 0.17$, $SD = 0.08$; $T = 1.00$, $z = -3.99$, $p < 0.001$). This comparison indicated that there was a slightly weaker preference for choosing scrambled

images against pareidolia images than choosing real faces, but the individual bias towards choosing scrambled faces in the P vs. S trial type was still above chance levels. There was no difference in the proportion of choices for faces among the F vs. N trials ($M = 0.84$, $SD = 0.07$) and the F vs. P trials ($M = 0.83$, $SD = 0.10$; $T = 110.00$, $z = -1.07$, $p = 0.29$). This comparison indicates that monkeys perceived the pareidolia images similarly to how they perceived the nonface objects, as reflected in the similar proportions across these two trial types (see Table 9).

In general, there were few effects of sex and age in the monkeys (see Table 8). Because all rhesus subjects were males, I only examined the relation between age and the proportions of stimulus choices for each trial type. There was a negative correlation between age and the proportion chosen for all trial types, but the only significant relation was for the F vs. N trial type. Therefore, the older rhesus monkeys chose a smaller proportion of faces in this trial type. For capuchin monkeys, there was no effect of sex on any trial type. However, older capuchin monkeys chose a smaller proportion of pareidolia images in P vs. N trials but there was no relationship of age and performance on any other trial types (Table 8). Overall, it is unlikely that there are age or sex effects on performance in this task for monkeys.

Finally, to illustrate better the difference between monkeys and children's bias towards selecting pareidolia images, I plotted each pareidolia image and the percentage of trials in which it was selected for each species (see Figures 6a-6c). These graphs demonstrate that children were more likely to select pareidolia images than either monkey species, where the likelihood of selecting a pareidolia image was largely below 50 percent. Further, there was no relation between the frequencies at which children and either species of monkey selected these images (children and capuchin monkeys: $r(79) = .11$, $p = .32$; children and rhesus monkeys: $r(79) = .05$, $p = .66$). I also looked at how frequently all species selected the nonface object images. Because

a portion of these images included capuchin, rhesus, and human body parts (184 stimuli/species from a total of 2,080 nonface object stimuli), I wanted to assess whether monkeys and children

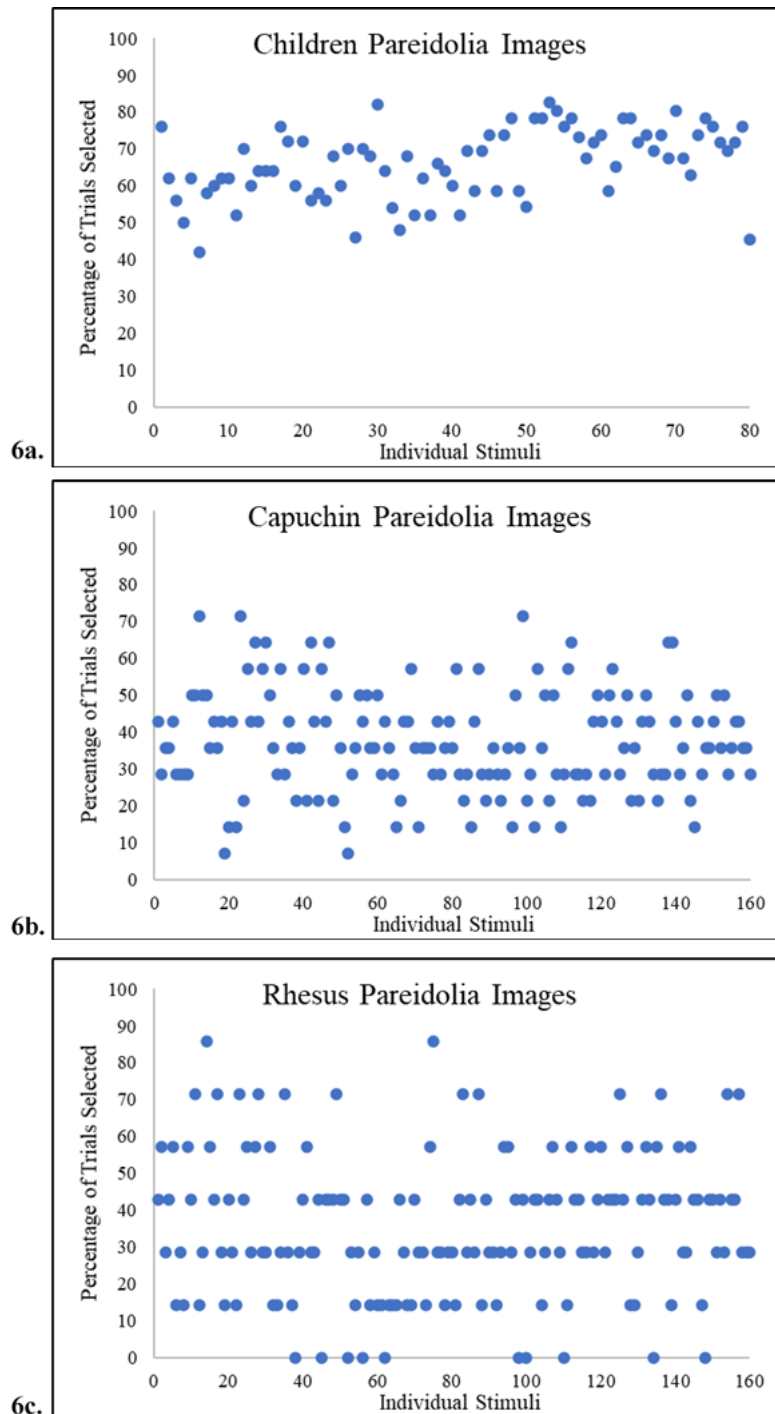


Figure 6a-6c. The percentage that each individual pareidolia stimulus was selected across each species (6a: children, 6b: capuchin monkeys, 6c: rhesus monkeys).

may have been more likely to choose these specific images, especially if the conceptual ‘rule’ they were using during the test phase was to select monkeys and/or people rather than faces. Only one nonface image was selected by capuchins >64% of the time it appeared in the task. This particular image was of a capuchin body. Of the seven rhesus monkeys tested, 5 out of 7 chose the same 9 nonface object stimuli. However, these stimuli were composed of random objects, rhesus body parts, and capuchin body parts. It is likely that such a small number of these images being selected by the majority of subjects is due to chance. Therefore, it is unlikely that monkeys were biased towards selecting specific nonface images, particularly toward images that contained body parts.

4 DISCUSSION

All species that were tested successfully passed the required pre-test and training phases. Children did not show a pre-existing bias towards selecting faces, despite evidence that children, from a young age, prefer to look at faces and face-like stimuli (Dupierrix et al., 2014; Farroni et al., 2005; Goren et al., 1975). In fact, many of the children chose nonface objects more than faces, when asked to choose one of the two images. Therefore, the children’s choice behavior did not match that of their looking preference towards faces. Additionally, these results suggest that children’s success in passing the training phase in the computerized task is a result of a specific strategy or rule used by children to select those images, rather than reflecting a pre-existing looking preference.

The monkeys underwent a matching-to-sample pre-test to provide sufficient experience and reinforcement with each type of stimulus. This test was intended to provide a reinforcement history for each image type so as not to result in a bias to avoid certain stimuli that only appeared in the test phase. For example, without the pre-test, monkeys may have avoided the selection of

scattered images having never encountered them throughout the training or generalization phases. From the results of the test data, it appears that monkeys did not avoid scattered images. In fact, monkeys chose scattered faces at levels above chance in P vs. S trials and chose scattered pareidolia images just as often as the non-scattered pareidolia images in P vs. X trials (Figure 5).

During the training phase, the two species of monkeys were required to pass more stringent training and generalization phases than the training phase the children were given. Not only did they pass a training phase by reaching a criterion of 80% on 40 trials, but they also had to generalize the rule to novel stimuli in a generalization phase. Additionally, the majority of monkeys maintained this rule immediately and throughout all 2,000 trials in the test phase (Table 3). Monkeys did not preferentially select nonface images that contained body parts or turned heads of monkeys, providing further evidence that the strategy they were using involved selecting faces and not another strategy such as selecting monkeys and people. Even throughout the test trials the monkeys remained particularly biased towards selecting faces, showing choices of faces at levels above chance levels in F vs. N, F vs. P and F vs. S trials. Taken together, monkeys were likely using a strategy consistent with the goal of this project (to select images with faces).

I initially proposed a series of 3 X 2 mixed ANOVAs with species as a between-subjects factor and trial types as within-subjects to assess for species differences for the specific trial type pairs I examined in post-hoc analyses. I hypothesized that no species differences would occur and that pareidolia images would be selected at similar rates across all trial types. Instead, I ran a Kruskal-Wallis test with species as the grouping factor and all six trial types as the dependent variables to assess for an overall species difference across every trial type. There was a species difference for four trial types: F vs. S, P vs. N, P vs. S, and P vs. X. Running the analyses this

way allowed me to detect species differences in trial types that would not have occurred in the planned comparisons initially proposed. This analysis also allowed me to compare all trial types among the two species of monkeys. This comparison showed that there were no significant differences in the proportions for any trial type, allowing me to collapse across the species of monkeys and analyze their data together.

There were no overall species differences for F vs. N and F vs. P trial types. All species chose faces at a level above chance for these two trial types, further suggesting that all subjects maintained performance on baseline trials but also chose faces more often than chance even when paired with pareidolia images. However, it is important to note that although children chose faces above chance levels in both of these trial types, they chose faces significantly more often in F vs. N trials than they did in F vs. P trials, as hypothesized above. This suggests that, whereas faces were consistently selected in these trials, the face-like configuration of the pareidolia images was interfering with the children's performance on F vs. P trials. Monkeys, on the other hand, chose faces equivalently across these trial types, suggesting that the face-like configuration of the pareidolia images did not interfere with their performance and providing evidence that monkeys may not perceive these images as being face-like.

Further, many interesting species differences occurred in trial types that did not present a face stimulus. Monkeys performed at chance on P vs. N and P vs. X trials. Monkeys chose pareidolia images significantly *less* often than chance levels on P vs. S. trials, contradictory to what I originally hypothesized. This suggests that monkeys are judging the nonface images similarly to the scattered pareidolia images. The scattered pareidolia images, that lack the facial configuration present in the pareidolia images, are chosen at similar rates as nonface objects when they are paired with pareidolia, confirming that this lack of local and configural facial

information results in a similar level of selection of the nonface images in these trial types. Monkeys showed a bias that was opposite of what I initially hypothesized, choosing the scattered faces images more often than chance levels when paired with a pareidolia image. Overall, monkeys' choice behavior on these three trial types provide further evidence that monkeys do not perceive the pareidolia images as face-like – choosing them just as often as nonface object images and less often than images that contain local facial features but not the facial configuration. Therefore, it appears that the monkeys favor the local face information in scattered faces over the configural information in the pareidolia images. However, it is also interesting to note that, even though the scattered faces were chosen above chance in P vs. S trials, monkeys still chose faces more often than chance in F vs. S trials, suggesting that real faces (with the accurate configuration of local features) were still favored over scrambled faces (with only local features).

The children's test sessions that were included in the overall species analysis were those children who passed the training phase without the aid of the being given the rule. I excluded sessions in which children were given the rule in order to compare test sessions across species in the most equivalent manner. Similarly, I wanted to use sessions in which children used their own strategies to pass the training phase and complete the test phase. On the trials that differed from monkeys (F vs. S, P vs. N, P vs. S, and P vs. X) trials, children selected the most face-like thing in each trial type based on configural properties. Children, like monkeys, chose faces significantly more than chance in F vs. S trials. However, children's average choice of faces in F vs. S was higher than that for monkeys. This suggests that children may have been more efficient than monkeys at ignoring the scrambled facial features in scattered faces in favor of selecting the face more often in these trial types. The most striking differences between children and monkeys,

however, lies in the trial types in which faces were not presented. Whereas monkeys selected pareidolia images at or below chance for these trials, children selected pareidolia images significantly *above* chance levels in P vs. N and P vs. X trials and performed at chance levels for P vs. S trials. That is, without being given the rule, children chose pareidolia images more often than images that did not have any facial information (nonface and scattered pareidolia images), showing that the face-like configuration of the pareidolia images likely influenced their performance. However, children performed at chance on trials that displayed images with no local, but configural information (pareidolia images) against images that had local but no configural information (scattered face images). Overall, their performance on these three trials indicated that children did perceive these images as having face-like information. What is also important to note is that children showed equivalent choice for the global and local information in the P vs. S trials. Despite children selecting the scattered faces equivalently to pareidolia images, it is also important to point out that they were less influenced by the local/featural information of the scattered faces than the monkeys, who consistently preferred these images over pareidolia images. Overall, despite the evidence that children experienced face pareidolia, local information clearly played a role in children's decision-making process in this task.

To summarize, these data do not support my initial hypotheses that there would be no overall species differences across the test trials presented. The children's choice behavior on each trial type confirms five of my initial hypothesis and rejects one. Children selected faces significantly more than chance on F vs. N trials, F vs. P trials, and F vs. S trials. Children also selected pareidolia significantly more than chance in P vs. N and P vs. X trials. However, children did not select pareidolia more than chance in P vs. S trials. Alternatively, the monkeys' choice behavior also confirms my initial hypotheses surrounding F vs. N, F vs. P, and F vs. S.

However, monkeys' performance on P vs. N, P vs. S, and P vs. X trials do not support my initial hypotheses and, instead, suggest that monkeys do not perceive face pareidolia. As part of these hypotheses, I proposed that monkeys and children would not perform at chance at F vs. S or P vs. X which would indicate that they were not using a strategy of avoiding nonface objects. Both species did select faces above chance in F vs. S trials, and children selected pareidolia image above chance levels in P vs. X. If children had been using a strategy to avoid nonface images, they would have performed at chance levels in P vs. X, so these results suggest that they were using a strategy to select images that did contain a face-like configuration. On the other hand, monkeys did perform at chance levels on P vs. X. Despite this, it is unlikely monkeys were using a nonface avoidance strategy, especially given their preference for selecting whole faces over scattered faces.

I also hypothesized that the proportion of choices of faces and of pareidolia images would be the same when comparing P vs. N to F vs. N trials and when comparing F vs. S to P vs. S trials. However, the data for the children and for the monkeys did not support either of these hypotheses. Instead, children's and monkeys' proportions of choices of faces in F vs. N and F vs. S was greater than the proportions of choices of pareidolia images in P vs. N and P vs. S, respectively. Although children chose pareidolia images significantly above chance in P vs. N and P vs. X trials, they did not choose them equivalently to how they chose faces in F vs. N and F vs. S. However, these data are still consistent with children perceiving face pareidolia. As described above, humans perceive these images as face-like, but can make a decision that they are not *so* face-like to be mistaken for real faces. Therefore, despite perceiving these images as more face-like than objects, children do not choose pareidolia at equivalent rates as real faces.

For the third comparison of interest, I hypothesized that children and monkeys would select pareidolia images significantly more often in P vs. S trials than in P vs. F trials. Confirming this hypothesis would suggest that pareidolia images are perceived, or selected as, more face-like when paired with scattered faces than when paired with a real face. The data from the children and the monkeys supported this hypothesis. All species chose pareidolia significantly more often when paired with an image that contained only the local features of a face than when it was paired with a whole face image. It is important to remember that monkeys chose scattered faces significantly above levels of chance when paired with a pareidolia image. So, it is likely that the results of this particular comparison are driven by the scattered face image being selected less often than faces rather than the pareidolia image being perceived as face-like, and thus selected more often in P vs. S.

For the final comparison of interest, I hypothesized that faces would be chosen significantly more often in F vs. N trials than in F vs. P trials. Confirming this hypothesis would indicate that the face-like configuration of pareidolia images interfered with participants' decisions toward selecting face images, relative to when faces were paired with an image that lacked a face-like configuration. The data from the children confirmed this hypothesis, but the monkeys chose faces equivalently in F vs. P and F vs. N trials. This provides further evidence that children's ability to select faces was influenced by pareidolia images, relative to nonface objects, and that monkeys were not influenced by the pareidolia images in a similar way. Overall, these data suggest that monkeys do not judge the pareidolia images similarly to how they judge real faces. Instead, monkeys are proficient at selecting faces in trials in which they appear and are influenced by the local facial features in scattered face images. The same is true

for children, but children also appear to perceive pareidolia images as being face-like, which is reflected in their choices across all trial types.

Because there were so many children that failed to pass training in sessions where no rule was provided *and* because many of the children that did pass training without the rule did not correctly state the rule as involving faces, I ran separate analyses to understand the difference that comprehending or being told the rule had on performance. In general, the data revealed that explicitly stating and/or being told the rule resulted in more pronounced results in support of experiencing face pareidolia. More specifically, children in the No Rule group differed from children in the Rule group on P vs. N, P vs. S, and P vs. X trial types, but not on trial types in which faces were presented. This could have been driven in part by the large number of children who stated the rule as choosing images of people and/or monkeys. However, even without the rule, pareidolia images were selected above chance levels when paired with nonface objects and scattered pareidolia images, but just as much as the scattered faces. Therefore, there was still a bias towards selecting these illusory faces without explicit rule comprehension.

Like children in the initial analysis, children in the no rule group selected the more face-like image above chance levels in each trial type except for P vs. S. However, children in the Rule group selected the more face-like image above chance levels in each trial type except for P vs. F trials. Overall, children who were either explicitly told or correctly stated the rule showed an increased choice for pareidolia images in P vs. N, P vs. S, P vs. X, *and* F vs. P trial types compared to the children in the No Rule group. Explicit comprehension of the rule resulted in children being more sensitive to the global configuration of the pareidolia images. This was also true for all children on their second test session when they were all given the rule regardless of whether they received the rule in their first session. Taken together, children experience face

pareidolia regardless of rule comprehension, but the aid of the rule results in a greater sensitivity to the configural properties of the pareidolia images.

Another point of interest is the relation between age and the proportion of choices of faces found in the two analyses in which I analyzed all children's first test session without the rule (Analysis 1) and the subsequent analysis in which I split the children into groups based on their rule comprehension (Analysis 2, No Rule group). Older children in these analyses were more likely than younger children to choose greater proportions of faces in F vs. P trials. Older children are typically more efficient at processing images using global information. However, this alone does not explain why older children may be better at ignoring the global face-like configuration of pareidolia images than younger children. Perhaps this relationship results from greater ability to inhibit the selecting the face-like pareidolia image in favor of the real face. Future work on the perception of face pareidolia in children could focus on replicating and understanding the relationship between age and inhibition and how that plays a role in judging these images as face-like.

Overall, despite a preference towards looking at faces and face-like stimuli (Sugita, 2008; Taubert et al., 2017), it appears that monkeys do not perceive or judge examples of face pareidolia as face-like whereas children do, and they do even without the aid of an explicitly stated instruction to do so. The goal of this project was to understand whether the perception of face pareidolia, at a later-processing, decision-making level occurs across multiple species of primates beyond an implicit attraction to faces and face-like stimuli that occurs at an early, pre-decision making stage. The results of this experiment suggest that monkeys, after successfully learning to choose faces over other stimuli and generalize that rule to novel images, do not generalize this behavior to images that include a face-like configuration but lack the local

features of a face. Instead, monkeys remain sensitive to the local information present in scattered face images. Alternatively, children do seem to be influenced by the configural information found in pareidolia images, selecting them above chance relative to objects, and equivalently to faces when explicitly guided to select images that look like faces. However, even though these data suggest that children perceive face pareidolia, there is still evidence that the local, featural information in scattered faces is playing an integral role in their perception and judgement of what is 'face-like.' This is apparent in trials such as P vs. S in which children, who were not given the rule, selected these images equivalently.

Therefore, despite children and monkey species being similarly proficient in discriminating images based on local and global information, the illusion of face pareidolia reveals an important species difference in these processing strategies. The face-like configuration of pareidolia images results in a stronger bias in children to select images that have configural face information over just the local information. On the other hand, monkeys consistently favor the local face information in scattered face stimuli over the configural information in pareidolia images. One explanation for this difference in processing strategy is experience. Humans, even from a young age, are often exposed to many forms of anthropomorphization. Many children grow up watching television in which objects and animals act, speak, and look like humans. This exposure to seeing and recognizing faces in objects could result in an increased sensitivity to extracting these patterns and explicitly recognizing something as face-like in our environment. Previous researchers have investigated whether cultural factors influence the perception and processing of faces and face pareidolia (Pavlova et al., 2018). Additionally, the perception of face pareidolia has been found to be influenced by one's religious or paranormal beliefs (Riekkii et al., 2013). For example, paranormal believers were better at detecting pareidolia faces but also

more prone to false alarms in nonface pictures, consistent with reports that individuals with paranormal beliefs are more likely to extract meaningful patterns out of objectively meaningless stimuli (Riekkki et al., 2013; Zhou & Meng, 2019). It is possible that individuals with greater religious and/or paranormal beliefs, and thus more liberal criteria for detecting illusory faces, have greater imaginative ability that plays a large role in detecting these patterns. Therefore, children with exposure to anthropomorphization may be more sensitive to detecting these patterns elsewhere, and this could explain why children were biased towards selecting images that resembled faces. In other words, children's experience, and resulting imagination and ability to recognize these patterns, allows them to efficiently generalize face-like patterns to other stimuli whereas monkeys do not. If these experiences do play an important role in the perception of face pareidolia, future research should focus on understanding how different levels of anthropomorphism are reflected in individual differences in children. For example, do children with limited experiences watching cartoons and movies struggle to perceive face pareidolia relative to children with greater exposure to these types of media.

It is important to note that, whereas experience and/or beliefs plays a role in children's exceptional ability at perceiving and selecting face pareidolia images, it not just these factors that allow for the perception of face pareidolia. Despite the many factors that can shape the degree to which someone perceives pareidolia, evidence for sensitivity towards faces and face-like patterns is apparent from infancy. I argue that this innate sensitivity to faces and face-like patterns (that is shared across species of primates) predisposes humans to generalize these patterns to other visual inputs in our environment through mechanisms such as cultural beliefs and experience (such as exposure to anthropomorphism through media), that are not shared across species of primates.

Overall, the perception of face pareidolia is likely an interaction and a balance of bottom-up and top-down, experience-driven processes. In other words, the bottom-up sensitivity towards faces provides an ideal basis for top-down, experience-driven factors to build off and make humans so prone to illusory face perception. As Zhou and Meng (2019) suggested, those with greater paranormal beliefs, who also are prone to more pareidolia ‘false alarms’ may represent individuals whose perception of face pareidolia is biased more towards top-down processes (that is, driven by beliefs and thus a greater ability to extract face-like patterns from noise). In fact, there are many factors that can influence the degree to which humans can detect face pareidolia including sex, personality, religious beliefs, mood, neurodevelopmental disorders, and more (see Zhou & Meng, 2019 for a review).

Despite the many proposed top-down mechanisms that can influence face perception, there are very few studies that have worked to understand or replicate these effects. Only one study has studied the influence of culture on gender differences in this illusion, but no studies (to the best of my knowledge) have specifically sought out to understand cultural-based differences in sensitivity and detection of face pareidolia. Further, it is important to understand whether religious, paranormal, or other types of beliefs are influencing other areas of cognition such as imagination. That is, do individuals with a greater degree of visual imagination or imagery have a broader detection system for face-like patterns in the environment? Future research must help us understand the factors contributing to individual differences within humans in the perception of face pareidolia to further help us understand how these factors also relate to the species differences reported in this experiment.

If the perception of face pareidolia in humans is driven by these various top-down processes, and results in an ability to generalize face-like patterns to other environmental stimuli,

future research should also investigate whether monkeys can be trained to be sensitive to and generalize these patterns to other stimuli. For example, if examples of face pareidolia are positively reinforced in nonhuman primates, can we train them to become more sensitive to generalizing, and thus detecting these configural patterns in other stimuli as well? If experience and reinforcement with these stimuli results in a greater sensitivity to detecting face-like patterns, this would further suggest that the perception of face pareidolia is both a combination of the early, bottom-up perceptual processes and top-down influences related to experience.

One limitation in this project is that the monkeys and children may not have been using a “always choose the most face-like image” during testing. As was apparent in the data from children, many who were not given the rule reported using a strategy that included choosing monkeys and/or people or were unable to state a reason or method to their strategy. Despite their inability to state the correct rule, however, children still demonstrated evidence of perceiving face pareidolia. The training regimen for the monkeys was more stringent, and the results suggest that they were likely using a strategy centered on selecting faces. Further, almost all monkeys maintained a high performance on trials where a real face was present, and there were very few nonface images that contained monkey and human body parts that were selected by more than half of the monkeys tested. Therefore, it is unlikely that monkeys were using a “monkeys and/or people” strategy and instead were selecting faces, but alternative strategies, such as a strategy based on specific low-level/featural information (shape(s), color(s), size(s), etc.), cannot be ruled out entirely. Given this possibility, future research should include stimuli that better control for certain features and can rule out strategies based solely on the selection certain features but a broader concept of “face.”

It is also important to note that the phenomenon of face pareidolia occurs on a spectrum. There are some examples of face pareidolia that result in a stronger experience of seeing a face than others, and this could vary from species to species and from individual to individual. For example, previous research has used stimuli ranging from hand-drawn blobs, vegetables arranged to look like a face on a plate, the highly detailed Arcimboldo images, and those used in this study (see Figure 1). It is likely that the wide range of pareidolia images that have appeared in the literature elicit different magnitudes of face pareidolia in humans. So, it is possible that the stimuli used in these experiments lacked the characteristics needed to elicit a face-like experience in nonhuman primates. However, in Taubert and colleagues (2017) eye tracking study, human adults were asked to rate pareidolia examples on a 200-pt “face-like” scale to assure that the examples presented to the monkeys elicited pareidolia in humans. Many of the same stimuli in that experiment were presented to monkeys in these experiments, without a behavioral bias for selecting them similarly to real faces. So even if the threshold for nonhuman primates to perceive an image as a face or face-like is higher than the threshold needed for humans, this study provides strong evidence that the perception of face pareidolia is *not* ubiquitous across species. In other words, the images used as stimuli in this study elicit the perception of face pareidolia in humans, but not in rhesus or capuchin monkeys.

Future research should include a broader range of stimuli that involve various examples of face pareidolia to understand where the threshold occurs for nonhuman primates to experience an image as a face or as face-like. Comparative research on face pareidolia should strive to include stimulus validation from human populations, in which human adults can rate the magnitude of their perception of face-pareidolia. These ratings can verify and measure the degree to which people experience face pareidolia and can be used to understand the threshold in which

nonhuman primates also perceive images as faces or as face-like. The scatter-plots (Figures 6a-c) show that children did select most of the pareidolia images above chance whereas the monkeys, as a whole, were not biased towards any specific pareidolia image, thus serving as a form of validation that children recognized these images as face-like across various examples whereas monkeys did not. However, for studies that expand their stimulus set to include other “forms” of pareidolia (for example, Arcimboldo images, cartoons, schematic face “blobs”) these ratings could lend insight into comparing the thresholds at which humans and nonhuman primates begin to classify things as being face-like.

Finally, future comparative research on face pareidolia should attempt to replicate the findings described above and include more species to understand better the phenomenon of face pareidolia across various species. More specifically, do species of great apes besides humans perceive pareidolia like humans or does their choice behavior, when selecting images of faces, ignore the configural information in pareidolia images similarly as monkeys. Chimpanzees, like humans, typically show a global processing strategy when discriminating stimuli, so perhaps they will be more sensitive to the face-like configuration of these images. Researchers should also remain open to others forms of measuring the perception of face pareidolia in nonhuman primates. For example, Flessert and Beran (in prep) have developed a computerized task that trains monkeys to place stimuli into different categorical “bins” that represent a pseudo-continuum, or a form of a ratings scale. It is a goal for this project to train nonhuman primates quickly to generalize and apply novel stimuli to this ratings scale. Therefore, future work investigating the illusion of face pareidolia can expand on these results by attempting to train monkeys accurately to categorize faces and nonface objects on either end of the scale and then introducing and studying where monkeys place pareidolia images on the scale.

Beyond studying visual perception at a comparative level, studying illusory face perception in clinical settings can pave the way for better understanding certain social disorders in which there are specific deficits in face perception such as prosopagnosia, autism spectrum disorder (ASD), schizophrenia, Williams syndrome, Capgras syndrome, and Turner syndrome (Anaki et al., 2016; Annaz et al., 2009; Barrelle & Luauté, 2017; Barton, 2003; Lazar et al., 2014; Megreya, 2016; Morin et al., 2015; Pavlova et al., 2016; Walker et al., 1984). Studying face pareidolia in these groups also can improve our understanding for how bottom-up processing of global and local features interacts with top-down, experience-driven factors. Specifically, several of these disorders are marked by a deficit or an inability to process faces holistically, and therefore accurately recognize faces. For example, individuals with ASD, schizophrenia, Williams syndrome, or prosopagnosia typically show a local processing bias (Avidan et al., 2011; Happé & Frith, 2006; Karmiloff-Smith et al., 2004; Morin et al., 2015; Watson, 2013). However, tests with Navon-style stimuli consistently show that individuals with ASD have intact holistic processing or equivalent reliance on global and local properties of these images (Behrmann et al., 2006; Brosnan et al., 2004; Mottron et al., 1999; Plaisted et al., 1999). Additionally, individuals with ASD are still sensitive to tests of holistic face processing, such as the inversion effect (Joseph & Tanaka, 2003; Lahaie et al., 2006; Scherf et al., 2008; Tavares et al., 2016; Teunisse & de Gelder, 2003). Therefore, people with social disorders such as those mentioned above represent important samples because they represent groups in which many of the human-unique experiences (such as anthropomorphism exposure) are shared with typically developing populations, but also have differences in global and local processing of stimuli. Currently, few studies have investigated how non-typically developing individuals perceive illusory faces. In one experiment, preschool age children with ASD struggled to attend and orient

towards face-like stimuli compared to typically developing (TD) controls. However, looking time between upright and inverted face-like objects showed no difference between TD or ASD individuals, suggesting that holistic processing played a role in allowing children with ASD to perceive illusory faces with a deficit in efficiently attending to these stimuli (Guillon et al., 2016). Another experiment also reported the perception of face-like objects in individuals with ASD (Akechi et al., 2015). However, several studies have reported marked deficits in illusory face perception in individuals with ASD and individuals with Williams syndrome (Pavlova et al., 2016, 2017; Ryan et al., 2016). Therefore, more research is needed to understand how individuals with various face processing deficits perceive and process these images.

The perception of face pareidolia is not common across all species of primates. It is possible that this illusion is unique to humans and a result of the tendency to anthropomorphize objects and animals in everyday life. Further research is needed to understand better whether face pareidolia occurs in other species, such as chimpanzees, to understand how large a role a global-processing precedence may play in the perception of face pareidolia. Overall, the results reported above represent an important first-step in understanding the role experience plays in shaping human perception and lays the groundwork for future research to continue studying how bottom-up and top-down perceptual processing work together to create various perceptual phenomena.

REFERENCES

- Adachi, I., Chou, D. P., & Hampton, R. R. (2009). Thatcher effect in monkeys demonstrates conservation of face perception across primates. *Current Biology*, *19*(15), 1270–1273. <https://doi.org/10.1016/j.cub.2009.05.067>
- Aglioti, S., DeSouza, J. F. X., & Goodale, M. A. (1995). Size-contrast illusions deceive the eye but not the hand. *Current Biology*, *5*(6), 679–685. [https://doi.org/10.1016/S0960-9822\(95\)00133-3](https://doi.org/10.1016/S0960-9822(95)00133-3)
- Agrillo, C., Parrish, A. E., & Beran, M. J. (2014). Do primates see the solitaire illusion differently? A comparative assessment of humans (*Homo sapiens*), chimpanzees (*Pan troglodytes*), rhesus monkeys (*Macaca mulatta*), and capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *128*(4), 402–413. <https://doi.org/10.1037/a0037499>
- Akechi, H., Stein, T., Kikuchi, Y., Tojo, Y., Osanai, H., & Hasegawa, T. (2015). Preferential awareness of protofacial stimuli in autism. *Cognition*, *143*, 129–134. <https://doi.org/10.1016/j.cognition.2015.06.016>
- Anaki, D., Zadikov Mor, T., Gepstein, V., & Hochberg, Z. (2016). Face perception in women with Turner syndrome and its underlying factors. *Neuropsychologia*, *90*, 274–285. <https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2016.08.024>
- Annaz, D., Karmiloff-Smith, A., Johnson, M. H., & Thomas, M. S. C. (2009). A cross-syndrome study of the development of holistic face recognition in children with autism, Down syndrome, and Williams syndrome. *Journal of Experimental Child Psychology*, *102*(4), 456–486. <https://doi.org/10.1016/j.jecp.2008.11.005>
- Avidan, G., Tanzer, M., & Behrmann, M. (2011). Impaired holistic processing in congenital prosopagnosia. *Neuropsychologia*, *49*(9), 2541–2552.

<https://doi.org/10.1016/j.neuropsychologia.2011.05.002>

Baenninger, M. A. (1994). The development of face recognition: Featural or configurational processing? *Journal of Experimental Child Psychology*, *57*(3), 377–396.

<https://doi.org/10.1006/jecp.1994.1018>

Barrelle, A., & Luauté, J. P. (2017). Capgras syndrome and other delusional misidentification syndromes. *Frontiers of Neurology and Neuroscience*, *42*, 35–43.

<https://doi.org/10.1159/000475680>

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology*, *25*(3), 281–316. <https://doi.org/10.1006/cogp.1993.1007>

Barton, J. J. (2003). Disorders of face perception and recognition. *Neurologic Clinics*, *21*(2), 521–548. [https://doi.org/10.1016/s0733-8619\(02\)00106-8](https://doi.org/10.1016/s0733-8619(02)00106-8)

Behrmann, M., Avidan, G., Leonard, G. L., Kimchi, R., Luna, B., Humphreys, K., & Minshew, N. (2006). Configural processing in autism and its relationship to face processing. *Neuropsychologia*, *44*(1), 110–129.

<https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2005.04.002>

Beran, M. J., Perdue, B. M., Kelly, A. J., & Parrish, A. E. (2017). What's in a face (made of foods)? Comparing children's and monkey's perception of faces in face-like images of food. *Animal Behavior and Cognition*, *4*(3), 324–339.

<https://doi.org/10.26451/abc.04.03.10.2017>

Bertin, E., & Bhatt, R. S. (2004). The Thatcher illusion and face processing in infancy.

Developmental Science, *7*(4), 431–436. <https://doi.org/10.1111/j.1467-7687.2004.00363.x>

Bhatt, R. S., Bertin, E., Hayden, A., & Reed, A. (2005). Face processing in infancy:

Developmental changes in the use of different kinds of relational information. *Child*

- Development*, 76(1), 169–181. <https://doi.org/10.1111/j.1467-8624.2005.00837.x>
- Bondarko, V. M., & Semenov, L. A. (2004). Size estimates in ebbinghaus illusion in adults and children of different age. *Human Physiology*, 30(1), 24–30.
<https://doi.org/10.1023/B:HUMP.0000013760.85499.17>
- Brace, N. A., Hole, G. J., Kemp, R. I., Pike, G. E., Van Duuren, M., & Norgate, L. (2001). Developmental changes in the effect of inversion: Using a picture book to investigate face recognition. *Perception*, 30(1), 85–94. <https://doi.org/10.1068/p3059>
- Broadbent, D. E. (1977). The hidden preattentive processes. *American Psychologist*, 32(2), 109–118. <https://doi.org/10.1037/0003-066X.32.2.109>
- Brosnan, M. J., Scott, F. J., Fox, S., & Pye, J. (2004). Gestalt processing in autism: Failure to process perceptual relationships and the implications for contextual understanding. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 45(3), 459–469.
<https://doi.org/10.1111/j.1469-7610.2004.00237.x>
- Bruce, C. (1982). Face recognition by monkeys: Absence of an inversion effect. *Neuropsychologia*, 20(5), 515–521. [https://doi.org/10.1016/0028-3932\(82\)90025-2](https://doi.org/10.1016/0028-3932(82)90025-2)
- Carey, S. (1996). Perceptual classification and expertise. In R. Gelman & T. Kit-Fong et al. (Eds.), *Perceptual and cognitive development* (pp. 49–69). Academic Press.
<https://doi.org/10.1016/b978-012279660-9/50020-8>
- Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science*, 195(4275), 312–314. <https://doi.org/10.1126/science.831281>
- Carey, S., & Diamond, R. (1994). Are faces perceived as configurations more by adults than by children? *Visual Cognition*, 1(2–3), 253–274. <https://doi.org/10.1080/13506289408402302>
- Carey, S., Diamond, R., & Woods, B. (1980). Development of face recognition: A maturational

- component? *Developmental Psychology*, 16(4), 257–269. <https://doi.org/10.1037/0012-1649.16.4.257>
- Cassia, V. M. C., Picozzi, M., Kuefner, D., Bricolo, E., & Turati, C. (2009). Holistic processing for faces and cars in preschool-aged children and adults: Evidence from the composite effect. *Developmental Science*, 12(2), 236–248. <https://doi.org/10.1111/j.1467-7687.2008.00765.x>
- Civile, C., McLaren, R., & McLaren, I. P. L. (2016). The face inversion effect: Roles of first-and second-order. *American Journal of Psychology*, 129(1). <https://doi.org/10.5406/amerjpsyc.129.1.0023>
- Civile, C., McLaren, R. P., & McLaren, I. P. L. (2014). The face inversion effect-Parts and wholes: Individual features and their configuration. *Quarterly Journal of Experimental Psychology*, 67(4), 728–746. <https://doi.org/10.1080/17470218.2013.828315>
- Cohen, L. B., & Cashon, C. H. (2001). Do 7-month-old infants process independent features or facial configurations? *Infant and Child Development*, 10(1–2), 83–92. <https://doi.org/10.1002/icd.250>
- Cooper, L. A., & Weintraub, D. J. (1970). Delboeuf-type circle illusions: Interactions among luminance, temporal characteristics, and inducing-figure variations. *Journal of Experimental Psychology*, 85(1), 75–82. <https://doi.org/10.1037/h0029503>
- Coren, S., & Enns, J. T. (1993). Size contrast as a function of conceptual similarity between test and inducers. *Perception & Psychophysics*, 54(5), 579–588. <https://doi.org/10.3758/BF03211782>
- Crouzet, S. M., Kirchner, H., & Thorpe, S. J. (2010). Fast saccades toward faces: Face detection in just 100 ms. *Journal of Vision*, 10(4), 1–17. <https://doi.org/10.1167/10.4.16>

- Dahl, C. D., Logothetis, N. K., Bühlhoff, H. H., & Wallraven, C. (2011). Second-order relational manipulations affect both humans and monkeys. *PLoS ONE*, *6*(10), 25793.
<https://doi.org/10.1371/journal.pone.0025793>
- Dahl, C. D., Logothetis, N. K., & Hoffman, K. L. (2007). Individuation and holistic processing of faces in rhesus monkeys. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1622), 2069–2076. <https://doi.org/10.1098/rspb.2007.0477>
- Dahl, C. D., Wallraven, C., Bühlhoff, H. H., & Logothetis, N. K. (2009). Humans and macaques employ similar face-processing strategies. *Current Biology*, *19*(6), 509–513.
<https://doi.org/10.1016/j.cub.2009.01.061>
- Dal Monte, O., Noble, P. L., Costa, V. D., & Averbeck, B. B. (2014). Oxytocin enhances attention to the eye region in rhesus monkeys. *Frontiers in Neuroscience*, *8*, 1–8.
<https://doi.org/10.3389/fnins.2014.00041>
- de Heering, A., Houthuys, S., & Rossion, B. (2007). Holistic face processing is mature at 4 years of age: Evidence from the composite face effect. *Journal of Experimental Child Psychology*, *96*(1), 57–70. <https://doi.org/10.1016/J.JECP.2006.07.001>
- De Lillo, C., Palumbo, M., Spinozzi, G., & Giustino, G. (2012). Effects of pattern redundancy and hierarchical grouping on global-local visual processing in monkeys (*Cebus apella*) and humans (*Homo sapiens*). *Behavioural Brain Research*, *226*(2), 445–455.
<https://doi.org/10.1016/j.bbr.2011.09.040>
- De Lillo, C., Spinozzi, G., Truppa, V., & Naylor, D. M. (2005). A comparative analysis of global and local processing of hierarchical visual stimuli in young children (*Homo sapiens*) and monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *119*(2), 155–165.
<https://doi.org/10.1037/0735-7036.119.2.155>

- Delboeuf, J. L. R. (1892). Sur une nouvelle illusion d'optique. *Academie Royale Des Sciences, de Lettres et Des Beaux Arts de Belgique., Belletins*(24), 545–558.
- Deruelle, C., & Fagot, J. (1998). Visual search for global/local stimulus features in humans and baboons. *Psychonomic Bulletin & Review*, 5(3), 476–481.
<https://doi.org/10.3758/BF03208825>
- Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology.*, 115(2), 107–117. <https://doi.org/10.1037//0096-3445.115.2.107>
- Dittrich, W. (1990). Representation of faces in longtailed macaques (*Macaca fascicularis*). *Ethology*, 85(4), 265–278. <https://doi.org/10.1111/j.1439-0310.1990.tb00406.x>
- Dukette, D., & Stiles, J. (1996). Children's analysis of hierarchical patterns: Evidence from a similarity judgment task. *Journal of Experimental Child Psychology*, 63(1), 103–140.
<https://doi.org/10.1006/jecp.1996.0044>
- Dukette, D., & Stiles, J. (2001). The effects of stimulus density on children's analysis of hierarchical patterns. *Developmental Science*, 4(2), 233–251. <https://doi.org/10.1111/1467-7687.00168>
- Dupierriex, E., de Boisferon, A. H., Méary, D., Lee, K., Quinn, P. C., Di Giorgio, E., Simion, F., Tomonaga, M., & Pascalis, O. (2014). Preference for human eyes in human infants. *Journal of Experimental Child Psychology*, 123(1), 138–146.
<https://doi.org/10.1016/j.jecp.2013.12.010>
- Ebbinghaus, H. E. (1902). *Grundzuge der Psychologie [Basic psychology]*. Von Veit.
- Elkind, D., Kogler, R. R., & Go, E. (1964). Studies in perceptual development: II. Part-whole perception. *Child Development*, 35(1), 81. <https://doi.org/10.2307/1126573>

- Evans, T. A., Beran, M. J., Chan, B., Klein, E. D., & Menzel, C. R. (2008). An efficient computerized testing method for the capuchin monkey (*Cebus apella*): Adaptation of the LRC-CTS to a socially housed nonhuman primate species. *Behavior Research Methods*, *40*(2), 590–596. <https://doi.org/10.3758/BRM.40.2.590>
- Fagot, J., & Deruelle, C. (1997). Processing of global and local visual information and hemispherical specialization in humans (*Homo sapiens*) and baboons (*Papio papio*). *Journal of Experimental Psychology: Human Perception and Performance*, *23*(2), 429–442.
- Fagot, J., & Tomonaga, M. (1999). Global and local processing in humans (*Homo sapiens*) and chimpanzees (*Pan troglodytes*): Use of a visual search task with compound stimuli. *Journal of Comparative Psychology*, *113*(1), 3–12. <https://doi.org/10.1037/0735-7036.113.1.3>
- Fagot, J., Tomonaga, M., & Deruelle, C. (2001). Processing of the global and local dimensions of visual hierarchical stimuli by humans (*Homo sapiens*), chimpanzees (*Pan troglodytes*), and baboons (*Papio papio*). In T. Matsuzawa (Ed.), *Primate origins of human cognition and behavior* (pp. 87–103). Springer-Verlag Publishing.
- Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is “special” about face perception? *Psychological Review*, *105*(3), 482–498. <https://doi.org/10.1037/0033-295x.105.3.482>
- Farroni, T., Johnson, M. H., Menon, E., Zulian, L., Faraguna, D., & Csibra, G. (2005). Newborns’ preference for face-relevant stimuli: Effects of contrast polarity. *Proceedings of the National Academy of Sciences*, *102*(47), 17245–17250. <https://doi.org/10.1073/pnas.0502205102>
- Feeney, S. M., & Stiles, J. (1996). Spatial analysis: An examination of preschoolers’ perception and construction of geometric patterns. *Developmental Psychology*, *32*(5), 933–941.

<https://doi.org/10.1037/0012-1649.32.5.933>

- Feng, L. C., Chouinard, P. A., Howell, T. J., & Bennett, P. C. (2017). Why do animals differ in their susceptibility to geometrical illusions? *Psychonomic Bulletin and Review*, *24*(2), 262–276. <https://doi.org/10.3758/s13423-016-1133-3>
- Flin, R. H. (1985). Development of face recognition: An encoding switch? *British Journal of Psychology*, *76*(1), 123–134. <https://doi.org/10.1111/j.2044-8295.1985.tb01936.x>
- Freire, A., Lee, K., & Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configurational information: Direct evidence. *Perception*, *29*(2), 159–170. <https://doi.org/10.1068/p3012>
- Frith, C. D., & Frith, U. (1972). The solitary illusion: An illusion of numerosity. *Perception & Psychophysics*, *11*(6), 409–410. <https://doi.org/10.3758/BF03206279>
- Fujita, K., & Matsuzawa, T. (1990). Delayed figure reconstruction by a chimpanzee (*Pan troglodytes*) and humans (*Homo sapiens*). *Journal of Comparative Psychology*, *104*(4), 345–351. <https://doi.org/10.1037/0735-7036.104.4.345>
- Goffaux, V., & Rossion, B. (2006). Faces are “spatial” --holistic face perception is supported by low spatial frequencies. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(4), 1023–1039. <https://doi.org/10.1037/0096-1523.32.4.1023>
- Goren, C. C., Sarty, M., & Wu, P. Y. K. (1975). Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics*, *56*(4), 544–549.
- Gothard, K. M., Brooks, K. N., & Peterson, M. A. (2009). Multiple perceptual strategies used by macaque monkeys for face recognition. *Animal Cognition*, *12*(1), 155–167. <https://doi.org/10.1007/s10071-008-0179-7>
- Gothard, K. M., Erickson, C. A., & Amaral, D. G. (2004). How do rhesus monkeys (*Macaca*

- mulatta*) scan faces in a visual paired comparison task? *Animal Cognition*, 7(1), 25–36.
<https://doi.org/10.1007/s10071-003-0179-6>
- Guastella, A. J., Mitchell, P. B., & Dadds, M. R. (2008). Oxytocin increases gaze to the eye region of human faces. *Biological Psychiatry*, 63(1), 3–5.
<https://doi.org/10.1016/j.biopsych.2007.06.026>
- Guillon, Q., Rogé, B., Afzali, M. H., Baduel, S., Kruck, J., & Hadjikhani, N. (2016). Intact perception but abnormal orientation towards face-like objects in young children with ASD. *Scientific Reports*. <https://doi.org/10.1038/srep22119>
- Hadjikhani, N., Kveraga, K., Naik, P., & Ahlfors, S. P. (2009). Early (M170) activation of face-specific cortex by face-like objects. *Neuroreport*, 20(4), 403–407.
<https://doi.org/10.1097/WNR.0b013e328325a8e1>
- Happé, F., & Frith, U. (2006). The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 36(1), 5–25.
<https://doi.org/10.1007/s10803-005-0039-0>
- Haxby, J. V., Ungerleider, L. G., Clark, V. P., Schouten, J. L., Hoffman, E. A., & Martin, A. (1999). The effect of face inversion on activity in human neural systems for face and object perception. *Neuron*, 22(1), 189–199. [https://doi.org/10.1016/S0896-6273\(00\)80690-X](https://doi.org/10.1016/S0896-6273(00)80690-X)
- Hayden, A., Bhatt, R. S., Reed, A., Corbly, C. R., & Joseph, J. E. (2007). The development of expert face processing: Are infants sensitive to normal differences in second-order relational information? *Journal of Experimental Child Psychology*, 97(2), 85–98.
<https://doi.org/10.1016/j.jecp.2007.01.004>
- Hershler, O., Golan, T., Bentin, S., & Hochstein, S. (2010). The wide window of face detection. *Journal of Vision*, 10(2010), 1–14. <https://doi.org/10.1167/10.10.21.Introduction>

- Hershler, O., & Hochstein, S. (2005). At first sight: A high-level pop out effect for faces. *Vision Research*, 45(13), 1707–1724. <https://doi.org/10.1016/j.visres.2004.12.021>
- Hopkins, W. D., & Washburn, D. A. (2002). Matching visual stimuli on the basis of global and local features by chimpanzees (*Pan troglodytes*) and rhesus monkeys (*Macaca mulatta*). *Animal Cognition*, 5(1), 27–31. <https://doi.org/10.1007/s10071-001-0121-8>
- Huang, G. B., Ramesh, M., Berg, T., & Learned-Miller, E. (2007). Labeled faces in the wild: A database for studying face recognition in unconstrained environments. *University of Massachusetts, Amherst, Technical Report 07-49*.
- Jaeger, T., Klahs, K., & Newton, D. (2014). Ebbinghaus illusions with disc figures: Effects of contextual size, separation, and lightness. *Perceptual and Motor Skills*, 118(3), 805–817. <https://doi.org/10.2466/24.27.pms.118k29w0>
- Joseph, J. E., DiBartolo, M. D., & Bhatt, R. S. (2015). Developmental changes in analytic and holistic processes in face perception. *Frontiers in Psychology*, 6, 1165. <https://doi.org/10.3389/fpsyg.2015.01165>
- Joseph, J. E., Gathers, A. D., Liu, X., Corbly, C. R., Whitaker, S. K., & Bhatt, R. S. (2006). Neural developmental changes in processing inverted faces. *Cognitive, Affective and Behavioral Neuroscience*, 6(3), 223–235. <https://doi.org/10.3758/CABN.6.3.223>
- Joseph, R., & Tanaka, J. (2003). Holistic and part-based face recognition in children with autism. *Journal of Child Psychology and Psychiatry*, 44(4), 529–542. <https://doi.org/10.1111/1469-7610.00142>
- Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *The Journal of Neuroscience*, 17(11), 4302–4311. <https://doi.org/10.1098/Rstb.2006.1934>

- Kanwisher, N., & Yovel, G. (2006). The fusiform face area: A cortical region specialized for the perception of faces. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *361*(1476), 2109–2128. <https://doi.org/10.1098/rstb.2006.1934>
- Karmiloff-Smith, A., Thomas, M., Annaz, D., Humphreys, K., Ewing, S., Brace, N., Duuren, M., Pike, G., Grice, S., & Campbell, R. (2004). Exploring the Williams syndrome face-processing debate: The importance of building developmental trajectories. *Journal of Child Psychology and Psychiatry*, *45*(7), 1258–1274. <https://doi.org/10.1111/j.1469-7610.2004.00322.x>
- Kato, M., & Mugitani, R. (2015). Pareidolia in infants. *PLoS ONE*, *10*(2), 1–10. <https://doi.org/10.1371/journal.pone.0118539>
- Kimchi, R. (1992). Primacy of wholistic processing and global / local paradigm : A critical review. *Psychological Bulletin*, *1*(112), 24–38. <https://doi.org/10.1037/0033-2909.112.1.24>
- Kobayashi, M., Otsuka, Y., Nakato, E., Kanazawa, S., Yamaguchi, M. K., & Kakigi, R. (2012). Do infants recognize the Arcimboldo images as faces? Behavioral and near-infrared spectroscopic study. *Journal of Experimental Child Psychology*, *111*(1), 22–36. <https://doi.org/10.1016/J.JECP.2011.07.008>
- Ku, S. P., Tolia, A. S., Logothetis, N. K., & Goense, J. (2011). FMRI of the face-processing network in the ventral temporal lobe of awake and anesthetized macaques. *Neuron*, *70*(2), 352–362. <https://doi.org/10.1016/j.neuron.2011.02.048>
- Kuwahata, H., Adachi, I., Fujita, K., Tomonaga, M., & Matsuzawa, T. (2004). Development of schematic face preference in macaque monkeys. *Behavioural Processes*, *66*(1), 17–21. <https://doi.org/10.1016/j.beproc.2003.11.002>
- Lahaie, A., Mottron, L., Arguin, M., Berthiaume, C., Jemel, B., & Saumier, D. (2006). Face

- perception in high-functioning autistic adults: Evidence for superior processing of face parts, not for a configural face-processing deficit. *Neuropsychology*, *20*(1), 30–41.
<https://doi.org/10.1037/0894-4105.20.1.30>
- Lamb, M. R., & Robertson, L. C. (1988). The processing of hierarchical stimuli: Effects of retinal locus, locational uncertainty, and stimulus identity. *Perception & Psychophysics*, *44*(2), 172–181. <https://doi.org/10.3758/BF03208710>
- Langton, S. R. H., Law, A. S., Burton, A. M., & Schweinberger, S. R. (2008). Attention capture by faces. *Cognition*, *107*(1), 330–342. <https://doi.org/10.1016/j.cognition.2007.07.012>
- Lazar, S. M., Evans, D. W., Myers, S. M., Moreno-De Luca, A., & Moore, G. J. (2014). Social cognition and neural substrates of face perception: Implications for neurodevelopmental and neuropsychiatric disorders. *Behavioural Brain Research*, *263*, 1–8.
<https://doi.org/10.1016/J.BBR.2014.01.010>
- Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2004). Impairment in holistic face processing following early visual deprivation. *Psychological Science*, *15*(11), 762–768.
<https://doi.org/PSCI753> [pii]\r10.1111/j.0956-7976.2004.00753.x
- Leder, H., & Bruce, V. (2000). When inverted faces are recognized: The role of configural information in face recognition. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *53*(2), 513–536. <https://doi.org/10.1080/713755889>
- Leder, H., & Carbon, C.-C. (2006). Face-specific configural processing of relational information. *British Journal of Psychology*, *97*(1), 19–29. <https://doi.org/10.1348/000712605X54794>
- Leonard, T. K., Blumenthal, G., Gothard, K. M., & Hoffman, K. L. (2012). How macaques view familiarity and gaze in conspecific faces. *Behavioral Neuroscience*, *126*(6), 781–791.
<https://doi.org/10.1037/a0030348>

- Leopold, D., & Rhodes, G. (2010). A comparative view of face perception. *Journal of Comparative Psychology, 124*(3), 233–251. <https://doi.org/10.1037/a0019460.A>
- Liu, J., Li, J., Feng, L., Li, L., Tian, J., & Lee, K. (2014). Seeing Jesus in toast: Neural and behavioral correlates of face pareidolia. *Cortex, 53*(1), 60–77. <https://doi.org/10.1016/j.cortex.2014.01.013>
- Lundy, B. (2001). Stimulus properties, attentional limitations, and young children's face recognition. *Perceptual and Motor Skills, 92*(3), 919. <https://doi.org/10.2466/pms.92.3.919-929>
- Mamiya, Y., Nishio, Y., Watanabe, H., Yokoi, K., Uchiyama, M., Baba, T., Iizuka, O., Kanno, S., Kamimura, N., Kazui, H., Hashimoto, M., Ikeda, M., Takeshita, C., Shimomura, T., & Mori, E. (2016). The pareidolia test: A simple neuropsychological test measuring visual hallucination-like illusions. *PLoS ONE, 11*(5), 1–14. <https://doi.org/10.1371/journal.pone.0154713>
- Maurer, D., Le Grand, R., & Mondloch, C. J. (2002). The many faces of configural processing. *Trends in Cognitive Sciences, 6*(6), 255–260. [https://doi.org/https://doi.org/10.1016/S1364-6613\(02\)01903-4](https://doi.org/https://doi.org/10.1016/S1364-6613(02)01903-4)
- McClain, A. D., Van Den Bos, W., Matheson, D., Desai, M., McClure, S. M., & Robinson, T. N. (2014). Visual illusions and plate design: The effects of plate rim widths and rim coloring on perceived food portion size. *International Journal of Obesity, 38*(5), 657–662. <https://doi.org/10.1038/ijo.2013.169>
- McKone, E. (2008). Configural processing and face viewpoint. *Journal of Experimental Psychology: Human Perception and Performance, 34*(2), 310–327. <https://doi.org/10.1037/0096-1523.34.2.310>

- McKone, E., & Boyer, B. L. (2006). Sensitivity of 4-year-olds to featural and second-order relational changes in face distinctiveness. *Journal of Experimental Child Psychology, 94*(2), 134–162. <https://doi.org/10.1016/J.JECP.2006.01.001>
- McKone, E., Kanwisher, N., & Duchaine, B. C. (2007). Can generic expertise explain special processing for faces? *Trends in Cognitive Sciences, 11*(1), 8–15. <https://doi.org/10.1016/J.TICS.2006.11.002>
- Megreya, A. M. (2016). Face perception in schizophrenia: A specific deficit. *Cognitive Neuropsychiatry, 21*(1), 60–72. <https://doi.org/10.1080/13546805.2015.1133407>
- Meinhardt-Injac, B., Persike, M., & Meinhardt, G. (2014). Development of visual systems for faces and objects: Further evidence for prolonged development of the face system. *PLoS ONE, 9*(6), e99942. <https://doi.org/10.1371/journal.pone.0099942>
- Melnick, J. (1997). Welcome “Gestalt Review”: An editorial. In *Gestalt Review* (Vol. 1, pp. 1–8). Penn State University Press. <https://doi.org/10.2307/44394007>
- Michel, C., Caldara, R., & Rossion, B. (2006). Same-race faces are perceived more holistically than other-race faces. *Visual Cognition, 14*(1), 55–73. <https://doi.org/10.1080/13506280500158761>
- Mondloch, C. J., Geldart, S., Maurer, D., & Le Grand, R. (2003). Developmental changes in face processing skills. *Journal of Experimental Child Psychology, 86*(1), 67–84. [https://doi.org/10.1016/S0022-0965\(03\)00102-4](https://doi.org/10.1016/S0022-0965(03)00102-4)
- Mondloch, C. J., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception, 31*(5), 553–566. <https://doi.org/10.1068/p3339>
- Mondloch, C. J., Pathman, T., Maurer, D., Le Grand, R., & de Schonen, S. (2007). The

- composite face effect in six-year-old children: Evidence of adult-like holistic face processing. *Visual Cognition*, *15*(5), 564–577. <https://doi.org/10.1080/13506280600859383>
- Morin, K., Guy, J., Habak, C., Wilson, H. R., Pagani, L., Mottron, L., & Bertone, A. (2015). Atypical face perception in autism: A point of view? *Autism Research*, *8*(5), 497–506. <https://doi.org/10.1002/aur.1464>
- Mottron, L., Burack, J. A., Stauder, J. E. A., & Robaey, P. (1999). Perceptual processing among high-functioning persons with autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(2), 203–211. <https://doi.org/10.1017/S0021963098003333>
- Murphy, J., Gray, K. L. H., & Cook, R. (2017). The composite face illusion. *Psychonomic Bulletin and Review*, *24*(2), 245–261. <https://doi.org/10.3758/s13423-016-1131-5>
- Myowa-Yamakoshi, M., & Tomonaga, M. (2001). Perceiving eye gaze in an infant gibbon (*Hylobates agilis*). *Psychologia: An International Journal of Psychology in the Orient*, *44*(1), 24–30.
- Nakabayashi, K., & Liu, C. H. (2014). Development of holistic vs. featural processing in face recognition. *Frontiers in Human Neuroscience*, *8*, 1–5. <https://doi.org/10.3389/fnhum.2014.00831>
- Nakata, R., & Osada, Y. (2012). The Thatcher illusion in squirrel monkeys (*Saimiri sciureus*). *Animal Cognition*, *15*(4), 517–523. <https://doi.org/10.1007/s10071-012-0479-9>
- Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, *9*(3), 353–383. [https://doi.org/10.1016/0010-0285\(77\)90012-3](https://doi.org/10.1016/0010-0285(77)90012-3)
- Navon, D. (1981). The forest revisited: More on global precedence. *Psychological Research*, *43*(1), 1–32. <https://doi.org/10.1007/BF00309635>
- Nayar, K., Franchak, J., Adolph, K., & Kiorpes, L. (2015). From local to global processing: The

- development of illusory contour perception. *Journal of Experimental Child Psychology*, 131(3), 38–55. <https://doi.org/10.1016/j.jecp.2014.11.001>
- Neiworth, J. J., Gleichman, A. J., Olinick, A. S., & Lamp, K. E. (2006). Global and local processing in adult humans (*Homo sapiens*), 5-year-old children (*Homo sapiens*), and adult cotton-top tamarins (*Saguinus oedipus*). *Journal of Comparative Psychology*, 120(4), 323–330. <https://doi.org/10.1037/0735-7036.120.4.323>
- Neiworth, J. J., Hassett, J. M., & Sylvester, C. J. (2007). Face processing in humans and new world monkeys: The influence of experiential and ecological factors. *Animal Cognition*, 10(2), 125–134. <https://doi.org/10.1007/s10071-006-0045-4>
- Nguyen, M. N., Matsumoto, J., Hori, E., Maior, R. S., Tomaz, C., Tran, A. H., Ono, T., & Nishijo, H. (2014). Neuronal responses to face-like and facial stimuli in the monkey superior colliculus. *Frontiers in Behavioral Neuroscience*, 8(3). <https://doi.org/10.3389/fnbeh.2014.00085>
- Nicolas, S. (1995). Joseph Delboeuf on visual illusions: A historical sketch. *The American Journal of Psychology*, 108(4), 563. <https://doi.org/10.2307/1423073>
- Overman, W. H., & Doty, R. W. (1982). Hemispheric specialization displayed by man but not macaques for analysis of faces. *Neuropsychologia*, 20(2), 113–128. [https://doi.org/10.1016/0028-3932\(82\)90002-1](https://doi.org/10.1016/0028-3932(82)90002-1)
- Parr, L. A. (2003). The discrimination of faces and their emotional content by chimpanzees (*Pan troglodytes*). *Annals of the New York Academy of Sciences*, 56–78. <https://doi.org/10.1196/annals.1280.005>
- Parr, L. A. (2011a). The evolution of face processing in primates. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1571), 1764–1777.

<https://doi.org/10.1098/rstb.2010.0358>

Parr, L. A. (2011b). The inversion effect reveals species differences in face processing. *Acta Psychologica*, *138*(1), 204–210. <https://doi.org/10.1016/j.actpsy.2011.06.005>

Parr, L. A., Dove, T., & Hopkins, W. D. (1998). Why faces may be special: Evidence of the inversion effect in chimpanzees. *Journal of Cognitive Neuroscience*, *10*(5), 615–622. <https://doi.org/10.1162/089892998563013>

Parr, L. A., & Heintz, M. (2006). The perception of unfamiliar faces and houses by chimpanzees: Influence of rotation angle. *Perception*, *35*(11), 1473–1483. <https://doi.org/10.1068/p5455>

Parr, L. A., & Heintz, M. (2008). Discrimination of faces and houses by rhesus monkeys: The role of stimulus expertise and rotation angle. *Animal Cognition*, *11*(3), 467–474. <https://doi.org/10.1007/s10071-008-0137-4>

Parr, L. A., Heintz, M., & Akamagwuna, U. (2006). Three studies on configural face processing by chimpanzees. *Brain and Cognition*, *62*(1), 30–42. <https://doi.org/10.1016/j.bandc.2006.03.006>

Parr, L. A., Winslow, J. T., Hopkins, W. D., & De Waal, F. B. M. (2000). Recognizing facial cues: Individual discrimination by chimpanzees (*Pan troglodytes*) and rhesus monkeys (*Macaca mulatta*). *Journal of Comparative Psychology*, *114*(1), 47–60. <https://doi.org/10.1037/0735-7036.114.1.47>

Parr, Winslow, J. T., & Hopkins, W. D. (1999). Is the inversion effect in rhesus monkeys face specific. *Animal Cognition*, *2*, 123–129.

Parrish, A. E., & Beran, M. J. (2014). When less is more: Like humans, chimpanzees (*Pan troglodytes*) misperceive food amounts based on plate size. *Animal Cognition*, *17*(2), 427–434. <https://doi.org/10.1007/s10071-013-0674-3>

- Parrish, A. E., Brosnan, S. F., & Beran, M. J. (2015). Do you see what I see? A comparative investigation of the Delboeuf illusion in humans (*Homo sapiens*), rhesus monkeys (*Macaca mulatta*), and capuchin monkeys (*Cebus apella*). *Journal of Experimental Psychology: Animal Learning and Cognition*, *41*(4), 395–405.
- Parron, C., & Fagot, J. (2007). Comparison of grouping abilities in humans (*Homo sapiens*) and baboons (*Papio papio*) with the Ebbinghaus illusion. *Journal of Comparative Psychology*, *121*(4), 405–411. <https://doi.org/10.1037/0735-7036.121.4.405>
- Parron, C., & Fagot, J. (2008). Baboons (*Papio papio*) spontaneously process the first-order but not second-order configural properties of faces. *American Journal of Primatology*, *70*(5), 415–422. <https://doi.org/10.1002/ajp.20503>
- Pascalis, O., de Martin de Viviés, X., Anzures, G., Quinn, P. C., Slater, A. M., Tanaka, J. W., & Lee, K. (2011). Development of face processing. *Wiley Interdisciplinary Reviews. Cognitive Science*, *2*(6), 666–675. <https://doi.org/10.1002/wcs.146>
- Paukner, A., Bower, S., Simpson, E. A., & Suomi, S. J. (2014). Sensitivity to first-order relations of facial elements in infant rhesus macaques. *22*(3), 320–330. <https://doi.org/10.1002/icd.1793.Sensitivity>
- Pavlova, M. A., Guerreschi, M., Tagliavento, L., Gitti, F., Sokolov, A. N., Fallgatter, A. J., & Fazzi, E. (2017). Social cognition in autism: Face tuning. *Scientific Reports*, *7*(1), 1–9. <https://doi.org/10.1038/s41598-017-02790-1>
- Pavlova, M. A., Heiz, J., Sokolov, A. N., & Barisnikov, K. (2016). Social cognition in Williams syndrome: Face tuning. *Frontiers in Psychology*, *7*, 1–8. <https://doi.org/10.3389/fpsyg.2016.01131>
- Pavlova, M. A., Heiz, J., Sokolov, A. N., Fallgatter, A. J., & Barisnikov, K. (2018). Even subtle

cultural differences affect face tuning. *PloS One*, *13*(6), e0198299.

<https://doi.org/10.1371/journal.pone.0198299>

Pellicano, E., & Rhodes, G. (2003). Holistic processing of faces in preschool children and adults.

Psychological Science, *14*(6), 618–622. [https://doi.org/10.1046/j.0956-](https://doi.org/10.1046/j.0956-7976.2003.psci_1474.x)

[7976.2003.psci_1474.x](https://doi.org/10.1046/j.0956-7976.2003.psci_1474.x)

Petrakova, A., Sommer, W., Junge, M., & Hildebrandt, A. (2018). Configural face perception in childhood and adolescence: An individual differences approach. *Acta Psychologica*, *188*(7), 148–176. <https://doi.org/10.1016/j.actpsy.2018.06.005>

<https://doi.org/10.1016/j.actpsy.2018.06.005>

Phelps, M. T., & Roberts, W. A. (1994). Memory for pictures of upright and inverted primate faces in humans (*Homo sapiens*), squirrel monkeys (*Saimiri sciureus*), and pigeons (*Columba livia*).

Journal of Comparative Psychology, *108*(2), 114–125.

<https://doi.org/10.1037/0735-7036.108.2.114>

Pinsk, M. a, DeSimone, K., Moore, T., Gross, C. G., & Kastner, S. (2005). Representations of faces and body parts in macaque temporal cortex: A functional MRI study. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(19), 6996–7001.

<https://doi.org/10.1073/pnas.0502605102>

Plaisted, K., Swettenham, J., & Rees, L. (1999). Children with autism show local precedence in a divided attention task and global precedence in a selective attention task. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(5), 733–742.

Journal of Child Psychology and Psychiatry and Allied Disciplines, *40*(5), 733–742.

<https://doi.org/10.1017/S0021963099004102>

Poirel, N., Mellet, E., Houdé, O., & Pineau, A. (2008). First came the trees, then the forest:

Developmental changes during childhood in the processing of visual local-global patterns

according to the meaningfulness of the stimuli. *Developmental Psychology*, *44*(1), 245–253.

<https://doi.org/10.1037/0012-1649.44.1.245>

Pokorny, J., & de Waal, F. B. (2009). Monkeys recognize the faces of group mates in photographs. *Proceedings of the National Academy of Sciences*, *106*(51), 21539–21543.

<https://doi.org/0912174106> [pii]r10.1073/pnas.0912174106

Pokorny, J. J., & de Waal, F. B. M. (2009). Face recognition in capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *123*(2), 151–160.

<https://doi.org/10.1037/a0014073>

Pokorny, J. J., Webb, C. E., & de Waal, F. B. M. (2011). An inversion effect modified by expertise in capuchin monkeys. *Animal Cognition*, *14*(6), 839–846.

<https://doi.org/10.1007/s10071-011-0417-2>

Prather, P. A., & Bacon, J. (1986). Developmental differences in part/whole identification. *Child Development*, *57*(3), 549–558. <http://www.ncbi.nlm.nih.gov/pubmed/3720392>

Proverbio, A. M., & Galli, J. (2016). Women are better at seeing faces where there are none: An ERP study of face pareidolia. *Social Cognitive and Affective Neuroscience*, *11*(9), 1501–1512. <https://doi.org/10.1093/scan/nsw064>

Quinn, P. C., & Tanaka, J. W. (2009). Infants' processing of featural and configural information in the upper and lower halves of the face. *Infancy*, *14*(4), 474–487.

<https://doi.org/10.1080/15250000902994248>

Rakover, S. S., & Teucher, B. (1997). Facial inversion effects: Parts and whole relationship.

Perception & Psychophysics, *59*(5), 752–761. <https://doi.org/10.3758/bf03206021>

Rhodes, G., Brake, S., & Atkinson, A. P. (1993). What's lost in inverted faces? *Cognition*, *47*(1), 25–57. [https://doi.org/10.1016/0010-0277\(93\)90061-y](https://doi.org/10.1016/0010-0277(93)90061-y)

Richardson, W. K., Washburn, D. A., Hopkins, W. D., Savage-Rumbaugh, E. S., & Rumbaugh,

- D. M. (1990). The NASA/LRC computerized test system. *Behavior Research Methods, Instruments, & Computers*, 22(2), 127–131. <https://doi.org/10.3758/BF03203132>
- Richler, J. J., Cheung, O. S., & Gauthier, I. (2011). Holistic processing predicts face recognition. *Psychological Science*, 22(4), 464–471. <https://doi.org/10.1177/0956797611401753>
- Richler, J. J., & Gauthier, I. (2014). A meta-analysis and review of holistic face processing. *Psychological Bulletin*, 140(5), 1281–1302. <https://doi.org/10.1037/a0037004>
- Riekki, T., Lindeman, M., Aleneff, M., Halme, A., & Nuortimo, A. (2013). Paranormal and religious believers are more prone to illusory face perception than skeptics and non-believers. *Applied Cognitive Psychology*, 27(2), 150–155. <https://doi.org/10.1002/acp.2874>
- Robbins, R., & McKone, E. (2007). No face-like processing for objects-of-expertise in three behavioural tasks. *Cognition*, 103(1), 34–79. <https://doi.org/10.1016/j.cognition.2006.02.008>
- Rosa-Salva, O., Regolin, L., & Vallortigara, G. (2010). Faces are special for newly hatched chicks: Evidence for inborn domain-specific mechanisms underlying spontaneous preferences for face-like stimuli. *Developmental Science*, 13(4), 565–577. <https://doi.org/10.1111/j.1467-7687.2009.00914.x>
- Rosa Salva, O., Farroni, T., Regolin, L., Vallortigara, G., & Johnson, M. H. (2011). The evolution of social orienting: Evidence from chicks (*Gallus gallus*) and human newborns. *PLoS ONE*, 6(4), e18802. <https://doi.org/10.1371/journal.pone.0018802>
- Rose, S. A., Feldman, J. F., & Jankowski, J. J. (2009). Information processing in toddlers: Continuity from infancy and persistence of preterm deficits. *Intelligence*, 37(3), 311–320. <https://doi.org/10.1016/j.intell.2009.02.002>
- Rose, S. A., Jankowski, J. J., & Feldman, J. F. (2008). The inversion effect in infancy: the role of

- internal and external features. *Infant Behavior & Development*, 31(3), 470–480.
<https://doi.org/10.1016/j.infbeh.2007.12.015>
- Rosenfeld, S. A., & Van Hoesen, G. W. (1979). Face recognition in the rhesus monkey. *Neuropsychologia*, 17(5), 503–509. [https://doi.org/10.1016/0028-3932\(79\)90057-5](https://doi.org/10.1016/0028-3932(79)90057-5)
- Rosenthal, G., Levakov, G., & Avidan, G. (2018). Holistic face representation is highly orientation-specific. *Psychonomic Bulletin & Review*, 25(4), 1351–1357.
<https://doi.org/10.3758/s13423-017-1381-x>
- Rossion, B. (2008). Picture-plane inversion leads to qualitative changes of face perception. *Acta Psychologica*, 128(2), 274–289. <https://doi.org/10.1016/J.ACTPSY.2008.02.003>
- Rousselet, G. A., Macé, M. J.-M., & Fabre-Thorpe, M. (2003). Is it an animal? Is it a human face? Fast processing in upright and inverted natural scenes. *Journal of Vision*, 3(6), 5.
<https://doi.org/10.1167/3.6.5>
- Ryan, C., Stafford, M., & King, R. J. (2016). Seeing the man in the moon: Do children with autism perceive pareidolic faces? A pilot study. *Journal of Autism and Developmental Disorders*, 46(12), 3838–3843. <https://doi.org/10.1007/s10803-016-2927-x>
- Scherf, K. S., Behrmann, M., Minshew, N., & Luna, B. (2008). Atypical development of face and greeble recognition in autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 49(8), 838–847. <https://doi.org/10.1111/j.1469-7610.2008.01903.x>
- Schwarzer, G. (2000). Development of face processing: The effect of face inversion. *Child Development*, 71(2), 391–401. <https://doi.org/10.1111/1467-8624.00152>
- Schwarzer, G., Zauner, N., & Jovanovic, B. (2007). Evidence of a shift from featural to configural face processing in infancy. *Developmental Science*, 10(4), 452–463.
<https://doi.org/10.1111/j.1467-7687.2007.00599.x>

- Sergent, J. (1984). An investigation into component and configural processes underlying face perception. *British Journal of Psychology*, 75(2), 221–242. <https://doi.org/DOI:10.1111/j.2044-8295.1984.tb01895.x>
- Slater, A., Quinn, P. C., Hayes, R., & Brown, E. (2000). The role of facial orientation in newborn infants' preference for attractive faces. *Developmental Science*, 3(2), 181–185. <https://doi.org/10.1111/1467-7687.00111>
- Spinozzi, G., De Lillo, C., & Salvi, V. (2006). Local advantage in the visual processing of hierarchical stimuli following manipulations of stimulus size and element numerosity in monkeys (*Cebus apella*). *Behavioural Brain Research*, 166(1), 45–54. <https://doi.org/10.1016/j.bbr.2005.06.043>
- Spinozzi, G., De Lillo, C., & Truppa, V. (2003). Global and local processing of hierarchical visual stimuli in tufted capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, 117(1), 15–23. <https://doi.org/10.1037/0735-7036.117.1.15>
- Spinozzi, G., De Lillo, C., Truppa, V., & Castorina, G. (2009). The relative use of proximity, shape similarity, and orientation as visual perceptual grouping cues in tufted capuchin monkeys (*Cebus apella*) and humans (*Homo sapiens*). *Journal of Comparative Psychology*, 123(1), 56–68. <https://doi.org/10.1037/a0012674>
- Stiles, J., Delis, D. C., & Tada, W. L. (1991). Global-local processing in preschool children. *Child Development*, 62(6), 1258–1275. <https://doi.org/10.1111/j.1467-8624.1991.tb01604.x>
- Stiles, J., & Tada, W. L. (1996). Developmental change in children's analysis of spatial patterns. *Developmental Psychology*, 32(5), 951–970. <https://doi.org/10.1037/0012-1649.32.5.951>
- Sugita, Y. (2008). Face perception in monkeys reared with no exposure to faces. *Proceedings of the National Academy of Sciences*, 105(1), 394–398.

<https://doi.org/10.1073/pnas.0706079105>

Susilo, T., Crookes, K., McKone, E., & Turner, H. (2009). The composite task reveals stronger holistic processing in children than adults for child faces. *PLoS ONE*, *4*(7), e6460.

<https://doi.org/10.1371/journal.pone.0006460>

Tada, W. L., & Stiles-Davis, J. (1989). Children's analysis of spatial patterns: An assessment of their "errors" in copying geometric forms. *Cognitive Development*, *4*(2), 177–195.

[https://doi.org/10.1016/0885-2014\(89\)90014-2](https://doi.org/10.1016/0885-2014(89)90014-2)

Talbot, C. F., Leverett, K. L., & Brosnan, S. F. (2016). Capuchins recognize familiar faces.

Animal Behaviour, *122*, 37–45. <https://doi.org/10.1016/j.anbehav.2016.09.017>

Tanaka, & Farah, M. J. (1993). Parts and wholes in face recognition. *The Quarterly Journal of Experimental Psychology Section A*, *46*(2), 225–245.

<https://doi.org/10.1080/14640749308401045>

Tanaka, J. W., Kay, J. B., Grinnell, E., Stansfield, B., & Szechter, L. (1998). Face recognition in young children: When the whole is greater than the sum of its parts. *Visual Cognition*, *5*(4),

479–496. <https://doi.org/10.1080/713756795>

Tanaka, & Simonyi, D. (2016). The "parts and wholes" of face recognition: A review of the literature. *Quarterly Journal of Experimental Psychology*, *69*(10), 1876–1889.

<https://doi.org/10.1080/17470218.2016.1146780>

Taubert, J. (2010). Evidence of human-like, holistic face processing in spider monkeys (*Ateles geoffroyi*). *Journal of Comparative Psychology*, *124*(1), 57–65.

<https://doi.org/10.1037/a0017704>

Taubert, J., Aagten-Murphy, D., & Parr, L. A. (2012). A comparative study of face processing using scrambled faces. *Perception*, *41*(4), 460–473. <https://doi.org/10.1068/p7151>

- Taubert, J., Apthorp, D., Aagten-Murphy, D., & Alais, D. (2011). The role of holistic processing in face perception: Evidence from the face inversion effect. *Vision Research*, *51*(11), 1273–1278. <https://doi.org/10.1016/j.visres.2011.04.002>
- Taubert, J., & Parr, L. A. (2009). Visual expertise does not predict the composite effect across species: A comparison between spider (*Ateles geoffroyi*) and rhesus (*Macaca mulatta*) monkeys. *Brain and Cognition*, *71*(3), 187–195. <https://doi.org/10.1016/j.bandc.2009.09.002>
- Taubert, J., & Parr, L. A. (2012). The perception of two-tone Mooney faces in chimpanzees (*Pan troglodytes*). *Cognitive Neuroscience*, *3*(1), 21–28. <https://doi.org/10.1080/17588928.2011.578737>
- Taubert, J., Qureshi, A. A., & Parr, L. A. (2012). The composite face effect in chimpanzees (*Pan troglodytes*) and rhesus monkeys (*Macaca mulatta*). *Journal of Comparative Psychology*, *126*(4), 339–346. <https://doi.org/10.1037/a0027287>
- Taubert, J., Wardle, S. G., Flessert, M., Leopold, D. A., & Ungerleider, L. G. (2017). Face pareidolia in the rhesus monkey. *Current Biology*, *27*(16), 2505-2509.e2. <https://doi.org/10.1016/j.cub.2017.06.075>
- Tavares, P. P., Mouga, S. S., Oliveira, G. G., & Castelo-Branco, M. (2016). Preserved face inversion effects in adults with autism spectrum disorder. *NeuroReport*, *27*(8), 587–592. <https://doi.org/10.1097/WNR.0000000000000576>
- Teunisse, J.-P., & de Gelder, B. (2003). Face processing in adolescents with autistic disorder: The inversion and composite effects. *Brain and Cognition*, *52*(3), 285–294. [https://doi.org/10.1016/S0278-2626\(03\)00042-3](https://doi.org/10.1016/S0278-2626(03)00042-3)
- Theeuwes, J., & Van der Stigchel, S. (2006). Faces capture attention: Evidence from inhibition

- of return. *Visual Cognition*, 13(6), 657–665. <https://doi.org/10.1080/13506280500410949>
- Thompson, P. (1980). Margaret Thatcher: A new illusion. *Perception*, 9, 483–484.
- Tomonaga, M. (1994). How laboratory-raised Japanese monkeys (*Macaca fuscata*) perceive rotated photographs of monkeys: Evidence for an inversion effect in face perception. *Primates*, 35(2), 155–165. <https://doi.org/10.1007/BF02382051>
- Tomonaga, M. (1999). Inversion effect in perception of human faces in a chimpanzee (*Pan troglodytes*). *Primates*, 40(3), 417–438. <https://doi.org/10.1007/BF02557579>
- Tomonaga, M. (2007). Visual search for orientation of faces by a chimpanzee (*Pan troglodytes*): Face-specific upright superiority and the role of facial configural properties. *Primates*, 48(1), 1–12. <https://doi.org/10.1007/s10329-006-0011-4>
- Tomonaga, M., & Imura, T. (2009). Faces capture the visuospatial attention of chimpanzees (*Pan troglodytes*): Evidence from a cueing experiment. *Frontiers in Zoology*, 6(1), 14. <https://doi.org/10.1186/1742-9994-6-14>
- Tomonaga, M., & Imura, T. (2015). Efficient search for a face by chimpanzees (*Pan troglodytes*). *Scientific Reports*, 5, 1–12. <https://doi.org/10.1038/srep11437>
- Tomonaga, M., & Matsuzawa, T. (1992). Perception of complex geometric figures in chimpanzees (*Pan troglodytes*) and humans (*Homo sapiens*): Analyses of visual similarity on the basis of choice reaction time. In *Journal of comparative psychology* (Vol. 106, Issue 1, pp. 43–52). <https://doi.org/10.1037/0735-7036.106.1.43>
- Tsao, D. Y., Freiwald, W. A., Knutsen, T. A., Mandeville, J. B., & Tootell, R. B. H. (2003). Faces and objects in macaque cerebral cortex. *Nature Neuroscience*, 6(9), 989–995. <https://doi.org/10.1038/nn1111>
- Tsao, D. Y., & Livingstone, M. S. (2008). Mechanisms of Face Perception. *Annual Review of*

- Neuroscience*, 31(1), 411–437. <https://doi.org/10.1146/annurev.neuro.30.051606.094238>
- Tsao, D. Y., Moeller, S., & Freiwald, W. A. (2008). Comparing face patch systems in macaques and humans. *Proceedings of the National Academy of Sciences*, 105(49), 19514–19519. <https://doi.org/10.1073/pnas.0809662105>
- Tsao, D. Y., Schweers, N., Moeller, S., & Freiwald, W. A. (2008). Patches of face-selective cortex in the macaque frontal lobe. *Nature Neuroscience*, 11(8), 877–879. <https://doi.org/10.1038/nn.2158>
- Turati, C., Di Giorgio, E., Bardi, L., & Simion, F. (2010). Holistic face processing in newborns, 3-month-old infants, and adults: Evidence from the composite face effect. *Child Development*, 81(6), 1894–1905. <https://doi.org/10.1111/j.1467-8624.2010.01520.x>
- Turati, C., Sangrigoli, S., Ruel, J., & de Schonen, S. (2004). Evidence of the face inversion effect in 4-month-old infants. *Infancy*, 6(2), 275–297. https://doi.org/10.1207/s15327078in0602_8
- Utz, S., & Carbon, C. C. (2016). Is the Thatcher illusion modulated by face familiarity? Evidence from an eye tracking study. *PLoS ONE*, 11(10), e0163933. <https://doi.org/10.1371/journal.pone.0163933>
- Van Belle, G., De Graef, P., Verfaillie, K., Rossion, B., & Lefèvre, P. (2010). Face inversion impairs holistic perception: Evidence from gaze-contingent stimulation. *Journal of Vision*, 10(5), 10. <http://www.ncbi.nlm.nih.gov/pubmed/20616142>
- Van Ittersum, K., & Wansink, B. (2012). Plate size and color suggestibility: The Delboeuf illusion's bias on serving and eating behavior. *Journal of Consumer Research*, 39(2), 215–228. <https://doi.org/10.1086/662615>
- Vermeire, B. A., & Hamilton, C. R. (1998). Inversion effect for faces in split-brain monkeys. *Neuropsychologia*, 36(10), 1003–1014. [https://doi.org/10.1016/S0028-3932\(98\)00054-2](https://doi.org/10.1016/S0028-3932(98)00054-2)

- Wagemans, J., Elder, J. H., Kubovy, M., Palmer, S. E., Peterson, M. A., Singh, M., & von der Heydt, R. (2012). A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. *Psychological Bulletin*, *138*(6), 1172–1217. <https://doi.org/10.1037/a0029333>
- Walker, E., McGuire, M., & Bettes, B. (1984). Recognition and identification of facial stimuli by schizophrenics and patients with affective disorders. *British Journal of Clinical Psychology*, *23*(1), 37–44. <https://doi.org/10.1111/j.2044-8260.1984.tb00624.x>
- Wardle, S. G., Seymour, K., & Taubert, J. (2017). Characterizing the response to face pareidolia in human category-selective visual cortex. *BioRxiv*, *233387*, 1–22. <https://doi.org/10.1101/233387>
- Wasserman, E. A. (2012). Illusory perception in animals: Observations and interpretations. In O. F. Lazareva, T. Shimizu, & E. A. Wasserman (Eds.), *How animals see the world: Comparative behavior, biology, and evolution of vision* (pp. 93–99). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780195334654.003.0007>
- Watson, T. L. (2013). Implications of holistic face processing in autism and schizophrenia. *Frontiers in Psychology*, *4*, 1–11. <https://doi.org/10.3389/fpsyg.2013.00414>
- Weintraub, D. J. (1979). Ebbinghaus illusion: Context, contour, and age influence the judged size of a circle amidst circles. *Journal of Experimental Psychology: Human Perception and Performance*, *5*(2), 353–364. <https://doi.org/10.1037/0096-1523.5.2.353>
- Weintraub, D. J., & Schneck, M. K. (1986). Fragments of Delboeuf and Ebbinghaus illusions: Contour/context explorations of misjudged circle size. *Perception & Psychophysics*, *40*(3), 147–158. <https://doi.org/10.3758/BF03203010>
- Weiss, D. J., Kralik, J. D., & Hauser, M. D. (2001). Face processing in cotton-top tamarins

(*Saguinus oedipus*). *Animal Cognition*, 3(4), 191–205.

<https://doi.org/10.1007/s100710000076>

Weldon, K. B., Taubert, J., Smith, C. L., & Parr, L. A. (2013). How the Thatcher illusion reveals evolutionary differences in the face processing of primates. *Animal Cognition*, 16(5), 691–700. <https://doi.org/10.1007/s10071-013-0604-4>

Wertheimer, M. (1938). Laws of organization in perceptual forms. In W. Ellis (Ed.), *A source book of Gestalt psychology* (pp. 71–88). Routledge & Kegan Paul.

Wright, A. A., & Roberts, W. A. (1996). Monkey and human face perception: Inversion effects for human faces but not for monkey faces or scenes. *Journal of Cognitive Neuroscience*, 8(3), 278–290. <https://doi.org/10.1162/jocn.1996.8.3.278>

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, 81(1), 141–145. <https://doi.org/10.1037/h0027474>

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configural information in face perception. *Perception*, 16(July), 747–759. <https://doi.org/10.1068/p160747>

Yovel, G., & Freiwald, W. A. (2013). Face recognition systems in monkey and human: Are they the same thing? *F1000Prime Reports*, 5, 1–8. <https://doi.org/10.12703/P5-10>

Zhou, L. F., & Meng, M. (2019). Do you see the “face”? Individual differences in face pareidolia. *Journal of Pacific Rim Psychology*, 1–8. <https://doi.org/10.1017/prp.2019.27>