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THE ROLE OF RACIAL INFORMATION IN INFANT FACE PROCESSING

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ABSTRACT OF DISSERTATION

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A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
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The present research addressed the development of specialization in face processing in infancy by examining the roles of race and emotion. An other-race face among own-race faces draws adults' attention to a greater degree than an own-race face among other-race faces due to the "other-race" feature in other-race faces. This feature underlies race-based differences in adults' face processing. The current studies investigated the development of this mechanism as well as the influence that this mechanism has on emotion processing in infancy.

In Experiment 1, Caucasian 3.5- and 9- month-olds exhibited a preference for a pattern containing an Asian face among seven Caucasian faces over a pattern containing a Caucasian face among seven Asian faces. This preference was not driven by the majority of elements in the images, because a control group of infants failed to exhibit a preference between homogeneous patterns containing eight Caucasian versus eight Asian faces. The asymmetrical attentional engagement by other-race faces indicates that the other-race feature is developed by 3.5 months of age.

Like race, emotions elicit asymmetrical attention in adults: an emotional face among neutral faces is more rapidly detected than vice versa. In Experiment 2a, 9-month-olds' preference for a pattern containing a fearful face among neutral faces over a pattern containing a neutral face among fearful faces was greater than their preference for all neutral over all fearful faces. Thus, 9-month-olds exhibited an asymmetry in the processing of emotions. Moreover, this asymmetry was not affected by the race of the faces depicting the emotion. In Experiment 2B, 3.5-month-olds failed to exhibit a preference when tested with the same procedure.

Overall, the data suggest that other-race information is processed as a feature by 3.5- and 9-month-olds, which indicates that infants process other-race information in a different, perhaps categorical, manner than own-race information. Also, other-race information does not disrupt emotion processing by 9-month-olds, which suggests that emotion and race information are processed separately in infancy. Finally, the current results indicate that adult-like asymmetrical attention to emotion develops between 3.5 and 9 months of age.

KEYWORDS: Infant Perception, Development, Race, Emotion, Perceptual Asymmetry

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RULES FOR THE USE OF DISSERTATIONS

DISSERTATION

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This dissertation is dedicated to my parents, Patricia and Michael Hayden, your support and love means the world to me. I can't even express in words how much you guys mean to me.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FILES

Chapter 1

Introduction

Information conveyed by faces serves several important functions for human adults. It allows adults to categorize and recognize individuals, and to respond to threat or to invitation, thereby enabling rapid and appropriate responses in social situations. One kind of information that modulates adults' response to faces is race. They treat own-race faces differently than other-race faces. In the following series of studies, I investigated whether the presence of other-race information leads to asymmetrical attentional engagement and the disruption of emotion processing for infants.

Expertise in Face Processing.

Adults' differential processing of own- and other-race faces may result from differences in levels of expertise with these faces. Therefore, investigating other-race face processing can provide a window into the development of face expertise. Expertise with particular categories of objects (including faces) drives processing to a finer, more specific level due to the importance of distinguishing among individual exemplars of the category. Thus, in the following sections, the development of face expertise is described and subsequently discussed in terms of levels of processing.

Models of early face processing.

Faces are one of the few objects in the environment on which humans gain expertise. The process of gaining expertise on faces begins early: infants prefer to look at faces over non-faces at birth (Goren, Sarty, & Wu, 1975), and also prefer their mother's face over other faces (Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995; Walton, Bower, & Bower, 1992). There is some controversy as to the mechanism for this remarkable newborn preference for faces (Farah, Rabinowitz, Quinn, & Liu, 2000; Johnson & Morton, 1991; Kanwisher, McDermott, & Chun, 1997; de Schonen & Mathivet, 1989; Turati, 2004). Some suggest that preference is due to a dedicated module located in the ventral occipitotemporal region of the cortex (generally in the fusiform gyrus- this region is called the Fusiform Face Area, or FFA) that is specific for processing faces (Farah et al., 2000; Kanwisher et al., 1997). Turati (2004) believes that preference is not specific to faces; she suggest that infants prefer objects, like faces, that contain top-down asymmetry (in which there is more information on the top of the object than the bottom), and that faces benefit from this initial preference. Furthermore, Turati suggests that infants learn the significance of human faces very quickly because of the mother's important role in their own well-being. A third theory, proposed by Johnson and Morton (1991; see also: de Schonen & Mathivet, 1989), suggests that there is more than one biological mechanism driving face preference over time. Their theory suggests that newborns prefer face over non-face patterns due to an innate subcortical mechanism labeled CONSPEC, in which the attention of young infants is directed to salient biological objects (salient, in this and all other mentions in this study, meaning important information or objects that draw attention relative to neighboring information or objects). At approximately 3 months, a separate, cortical mechanism labeled CONLERN emerges, through which infant attention is directed to information regarding their own species. Own-species face processing then becomes more sophisticated to the detriment of other-species face processing. The development of expertise on own-species faces has been associated with the ability to process specific kinds of information from faces. In particular, expertise has been linked to the ability to process second-order relational information. This is discussed next.

Development of tools for expertise in face processing.

According to Diamond and Carey (1994) and others (Gauthier & Curby, 2005; Mondloch, Le Grand, & Maurer, 2002), processing of second-order information is the hallmark of expertise with faces. Second-order information is defined as the spacing relations among the features of the face (e.g., the distance between the eyes, the distance between the nose and the mouth). Research suggests that even 5-month-olds have the ability to detect second-order information changes (Bhatt , Bertin, Hayden, & Reed, 2005; Hayden, Bhatt, Reed, Corbly, & Joseph, 2007). This suggests that at least one of the necessary 'tools' for face processing expertise is available by 5 months of age. An important indicator of second-order processing is the presence of the inversion effect when second-order information is manipulated. The inversion effect is the phenomenon in which facial information is processed much better and much more rapidly in the canonical upright position than in the non-canonical inverted position (e.g., Diamond & Carey, 1977; Friere, Lee, & Symons, 2000; Itier & Taylor, 2004). According to Yin (1969), the inversion effect is much stronger for faces than for objects in adults due to the expert nature of adult face processing. The inversion effect is present as early as 5 months of age: Infants detect changes in second-order information when faces are presented upright but not when they are inverted (Bhatt et al., 2005; Hayden et al., 2007). In addition to second-order information, infants also process faces holistically (e.g., Cashon & Cohen, 2001; Cohen & Cashon, 2004; Schwarzer, Zauner, & Jovanovic, 2007), which is defined as processing in which the individual elements of an object are processed to a lesser degree than the object as a whole. Although these and other such aspects of face-processing expertise are evident early in life, it takes up to 10-14 years of age before adult-like levels of processing are achieved.

Levels of processing differences in conspecific faces versus other objects.

As discussed above, expertise in face processing is characterized by the fact that conspecific faces are processed differently than other objects. Conspecific faces are processed at a more specific level of abstraction than most other objects, namely the subordinate level. The subordinate level of face processing involves individuation which requires that the viewer detect the unique properties of a face that distinguish it from other faces (Tanaka, 2001; Tanaka & Pierce, 2009). Non-face objects (and faces that do not belong to familiar categories of people) in the environment are generally processed initially at a less specific level, namely the basic level (Tanaka, Curran, & Sheinberg, 2005). The basic level of abstraction is the level at which objects can be identified and discriminated based on a general knowledge of the object, a prototypical representation of the object due to similarity in shape of different exemplars, and similarity in terms of interaction with and/or motor movements towards the object (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Thus, the basic level of abstraction allows non-face objects or living things to be processed based on the similarities to other objects or living things of the same general category. The basic level serves as the *entry point* of processing for objects, meaning that it is the level at which most objects are initially processed (Rosch et al., 1976; Tanaka et al., 2005). For example, a tabby cat or a wrench would be more readily identified as a ‘cat’ and a ‘tool’ (basic-level categories) than a ‘tabby cat’ and a ‘wrench’ (subordinate categories), or an ‘animal’ and a ‘non-living thing’ (superordinate categories; Rosch et al., 1976). In contrast, adults process conspecific faces as quickly at the subordinate level as at the basic level; for example, identifying the face of Bill Clinton as rapidly as categorizing it as a human face (Tanaka, 2001). The subordinate level of processing is therefore the entry point in processing for faces (at least faces that belong to familiar categories of people).

When the subordinate level becomes the typical mode of processing of a particular object (whether it be conspecific faces, other living organisms, or non-living objects), it is an indication of expertise on that class of objects. Adult expertise is generally limited to face processing, but adults can be trained to process other objects (such as owls and water birds, for example; Tanaka et al., 2005) at the subordinate level. When expertise is attained with a particular class of objects, the processing of these objects seems to be qualitatively different from that of non-expert object processing. For instance, expert object processing, according to several studies, involves more holistic processing than non-expert object processing (e.g., Farah, Wilson, Drain, & Tanaka, 1998; Tanaka & Farah, 1993, 2003); in the latter case, featural processing is more likely (but see Cabeza and Kato, 2000). Experts also exhibit a stronger inversion effect with objects on which they are experts than with other objects (Diamond & Carey, 1996). This suggests that expertise with objects, like expertise with faces, involves becoming skilled at processing these objects in an upright canonical orientation to the detriment of processing the same objects when they are inverted. In addition to clear behavioral differences when comparing expert versus non-expert processing, investigators using physiological techniques such as fMRI as well as ERP have also found differences when adults process faces versus objects.

Physiological evidence of face and object specialization.

Studies that employ fMRI techniques indicate that participants exhibit greater activation in the FFA with conspecific faces relative to other natural and unnatural objects (e.g., Aguirre, Singh, & D'Esposito, 1999; Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Haxby, Ungerleider, Clark, Schouten, Hoffman, & Martin, 1999; Kanwisher, Tong, & Nakayama, 1998) and inverted faces (e.g., Gauthier et al., 1999; Haxby et al., 1999; Joseph, Gathers, Liu, Corbly, Whitaker, & Bhatt, 2006; for a review, see Rossion & Gauthier, 2002), suggesting that the FFA is more specialized to face processing than object processing. It is important to note, however, that objects activate the FFA as well (Joseph, Bhatt, & Gathers, in press), albeit to a lesser degree than faces, indicating that the function of the FFA is not solely to process faces (but see McKone, Kanwisher, & Duchaine, 2006; McKone & Robbins, 2007; Rhodes, Byatt, Michie, & Puce, 2004). In addition, the FFA is not the only area that has been identified as being involved in face processing: recent research also indicates that face processing involves an extensively connected network of areas of the brain that include the Occipital Face Area (OFA- also activated to a greater extent with faces than other objects), and other areas that are non-specific to face processing (e.g., Joseph et al., in press; Pitcher, Walsh, Yovel, & Duchaine, 2007; Rossion, Caldera, Seghier, Schuller, Lazeyras, & Mayer, 2003).

Research also suggests that experts on non-face objects such as cars exhibit greater activation in the FFA when processing cars than novices (e.g., Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier et al., 1999) although there is major controversy to this claim (see McKone et al., 2006; McKone & Robbins, 2007). Thus, although some claim that the main function of the FFA is face-processing (e.g., McKone et al., 2006; McKone & Robbins, 2007, Rhodes et al., 2004), others contend that the FFA is an area of expertise that mediates subordinate-level processing in general (e.g., Gauthier & Curby, 2005, Gauthier & Tarr, 1997, 2002; Gauthier et al., 2000; Wong, Palmeri, & Gauthier, 2009). This seems to mirror the behavioral studies mentioned above that investigated level of processing differences when comparing experts and novices: experts identified objects as rapidly at a subordinate level of processing as at a basic level of processing, whereas novices identified the same objects more rapidly at a basic level than a subordinate level of processing (Rosch et al., 1976; Tanaka et al., 2005). This body of research indicates that, although there may or may not be a dedicated brain area that is entirely specific to face processing alone (but see Joseph et al., in press), visual objects of expertise, which include faces, are clearly processed differently than objects that are outside areas of expertise.

Research with ERP techniques suggest that both the canonical processing of faces as well as other objects of expertise elicit a similar-if-not-identical increase in the amplitude as well as a more rapid onset of the N170 relative to non-canonical versions of faces or objects (e.g., Rossion, Gauthier, Goffaux, Tarr, & Crommelinck, 2002; Tanaka & Curran, 2001). The N170 is an ERP component that had originally been associated with expert face processing. Thus, both behavioral as well as physiological studies indicate that faces as well as objects of expertise are processed differently than objects with which adults have no expertise. This difference in processing seems to originate with the difference in the level of processing (basic versus subordinate) between objects within and outside areas of expertise (including conspecific faces).

Development of levels of processing in infancy.

Quinn (2004) and a follow-up study by Quinn and Tanaka in 2007 suggested that infants' object processing increases in specificity over time from superordinate, to basic, to subordinate. According to Quinn and colleagues, infants (tested at 2 months) begin by processing objects (and non-conspecifics) at a superordinate level, meaning that their entry-point to processing objects is even more general than that of adults. Infants then begin to categorize objects at the basic level at 3-4 months, and have the capacity to be trained to individuate objects at the subordinate level at 6-7 months of age. For example, 6- to- 7-month-old infants in Quinn (2004), when shown a series of Tabby cats or Beagles, could distinguish between a new exemplar of the species that they had previously been exposed to (i.e., a new tabby cat if they had been shown a series of tabby cats) and an exemplar of Siamese cat (or Saint Bernard if they had been exposed to beagles), thus suggesting that they had been 'trained' to identify exemplars of a subordinate-level category of cat (or dog). This series of studies highlights the uniqueness of face processing in infancy: infants are able to individuate (i.e., process faces on a subordinate level) faces at least as early as 3 months (e.g., Barrera & Maurer, 1981; Kelly, Quinn, Slater, Lee, Ge, & Pascalis, 2007; Sangrigoli & de Schonen, 2004b, although some studies suggest that this ability is available at birth: e.g., Bushnell, 2001; Pascalis et al., 1995), but only process non-faces at less specific levels (i.e., basic and superordinate) at this age.

Explanation for level of processing differences.

Evidence suggests that the tendency to individuate faces but process non-face objects only at a basic category level may be a mechanism of efficiency, whereby processing resources are utilized to individuate only when it is necessary (faces) but not otherwise (non-face objects). A study by Tanaka et al. (2005) supports the claim that the level at which adults discriminate among objects depends upon the level that is necessary for successful negotiation of the world. Tanaka et al. trained two groups of participants with owls and water birds. One group was trained at the basic level of categorization-for instance, in one task, these participants were required to indicate whether two photographs were of the same basic category (i.e., whether both photographs depicted owls or, in a separate condition, both depicted water birds) and were given feedback. The other group of participants was trained at the subordinate level of categorization. These participants, in a similar task, were asked to indicate whether both photographs depicted owls (or water birds) of the same species or different species. Participants trained at the subordinate level of categorization were able to distinguish among species of owls (or water birds) within six sessions of training, and were much better at distinguishing among exemplars of entirely new species of owls (or water birds) than those trained at the basic level of categorization. These results suggest that adults have the ability to use the subordinate level of categorization for non-conspecific organisms and objects, but they utilize this ability only when it is necessary to do so.

Processing other-race faces at a basic level.

In addition to processing objects that require only basic level processing in a categorical manner, the perceptual system also seems to process faces that are deemed 'unnecessary' for individuation in a basic (i.e., categorical) manner, as well (Levin, 1996, 2000). One factor that might determine the significance of a face (and thus the depth of processing of the face) is race. Many adults process faces that are not of their own race at a basic rather than a subordinate level (Tanaka & Pierce, 2009). Therefore, like participants trained with basic-level comparisons of owls or water birds in Tanaka et al. (2005), humans identify faces of other races based on category rather than individually. Therefore, other-race faces may be more difficult to recognize than own-race faces because of the natural bias of the perceptual system to process non-salient objects categorically. Tanaka and Pierce (2009) employed a procedure similar to that of their 2005 study in which they trained Caucasian participants to differentiate among African American or Hispanic faces at the subordinate (individual) level or the basic level ('basic level' defined as race). They found that participants trained at the subordinate level discriminated among other-race faces after a brief period of training, whereas those trained at the basic level were significantly less skillful at discriminating among individual other-race faces. ERP measures also suggested that training at the subordinate level increased the N250, a component associated with expertise, whereas training at the basic level failed to increase the N250.

It is clear, therefore, that other-race faces are discriminated at a qualitatively different level of processing than own-race faces. It seems that the racial information itself is the means by which these faces are categorically discriminated. This categorical discrimination of other-race faces based on racial information, versus the subordinate level of categorization based on the unique facial characteristics of the individual, contributes to a mechanism of race-based face processing proposed by Levin (1996, 2000). Briefly (as this mechanism will be described in detail below), Levin proposed that that the detection of other-race information drives an attentional asymmetry such that other-race faces are detected more rapidly among own-race faces than own-race faces are detected among other-race faces. Levin suggests that other-race information serves as a fundamental 'feature' that indicates to the perceptual system that individuation of the face is unnecessary. Thus, the face is categorized based on racial features (i.e., at the basic level of categorization) rather than individuated. One of the major purposes of the present series of studies was to investigate the development of this mechanism in infancy.

Another issue addressed by the current research concerns the effects of race on emotion processing in infancy. The presence of other-race characteristics may affect the encoding of many types of information conveyed by faces, one of which is emotion. For instance, many studies suggest that adults can more accurately identify emotion conveyed by own-race than other-race faces (Chiao et al., 2008; Elfenbein & Ambady, 2002; Elfenbein, Beaupré, Lévesque, & Hess, 2007; Lee et al., 2008; Thibault, Bourgeois, & Hess, 2006, but see Beaupré & Hess, 2005; Matsumoto, Olide, & Willingham, 2009). The second major purpose of this series of studies was therefore to investigate the role that Levin's (1996, 2000) proposed mechanism for other-race face processing (described below) plays in emotion processing in infancy.

Identity Processing: The Other-Race Effect (ORE).

The tendency of adults to distinguish between same-race faces (i.e., faces in their own racial category) more easily than between other-race faces (i.e., faces that are not in their own racial category) is called the Other-Race Effect (ORE). While the previous sections made clear that own-race faces are processed at a perceptual level that is subordinate to that of other-race faces, there are several theories that have attempted to explain this ORE. The following sections describe early as well as current theories of the ORE. In addition, Levin's race coding hypothesis (1996, 2000) that describes a mechanism for other-race face processing that was tested in the current series of studies is discussed in detail, and the mechanism's place in a theory that integrates several models of the ORE (Sporer, 2001) is also described.

Early theories of the ORE.

In order to understand the specific underlying mechanism that Levin (1996, 2000) proposed regarding initial processing of other-race information, it is important to understand the differing theories regarding the Other-Race Effect. The ORE has been explained in many ways over the years. Early researchers believed that the ORE was a function of an unwillingness to individuate faces of other races due to negative attitudes towards those of other races (Secord, Bevin, & Katz, 1956). This theory was cast aside due to inconsistent results (Brigham & Barkowitz, 1978; Meissner & Brigham, 2001). However, the attitude hypothesis contributed to a second explanation for the ORE: the *contact hypothesis*. The contact hypothesis describes the ORE in terms of exposure: the more that someone is exposed to and is in contact with other-race faces, the less the person will be affected by other-race information (Cross, Cross, & Daly, 1971). While the results of some studies confirmed this (Cross et al., 1971; Feinman & Entwisle, 1976), others did not (Ng & Lindsay, 1994). This was puzzling, until several groups of researchers (see Brigham, Maass, Snyder, & Spaulding, 1982; Carroo, 1986) proposed that, in addition to the amount of contact that a person has with another race, the quality of interaction that this person has with others is also important. This led to discussion of the ORE in the context of Valentine's (1991) multidimensional 'face-space' hypothesis.

Valentine's face-space hypothesis.

Valentine's (1991) 'face-space' hypothesis describes the method by which faces are represented in memory. According to Valentine, faces are stored based on dimensions that are relevant to recognizing them. Some researchers claim that the relevant dimensions that adults use to successfully individuate faces can vary according to race (Deregowski, Ellis, & Shepherd, 1975; Shepherd & Deregowski, 1981). This idea has been incorporated into the *exemplar-based model* of face processing (Byatt & Rhodes, 1988). There are two major theories included in the exemplar-based model of face processing: the Norm-Based Encoding (NBE) theory in which all faces lie on a specific vector that is derived from a central tendency, and the Purely Exemplar-Based Model (PEBM), in which there is no central tendency and faces are evaluated in relation to all other faces in the face-space (Valentine, 1991). There is greater support for the PEBM model in the face-space literature (e.g., Lewis & Johnston, 1999; Valentine & Endo, 1992). In the exemplar-based model, a novel face is 'placed' near faces that most closely resemble it in relevant dimensions. Therefore, faces with similar characteristics are represented by clusters in face space. The 'face-space' model describes the ORE in the following exemplar-based terms: own-race faces are experienced more often, and therefore, when encountering other-race faces that have to be identified, attempts are made to use dimensions for identifying *own-race* faces instead of dimensions that may be more appropriate for the other-race faces. This use of inappropriate dimensions results in the representation of other-race faces far from the main cluster of own-race faces in multi-dimensional "face-space" (Byatt & Rhodes, 1998). Also, a unique property of the PEBM is that other-race faces are clustered more tightly than own-race faces in face-space. Thus, in addition to the pitfalls of attempting to identify other-race faces based on own-race dimensions, identification is made more difficult because the activation of a tighter cluster of faces in face-space results in the greater (psychological) appearance of homogeneity of other-race faces. It is important to note that, in contrast to the psychological appearance of homogeneity of other-race faces, research has suggested that the actual amount of physiognomic difference among members of a particular racial group is relatively equivalent for all racial groups (Goldstein, 1979).

Theories based on the presence of racial markers.

As noted above, one assumption of the face-space model is that faces that have similar characteristics will be located near to one another in 'face-space.' However, MacLin and Malpass (2001) found that racial markers (e.g., hairstyles associated with different races) on otherwise identical faces, can elicit differences in encoding that are inexplicable by the current face-space model. They suggest that in addition to clusters of faces that are similar in relevant dimensions, face-space may also have categories of faces based solely on race. In other words, race as an independent feature might itself determine location of faces in face space. Therefore, when participants in their study were presented with ambiguous faces that had different racial markers, they categorized those faces based on race and then identified the face based on their own construction of 'face-space.' MacLin and Malpass also suggested (in agreement with Levin [1996, 2000], whose theory is presented below) that one's own race serves as a 'default' and that it is unnecessary to categorize faces of one's own race (based on racial characteristics and as 'own-race') in face-space. Faces of other races (or ambiguous faces with racial markers) are categorized as 'other-race' first, and then subsequently encoded. Levin's (1996, 2000) theory extends this idea using a visual search procedure.

Levin's race coding hypothesis (1996, 2000).

Levin (1996, 2000) suggested that, for adults, other-race information is a fundamental 'feature' of faces. According to Levin, it is not necessary to categorize faces of one's own race based on this feature. One's own race serves as the 'default' position. Adults, according to Levin, learn over time to relegate faces of races other than their own to the category of 'other-race' in face-space when the race feature is present, and subsequently fail to adequately individuate the person because faces containing the race feature are considered to be less relevant for social function. He cited studies in which participants exhibited a significant decrease in the ORE with a brief amount of training (Elliot, Wills, & Goldstein, 1973; Goldstein & Chance, 1985) in order to argue that if the ORE was solely due to lack of expertise and lack of quality interaction (Lindsay, Jack, & Christian, 1991), then the ORE could not be so easily mitigated.

The origin of the procedure that Levin used to determine that race is a feature for adults was a visual-search task employed by Treisman and Gormican (1988). In this study, adults were asked to detect a feature-positive Q among feature-negative O's or vice-versa. An important characteristic of this phenomenon is that a pop-out asymmetry emerges: a feature-positive element surrounded by feature-negative elements is rapidly detected (i.e., it pops out) but a feature negative element amid feature-positive elements is not detected as easily. That is, a Q among O's is detected more rapidly than an O among Q's. In Levin's studies, Caucasian participants exhibited a similar asymmetry: they more readily identified an African American target face (a feature-positive target) among

Caucasian faces (feature-negative distracters) than a Caucasian face (feature-negative target) among African American faces (feature-positive distracters). That is, these participants identified the presence of a unique face much more rapidly when the African American face was the target face than when the Caucasian face was the target. Thus, Levin argued, the feature of race among non-race was more easily identified than vice-versa. Levin (and others: Thibault et al., 2006) claims that the ORE manifests itself in social functioning: people of other races become an ‘out-group,’ whereas those of a person’s own race remain within his or her ‘in-group’ and elicit a greater degree of individuation.

The results of an ERP study conducted by Kubota and Ito (2007) support Levin’s (2000) theory. White participants who were faster at categorizing black faces than white faces (i.e., faster at identifying the race of black faces) also exhibited a smaller N200 when asked to categorize black faces relative to categorizing white faces. The N200 is a component that has been linked to depth of processing for faces. A smaller N200 indicates a shallow depth of processing. These results suggest, therefore, that people that are faster at categorizing black faces than white faces based on race information are processing black faces at a more shallow level of processing relative to white faces. Levin’s theory has caused controversy because, although it is empirically supported and has been replicated with Asian faces (Lipp, Terry, Smith, Tellegen, Kuebbeler, & Newey, 2009), others suggest that the claims put forth by Levin are at odds with other empirically-supported theories such as Valentine’s face-space theory (e.g., Papesh & Goldinger, 2009; Rhodes, Lie, Ewing, Evangelista, & Tanaka, 2010; Rhodes, Locke, Ewing, & Evangelista, 2009).

Sporer’s (2001) In-group/Out-group model (IOM) attempts to integrate several differing theories regarding the ORE, including Levin’s (1996) theory. Sporer suggests that the rapid detection of the other-race feature that Levin (1996, 2000) proposed may serve as an initial filter to differential processing of own- and other-race face information. Therefore, when adults rapidly detect other-race information, this detection designates how the other-race face is encoded further down the processing stream. According to Sporer, further processing of other-race information may be explained by several different theories-which could include the PEBM variation on Valentine’s face-space theory (1991). Thus, it is important to investigate the development of this initial 'filter' in order to gain insight into the exact nature of other-race face processing in infancy. If infants exhibit evidence of this filter (by showing a perceptual asymmetry favoring an other-race face among own-race faces over an own-race face among other-race faces), then it would suggest that infant perceptual processing of other-race faces resembles that of adults.

The ORE in childhood and infancy

A study conducted by Corenblum and Meissner (2006) suggested that even young children exhibit the ORE. All age groups of children tested in this study (Caucasian children in grades 2 through 8, and young adults) were less accurate at identifying faces that they had seen previously if these faces were of another race (i.e., African American). Six- to 14-year-old non-adopted Caucasian children living in Western Europe, in de Heering, de Liedekerke, Deboni, & Rossion (2010), exhibited an ORE for Asian faces, suggesting that children exhibit the ORE with more than one type of other-race face (i.e., Asian as well as African American for Caucasians). Several other studies suggest that children from 3 years to 20 years exhibit the ORE (Chance, Turner, & Goldstein, 1982; Corenblum & Meissner, 2006; Sangrigoli & de Schonen, 2004a; Walker & Hewstone, 2006), and that this effect is not limited to Caucasian children (Pezdek, Blandon-Gitlin, & Moore, 2003). In addition, it is also clear that the race of the child does not influence the ORE as much as the race of the surrounding population; Korean children that were adopted by French adults exhibited evidence of the ORE with Asian faces but not with Caucasian faces (Sangrigoli, Paullier, Argenti, Ventureyra, & de Schonen, 2005). These studies suggest that the ORE develops early in life, is not limited to Caucasian children, and is not based on racial phenotype but rather by surrounding populations of people. In addition, children's processing of race can be highly influenced by context. Two-and-a-half- to 5- year-old children that were raised in a majority Caucasian population who were presented with an own-race face or other-race face as context for a morphed ambiguous-race face perceived the morphed face to more strongly resemble that of the non-morphed contextual face, and differentially processed the perceived own-race and other-race faces (Shutts & Kinzler, 2007). This indicates that the ORE is fairly complex, even in early childhood. Moreover, the ORE develops very rapidly after birth (Hayden, Bhatt, Joseph, & Tanaka, 2007; Sangrigoli & de Schonen, 2004b).

A recent study conducted by Anzures, Quinn, Pascalis, Slater, & Lee (in press) found that both 6- and 9-month-olds failed to exhibit a novelty preference when habituated to an Asian face and tested with the familiar face and a novel Asian face. They exhibited a novelty preference under the same conditions for Caucasian faces, however, suggesting that infants seem to exhibit the ORE at both 6 and 9 months. Other studies suggest that infants as young as 3.5 months exhibit the ORE (Hayden et al., 2007; Sangrigoli & de Schonen, 2004b). Sangrigoli and de Schonen habituated 3-month-old infants to either an Asian face or a Caucasian face. Infants exhibited a preference for novel Caucasian faces following habituation to a Caucasian face, but failed to show a preference for novel Asian faces when habituated to an Asian face.

One possible alternative to the claim that infants in Sangrigoli and de Schonen (2004b) exhibited the ORE was that the Caucasian faces that the authors selected could have been more discriminable than the selected Asian faces. If this were the case, then infants in Sangrigoli and de Schonen could have discriminated between Caucasian faces (but not between Asian faces) because the Caucasian faces were ‘easier’ to distinguish. Hayden et al. (2007) conducted a habituation study that equated for discriminability in order to rule out this possibility. They employed a morphing procedure in which Caucasian infants were habituated to either a 100% Asian or a 100% Caucasian face and then tested with the same face paired with a face that was 70% of the original face and 30% of a face of the other race. They used this morphing procedure in order to ensure that the distance in physical similarity space between the habituated and tested faces could be equivalent for Asian and Caucasian faces (Walker & Tanaka, 2003). Infants in Hayden et al. (2007) exhibited a novelty preference when habituated to a Caucasian face and tested with a morphed face, but failed to exhibit a novelty preference when habituated to an Asian face and tested with a morphed face. This outcome ruled out the alternative explanation of the Sangrigoli and de Schonen (2004b) finding that infants exhibited differential processing of Asian and Caucasian faces due to differences in discriminability of the faces. In addition, Hayden et al. replicated the finding that infants exhibit the ORE as young as 3 months of age.

A study by Kelly et al. (2007) suggests that the ORE may not be robust until 9 months of age. Caucasian 3-month-olds failed to exhibit an ORE in this study, while 6-month-olds exhibited an ORE with Middle-Eastern and African faces, but not with Asian faces. Nine-month-olds, however, exhibited the ORE with Asian faces as well, suggesting that the ORE is quite well-developed at 9 months of age. Kelly et al. (2007) suggested that the increasing inability of infants to discriminate other-race faces indicates a perceptual narrowing of face-processing abilities. Initially, infants process all faces (including other-race faces) equally well, but, with increasing exposure to own-race but not other-race faces, infants become specialized in their processing of own-race faces-to the detriment of other-race face processing (see Pascalis, de Haan, & Nelson [2002], and Pascalis et al. [2005] for a similar timetable for the development of the other-species effect). The variable conclusions from different studies regarding the initial development of the ORE is evidence that the timeline for the development of the ORE is not completely pinned down, and that slightly different timelines for perceptual narrowing may be with found with different procedures.

In addition to finding that both 6- and 9-month-olds exhibit the ORE with Asian faces, Anzures et al. (in press) found that 6-month-old Caucasian infants can form a discrete category of Caucasian faces, but not of Asian faces (but that 9-month-olds can form discrete categories in both cases). In this experiment, infants were familiarized with six different Asian or Caucasian faces. They were then tested with a novel face of the same race, followed by a novel face of a different race. For instance, infants familiarized to a set of six Caucasian faces would be tested with a novel Caucasian face, followed by a novel Asian face. Six-month-olds failed to exhibit a novelty preference for the new race category when familiarized with Caucasian faces and tested with Asian faces, but exhibited a novelty preference for the new race category when familiarized with Asian faces and tested with Caucasian faces. Nine-month-olds preferred the novel race faces in both the Asian and Caucasian conditions. The authors suggest that 6-month-olds' failure is due to the inability of 6-month-olds to categorize Asian faces at 6 months (while the success of 9-month-olds in the same condition is evidence that categorization of Asian faces develops between 6 and 9 months). An important caveat that the authors mention, however, is that infants exhibit a preference for own-race over other-race faces as early as

3 months (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005); thus, preference for own-race faces may be stronger than preference for novel other-race faces for 6-month-old infants. In effect, 6-month-old infants may be categorizing Asian faces, but strong preferences for Caucasian faces could be obscuring their ability to exhibit categorization in Anzures et al. These preferences, if they are still present at more advanced ages in infancy, did not affect 9-month-old novelty preference for Asian faces. Overall, Anzures et al. (in press) conclude from the results that infants have differently-developed levels of categorization for other-race and own-race faces. They suggest that infants have a basic-level as well as a subordinate-level category for Caucasian faces. In effect, they have a category of ‘Caucasian’ and they can also individuate faces, thus showing evidence for a ‘subordinate-level’ category, but 6-month-olds do not have a basic-level category of ‘Asian’, and, subsequently, fail to individuate Asian faces at the subordinate-level category.   Nine-month-olds have a basic-level category of Asian faces, but again fail to individuate these faces at the subordinate-level category. This study therefore indicates that infants’ categories of own- and other-race faces develop at vastly different rates (although preference for Caucasian faces could be a factor for the 6-month-old group). This suggests that even in early infancy, there is a clear differentiation in the way that other-race and own-race faces are treated. Own-race faces are treated as salient objects in which individuation is important, whereas other-race features are treated as non-salient objects in which the development of even a basic-level category is not as important to the perceptual system.

While the studies described above suggest that infants clearly exhibit the ORE at a very young age (the ORE most likely becomes robust at around 9 months of age, but infants show evidence of the ORE as early as 3 months of age), that other-race faces are categorized differently from own-race faces, and that other-race face categories develop at a different rate than own-race faces, we do not know how infants perceptually process other-race information. As discussed earlier, Levin (1996, 2000) suggested that the key difference in the processing of other-race versus own-race faces is the segregation based on the “other-race” feature. One question that arises is whether a similar mechanism underlies ORE in infancy also. I addressed this issue in Experiment 1 with 3.5- and 9-month-old infants. Experiment 1 was designed based on Levin’s (1996, 2000) finding that, for Caucasian adults, an other-race target face is detected much more rapidly among Caucasian distracter faces than vice-versa. Thus, if other-race information is a fundamental feature for infants also, then their attention will be drawn to a singleton Asian face among Caucasian distracter faces more than to a Caucasian singleton face among Asian distracter faces. Research, described next, suggests that infant attention is drawn to fundamental features in an asymmetrical fashion. I utilized the procedures used in this research in Experiment 1 to examine the asymmetrical nature of attention to own-race and other-race faces in infancy.

Research suggests that discrepancies based on fundamental features attract even young infants' attention (e.g., Bhatt, 1997; Bhatt, Bertin, & Gilbert, 1998; Quinn & Bhatt, 1998; Rovee-Collier, Hankins, & Bhatt, 1992). For example, when 3- to 4-month-olds in Quinn and Bhatt were habituated to a display of 25 +'s, they subsequently exhibited a preference for a display containing a single feature discrepancy (an "L" among 24 +'s) over another display containing a single familiar + surrounded by 24 novel "L"s. In other words, infants' performance was determined by a single "pop-out" element rather than the large number of surrounding elements in the array, thereby indicating attentional engagement by the discrepant element. Subsequent research by Bhatt, Hayden, Reed, Bertin, and Joseph (2006) found that infants also exhibit asymmetries in discrepancy detection. In that study, infants detected concave elements among convex distracters but not vice versa. This is analogous to the finding that for adults concavities (signals for object parts) pop-out of displays when surrounded by convex elements but not vice versa (Hulleman, te Winkel, & Boselie, 2000; Wolfe & Bennett, 1997). Thus, prior studies not only demonstrate that infants' attention is drawn to discrepancies but that, in infancy, as in adulthood, attention can be asymmetrical, such that features-positive elements amid feature-negative elements attract attention but feature-negative elements amid feature-positive elements do not.

In the current series of studies, I adopted the logic of the studies described above to test whether a single other-race face among own-race faces would capture attention. If infants do in fact show a perceptual asymmetry by preferring the other-race among own-race face display over the reverse display, this asymmetry would be consistent with Levin's (1996, 2000) idea of a feature early in life.

The Effect of the Presence of Other-Race Information on Emotion Processing: The In-Group Advantage (IGA)

To date ORE studies have primarily focused on the disruption of identity processing when other-race characteristics are detected. In addition to identity information, however, the processing of other forms of information that can be conveyed by faces may also be disrupted by the presence of other-race information for infants. One type of information that may be disrupted is emotion. Many studies have examined emotion-processing in infancy (e.g., Bornstein & Arterberry, 2003; Nelson, Morse, & Leavitt, 1979; for a review, see de Haan & Matheson, 2009), but no study has explored the effect of race on infants' processing of this type of information. Therefore, the purpose of Experiments 2a and 2b (described in more detail below) was to explore the effect of race on emotion processing in infancy. As emotion is a salient type of information conveyed by faces, it is important to investigate how other-race information affects emotion processing in order to gain a more complete understanding of how other-race information affects face processing. The following sections detail why emotion is an important facial characteristic to process and describe various views and theories related to the effect of race information on emotion processing.

The importance of emotion processing.

The perception of emotion in faces is an important social function because the understanding of the emotions of those around us enables us to respond to them appropriately. Research on emotion-processing by adults suggests that there are six universal emotions (anger, happiness, fear, sadness, surprise, and disgust) that are identifiable in all cultures (Beihl et al., 1997; Ekman, 1972; Izard, 1971, 1994). Early researchers cited the fact that humans perform at above-chance levels at identifying each of these emotions from both own-culture (i.e., own-race) faces as well as well as cross-cultural (i.e., other-race) faces (Ekman, 1972; Izard, 1971) as evidence that emotions are decoded equivalently across cultures. Later researchers (e.g., Matsumoto, 1989) explored the data sets that these early researchers had collected and suggested that there were differences in cultural emotion identification, but that early researchers may not have investigated these differences further because they were highlighting similarities across cultures. Thus, although adults performed above chance in identifying emotions depicted by other-race individuals, the level at which they identified these emotions differed in comparison to identification of emotions depicted by own-race individuals.

Investigations of the In-Group Advantage.

A meta-analysis conducted by Elfenbein and Ambady (2002) included several studies that examined both the similarities and differences across cultures in emotion recognition. A major focus of this study was the effect of other-race information on emotion processing; emotion researchers call this effect the *in-group advantage* (IGA). Elfenbein and Ambady found that humans have more difficulty recognizing emotions of those of other races than those of their own race. This study and others (Elfenbein & Ambady, 2003; Thibault et al., 2006) suggest that the effect of other-race information on emotion information (the IGA) parallels the effect of other-race information on identity information (the ORE). In fact, the ORE and the IGA may share the same mechanism: essentially, the detection of other-race information might disrupt further processing of facial information. The Elfenbein and Ambady meta-analysis concluded that, as in the case of identity processing, exposure to other cultures lessened the IGA (those that lived closer to other cultures exhibited this phenomenon to a smaller degree than those that lived further away, for instance), and minority groups exhibited less of this IGA (apparently due to the overwhelming presence of the majority group in society). This study also found that some emotions (fear and disgust) elicited a strong IGA, while other emotions (happiness and anger) elicited less of an IGA. Elfenbein and Ambady suggested that this difference is due to happiness and anger being the universal signals for approach and avoidance. Thibault et al. (2006) reinforced the conclusions of Elfenbein and Ambady. Paralleling the claims of researchers investigating the effect of other-race information on identity processing, they suggested that this IGA was due to people viewing others of their own race as members of their 'in-group' and those of other races as members of an 'out-group,' whose emotions they need not process to the same extent. Beauprè and Hess (2006) investigated whether confidence in the ability to detect emotional expressions depicted by people of other races was moderated by familiarity and quality of interaction with individuals of that race. Their results suggested that, similarly to the ORE pertaining to identity processing, familiarity with other-race individuals in addition to increased quality of interaction strongly predicted confidence in correctly recognizing facial expressions depicted by other-race individuals.

Finally, a more recent conducted by Chiao et al. (2008) suggests that there is a neurological component accompanying the behavioral IGA, at least for fearful faces. Japanese participants in Japan and Caucasian participants in the United States were presented with images of fearful expressions. Functional Magnetic Resonance Imaging (fMRI) recordings showed a clear cross-over effect in terms of amygdala response to own- and other-race faces: Japanese participants exhibited greater amygdala response to Japanese faces depicting fear, and Caucasian participants exhibited greater amygdala response to Caucasian faces depicting fear. This outcome reinforces Elfenbein and Ambady's (2002) meta-analytic claim that fear is an emotion that is processed more strongly for own-race faces than other-race faces. Moreover, fear is not the only emotion in which other-race faces elicit activation differentially from own-race faces: Lee et al. (2008) suggested that own-race faces depicting happy and sad expressions activated the hippocampus and the amygdala to a greater degree than other-race faces depicting happy and sad expressions. These clear neural differences in the processing of other-race versus own-race emotional faces support the theory that emotion processing may be disrupted by the presence of other-race information.

The Dialect Theory of the IGA.

The *dialect* theory of emotion processing (Elfenbein et al., 2007) derived from the dialect theory of language (e.g., Francis, 1992), suggests that, although emotion comprehension is universal in that all emotions are detected among all cultures, greater difficulty identifying cross-cultural depictions of emotion derives from unique differences in the manner in which specific cultures exhibit emotions (much like people in different regions speak the same language, but there are differences in dialects based on location). Elfenbein et al. (2007) found that naturally posed facial expressions (i.e., asking the poser to exhibit a specific facial expression) elicited the IGA, with Quebecois and Gambonese participants judging facial expressions exhibited by people of their own culture more accurately than those exhibited by people of a different culture. On the other hand, participants failed to exhibit the IGA with posed facial expressions when the posers were asked to mimic 'prototyical' facial expressions. Elfenbein claimed that this outcome supported the dialect theory of emotion processing. Interestingly, however, judgment of fearful expression was not found to differ between naturally posed and prototypical expressions, suggesting that the IGA elicited by cross-cultural fearful expressions may not be explained by dialect theory. Based on the Elfenbein and Ambady (2002) meta-analysis as well as Chiao et al. (2008), however, there seem to be clear differences in detection of fear based on the culture/race of the poser and the participant. Elfenbein and Ambady suggest it is one of the two emotions that elicits the strongest IGA. It is possible, therefore, that fear is an emotion in which detection is disrupted by the presence of other-race information rather than cultural differences in depiction of the emotion (of which there appears to be little supporting evidence).

Research that fails to support the IGA.

There are other studies, however, (e.g., Beaupré & Hess, 2005; Matsumoto et al., 2009) that do not seem to support the IGA hypothesis. These studies find differences in detection of emotion across culture, but differences were generally not based strictly on cross-cultural deficiencies in emotion detection. Matsumoto et al. (2009) suggested that natural expressions such as the spontaneous emotional expressions of Caucasian and Japanese medal winners employed in their study do not elicit the IGA, whereas posed expressions tend to elicit the IGA. However, they only tested participants with expressions of happiness, sadness, and surprise-expressions that do not elicit a strong IGA. In addition, Kubota and Ito (2007), in an ERP study investigating the differential time-course of emotion and race processing, found that these facial characteristics were processed independently at both early and late stages of processing. They suggest, in accordance with models proposed by Bruce and Young (1986) and Haxby, Hoffman, & Gobbini (2000), that invariant components of facial information such as social identity (e.g., race) and information that is variable (like emotion information) are processed in a separate and parallel fashion. However, like Matsumoto et al., they only tested participants with happy, angry, and neutral faces. They did find, however, in accordance to the behavioral literature (e.g., Hugenberg & Bodenhausen, 2004), that anger (or neutrality) expressed by a black poser elicited a stronger N100 component in Caucasian participants than the same expressions posed by a white person. The N100 is an ERP component associated with the detection of threatening stimuli. The N100 was equivalent for black and white posers expressing happiness.

Studies investigating the IGA in childhood.

Few studies have examined the IGA in childhood. Gitter, Mostofsky, & Quincy (1971) examined 4- to 6- year-olds' emotion recognition as a function of both the judger (children were African American or Caucasian) and the photographs being judged (face photographs were either African American or Caucasian). The authors failed to find differences in emotion recognition in either case. However, their methods may have been flawed in that they gave participants a fairly simple procedure and failed to independently validate it. A study conducted by Eiland and Richardson (1976) yielded slightly different results: these authors gave African American and Caucasian second-graders (7-year-olds) and college students several laminated photographs of African American and Caucasian, young and old, male and female faces, and asked them to place these photograph into bins labeled with an emotion term (happiness, sadness, fear, anger, and disgust). Although overall main effects for race of participant and photograph were non-significant, the authors found an interesting 3-way interaction among race of photograph, age of photograph, and the way that participants responded to the emotion exhibited by the face. This suggests that participants judged emotions differently based on race (and age) of the person in the photograph. As the authors did not directly measure accuracy of emotion recognition, it is difficult to claim that they found an IGA for emotion recognition, but this study does indicate that children respond differently when identifying emotions exhibited by people of different races.

More recent studies investigating the IGA with children have also yielded mixed results. Glanville and Nowicki (2002) investigated whether young African American and Caucasian children exhibit the IGA. They tested second through fourth grade African American and Caucasian children on two different standardized tests measuring accuracy of emotion recognition. One test, the Diagnostic Analysis of Nonverbal Accuracy test--Form 2, Adult Faces (DANVA2-AF; Nowicki & Carton, 1993), measures accuracy of emotion recognition of Caucasian adult faces, and the other test, Diagnostic Analysis of Nonverbal Accuracy test--Form 2, African American Adult Faces (DANVA2-AAAF; Nowicki, Glanville, & Demertzis, 1998), measures accuracy of emotion recognition of

African American adult faces. Each child was tested with both African American (DANVA2-AAAF) and Caucasian (DANVA2-AF) adult faces displaying happiness, anger, fear, or sadness. African American and Caucasian children in the study performed equally well (i.e., performed at similar rates of accuracy) whether identifying emotions displayed by African American adults or Caucasian adults. The authors therefore suggest that second to fourth grade children do not exhibit the IGA. However, a study conducted by Markham and Wang (1996) suggests that, at least under some circumstances, young children do exhibit the IGA. They tested 4- to 8-year-old Chinese (Asian) and Australian (Caucasian) children in a task in which they were shown a Chinese or Australian face exhibiting one of the six basic emotions (i.e., anger, happiness, fear, surprise, disgust, sadness). They were asked to describe a situation in which someone would exhibit that particular emotional expression. Chinese children were better at describing appropriate situations when shown Chinese faces, and Australian children were better at describing appropriate situations when shown Australian faces. Thus, the authors concluded that Chinese and Australian children exhibited the IGA in this task. The results of this study indicate that children as young as four years of age exhibit the IGA under certain circumstances. The conflicting results about IGA in childhood suggests that further research is necessary to understand the development of IGA early in life.

The primary purpose of Experiment 2a of the current research was to explore the influence of other-race information on emotion processing (the IGA, according to emotion-recognition researchers) in order to determine if the presence of the other-race feature disrupts the processing of emotional information by 9-month-olds (Experiment 1). Experiment 2a capitalized on research that suggests that adults more rapidly attend to an emotional (non-neutral) singleton face among neutral distracter faces than to a singleton neutral face among emotional (non-neutral) faces (Williams, Moss, Bradshaw, & Mattingley, 2005). This is due to the featural, ‘pop-out’ status of emotion information: faces displaying a neutral emotion serve as ‘default’ faces in that they do not display an emotion that is attention-grabbing (they are ‘feature-negative’), whereas faces exhibiting emotion (‘feature-positive’ faces) capture attention when located among neutral faces. Experiment 2b was designed to extend the findings in Experiment 2a to younger infants.

Chapter 2

Experiment 1

Experiment 1 investigated the nature of other-race information processing using procedures that have previously been used to study the nature of attention to discrepancies based on fundamental features in the environment. As discussed earlier, analogous to the asymmetries exhibited by infants (e.g., Bhatt et al., 2006), Levin (1996) documented asymmetries in the detection of faces of different races by adults. In those studies, an African American singleton face was detected by Caucasian adults more quickly among Caucasian distracter faces than vice-versa. In Experiment 1, I examined whether a similar asymmetry is exhibited by 3.5- and 9-month-olds. These age groups were chosen because studies have shown that, while the ORE is evident as early as 3 months of age (Sangrigoli & de Schonen, 2004b), it is not robust until 9 months (Kelly et al., 2007). Therefore, the featural status of other-race face characteristics may develop significantly over the course of these 5.5 months.

Infants in the experimental condition viewed a display containing a single Asian face among 7 Caucasian faces paired with another display containing a single Caucasian face among 7 Asian faces (see Fig. 2.1). As stated above, featural discrepancies engage infants' attention (e.g., Bhatt, 1997; Bhatt et al., 1998; Quinn & Bhatt, 1998; Rovee-Collier et al., 1992); therefore, if an Asian face amid Caucasian faces attracts attention but not vice versa, then infants should look longer at the former image than at the latter. It is possible, however, that infants could look longer at the Asian among Caucasian display than at the Caucasian among Asian display because of the greater number of Caucasian faces in the former display than Caucasian faces in the latter display (see Fig. 2.1). In other words, infant preference may be driven by the majority of faces in the displays rather than by the singleton discrepant faces. Therefore, a control condition of infants was tested for preference between a homogeneous display of Caucasian faces and a homogeneous display of Asian faces (see Fig. 2.1). If infants in the experimental condition exhibit a preference for the single Asian among Caucasian pattern, and if this preference is significantly different than the preference for the homogeneous Caucasian pattern in the control condition, then it would suggest that an Asian face among Caucasian faces did attract the infant's attention to a greater degree than the Caucasian face among Asian faces. Such a result would indicate that the infant perceptual system is specialized to own-race faces to the extent that other-race faces are feature-positive stimuli that attract attention when surrounded by own-race faces, whereas own-race faces are feature-negative stimuli that do not attract attention when surrounded by other-race faces.

Method

Participants.

Forty 3.5-month-old (mean age = 112.20 days, *SD* = 4.47, 20 females), and 32 9-month-old Caucasian infants (mean age = 271.69 days, *SD* = 7.82, 12 females) participated in this experiment. Infants were recruited using birth announcements in the local newspaper, by word-of-mouth, and through a local hospital. Data from 18 additional infants were excluded, 12 due to position preference (95% or more looking to one side), 2 due to sibling interference, 1 due to fussiness, 1 due to disinterest (less than 1 second of looking over 2 trials), 1 due to stimulus preference (90% or more looking to one stimulus), and 1 due to experimenter error.

Materials.

The stimuli were colored photographs of four female Asian faces and four female Caucasian faces exhibiting neutral emotions (see Fig. 2.1). Two of the Asian faces and two of the Caucasian faces were from the JACNeuf set (Matsumoto & Ekman, 1988). The Asian faces were N48 and N43 and the Caucasian faces were N25 and N16. The other four faces (two Asian, two Caucasian) were taken from the MacBrain Stimulus set. (Development of the MacBrain set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Networkon Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information.) I am unable to publish these photographs because I could not obtain permission to do so. However, for those who wish to view the faces by accessing the MacBrain website, the Asian faces are listed as Faces 16 and 19 and the Caucasian faces are listed as Faces 02 and 08. An individual Asian face was paired with an individual Caucasian face from the same face bank to form a total of four pairs. The same face pairs were used in the experimental and control conditions. Using Adobe Photoshop, the hair was removed from the head (this is a common practice in studies investigating the ORE (e.g., Hayden et al., 2007; Walker & Tanaka, 2003). In addition, in order to avoid performance based on low-level features, I equated for skin tone within the pairs of faces. In two of the Asian-Caucasian face pairings, the skin tones of the Asian faces were matched to those of the corresponding Caucasian faces; in the other two pairings, the skin tones of the Caucasian faces were matched to those of the Asian faces. Thus, equal numbers of Asian and Caucasian faces had natural and artificial skin tones, but within each Asian-Caucasian pair, the skin tones matched.

Eight faces were arranged on a black background in a diamond formation (as in Levin's [1996, 2000] studies; see Fig. 2.1). Faces were located 0.76° apart from one another. The diamond-shaped face pattern subtended approximately 22° X 17.25°. Individual faces subtended approximately 3.69° X 5.60°. Homogeneous displays were created for the control condition, and pop-out displays for the experimental condition. Homogeneous displays assessed overall preference for groups of Caucasian over Asian faces: They contained eight identical Asian or Caucasian faces (Fig. 2.1). Discrepant displays created for the experimental condition contained a single Asian or Caucasian face surrounded by seven identical faces of the opposite race. The singleton Caucasian and Asian faces in these patterns were in the same location within face pairing but varied between face pairings.

Procedure.

Infants were tested using a spontaneous preference procedure that is commonly employed in infancy studies (e.g., Kelly et al., 2005; Quinn, Kelly, Lee, Pascalis, & Slater, 2008). They were randomly assigned to the experimental and control conditions. In addition, within each condition, the infants were randomly assigned to one of the four Asian-Caucasian face pairings. Infants were seated in a darkened chamber, approximately 45 cm in front of a 20-inch computer monitor. They were tested on a total of two spontaneous preference trials, each of which lasted 8 s. Each trial began with the presentation of an attention-getter (rapidly alternating shapes) in the center of the screen. When the infant's attention was drawn to the center of the screen, the shapes disappeared, and a paired display of faces appeared on the screen. The left-right locations of the homogeneous Asian/Caucasian and the Asian among Caucasian/Caucasian among Asian patterns were randomly determined and counterbalanced across the set of infants in each condition; this location was also changed from one trial to the next to avoid side bias.

A video camera, located on top of the computer monitor, and an associated DVD recorder were used to record the infants' behavior. Coding of the infants' performance was conducted offline, with the coder unaware of the left-right location of the stimulus patterns. The DVD player was slowed to 20% of the normal speed during coding. A separate coder recoded data from 16 infants in order to obtain a reliability measure. The Pearson correlation between the two observers was .92.

Results

Performance was assessed by computing a percent preference score that measured preference for the display in which the majority of the pattern was Caucasian faces (i.e., the homogeneous Caucasian display in the control condition, and the Asian among Caucasian display in the experimental condition). This score was computed by dividing the total duration of looking to the Caucasian face majority display by the total duration of looking time to both displays and multiplying this ratio by 100 to obtain a percentage. In effect, these scores indicated how much infants in the experimental conditions preferred the Asian among Caucasian display over the Caucasian among Asian display and how much infants in the control conditions preferred the homogeneous Caucasian display over the homogeneous Asian display.

An analysis of outlier status based on box plots (Tukey, 1977; using SPSS version 17.0) revealed that preference scores for two 3.5-month-old infants in the experimental condition were outliers, and the preference score for one 9-month-old in the control condition was an outlier. Preference scores considered as outliers were defined as scores that were beyond 1.5 times the interquartile range. The final analyses were conducted without preference scores from these infants. Outlier analysis is a common practice in infancy research (e.g., Bhatt et al., 2006) due to the high variability inherent in infant preference.

See Table 2.1 and Fig. 2.2 for preference scores for both 3.5- and 9-month-old infants. In order to explore age and condition differences, as well as to ensure that performance on individual face pairs did not differ from one another, I conducted an age (3.5-month-olds, 9-month-olds) X face pair (Face Pair 1, Face Pair 2, Face Pair 3, Face

Pair 4) X condition (experimental, control) ANOVA. There was a significant condition main effect, indicating that infant preference was significantly different in the control condition versus experimental condition, $F(1,67) = 10.48$, $p < .01$. Neither the face pair main effect nor the face pair X condition interaction was significant (face pair main effect: $F(3,65) = 1.44$, $p > .20$; face pair X condition interaction: $F(3,61) = .88$, $p > .20$), indicating that the infants performed similarly in their assigned conditions, irrespective of face pair. Recall that two of the four faces of each race were tested with the natural skin tone, whereas the others had their skin tone changed to match their corresponding opposite race faces. The fact that face pair was not a statistically significant main or interaction factor therefore indicates that the preference for the Asian-among-Caucasian pattern over the reverse pattern exhibited in the experimental condition and the lack of preference between the homogeneous patterns in the control condition did not vary as a function of whether the faces of the two races had natural or unnatural skin tones. In other words, performance was driven by physiognomic characteristics of faces, rather than by any ‘weirdness’ factor based on the mismatch between races and their skin tones. Significantly, there was also no main effect of age, $F(1, 67) = .09$, $p > .50$, nor any interactions associated with age: face pair X age: $F(3, 61) = .58$, $p > .50$; condition X age: $F(1, 65) = .34$, $p > .50$; face pair X condition X age: $F(3, 53) = .82$, $p > .40$, suggesting that there were no overall differences in performance between 3.5-month-olds and 9-month-olds, and no age differences in performance based on condition or face pair (see Table 2.1 and Fig. 2.2).

Separate pre-planned independent-samples *t*-tests investigating group differences were conducted for 3.5- and 9-month-olds, respectively. Infants in both age groups exhibited a significantly greater preference for the Asian-among-Caucasian face display in the experimental condition than the Caucasian face display in the control condition: 3.5-month-olds: $t(36) = 2.32$, $p < .03$, two-tailed; 9-month-olds: $t(29) = 2.74$, $p < .02$, two-tailed. This suggests that the Asian discrepant face drove preference for both age groups in the experimental condition.

Single-sample *t*-tests comparing performance against the chance level of 50% indicated that 9-month-old infants in the experimental condition preferred the Asian-among-Caucasian patterns to the Caucasian-among-Asian patterns significantly above chance level of 50%, $t(15) = 2.73$, $p < .02$, two-tailed, but the infants in the control condition did not significantly prefer either of the homogeneous displays, $t(14) = -.93$, $p > .30$, two-tailed. Similarly, 3.5-month-old infants in the experimental condition preferred the Asian-among-Caucasian patterns to the Caucasian-among-Asian patterns significantly above chance level, $t(17) = 2.62$, $p < .02$, two-tailed, but the infants in the control condition did not significantly prefer either of the homogeneous displays, $t(19) = -.70$, $p > .30$, two-tailed.

These results suggest that infants at both ages preferred the Asian-among-Caucasian face display over the Caucasian-among-Asian face display. This preference for the Asian-among-Caucasian face display was significantly greater than preference for the Caucasian homogeneous display, suggesting that the singleton Asian face drove attention in the experimental condition. Thus, other-race faces elicit a perceptual asymmetry for both 3.5- and 9-month-old infants such that a feature-present Asian face draws attention when surrounded by feature-absent Caucasian faces to a greater degree than a feature-absent Caucasian face among feature-present Asian faces.

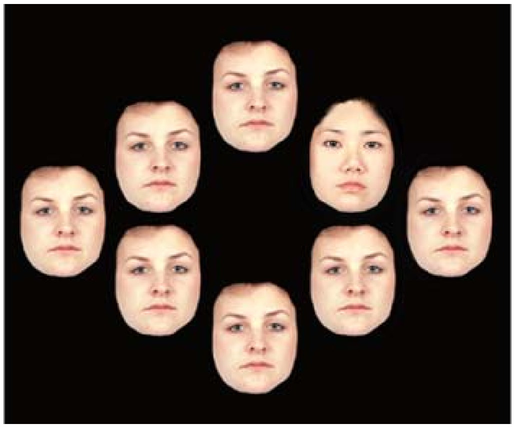
Discussion

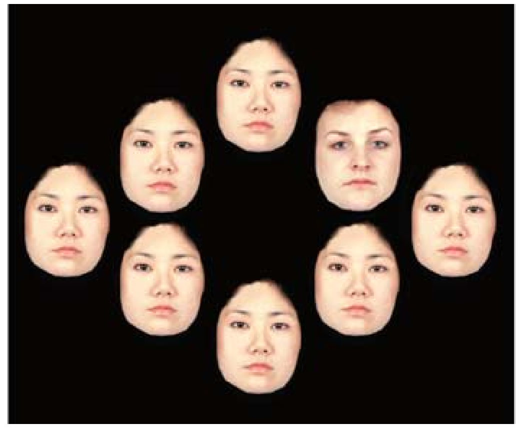
For both 3.5- and 9-month-old Caucasian infants, as for adults, other-race faces appear to have a distinctive other-race feature that captures attention, whereas own-race faces do not seem to have the same attention-capturing feature. These results suggest that own- and other-race faces are processed differently in the perceptual system very early in life, and that this other-race feature is evident by as early as 3.5 months of age. Previous studies suggest that the ORE may not be robust until 9 months of age (Kelly et al., 2007), but it is clear that categorization and processing differences between other-race and own-race faces occur much earlier based on the current study and the two other studies that have found differences in processing own- and other-race faces at 3.5 months of age (Hayden et al., 2007, Sangrigoli & de Schonen, 2004b). The current experiment in particular suggests that a filtering mechanism may develop early in life in order to appropriately and efficiently process own-and other-race faces (i.e., the basic level for other-race faces and the subordinate level for own-race faces).

Table 2.1. Overall Preference Scores for the Majority Caucasian Display in the Experimental and Control Conditions for 3.5-month-olds and 9-month-olds in Experiment 1

	Preference for the Majority Caucasian Display							
	3.5-month-olds				9-month-olds			
	n	*M*	*SE*	*t*	n	*M*	*SE*	*t*
JACNeuf Faces 16, 43								
Experimental Condition	4	57.83	6.22	n/a	4	58.11	5.19	n/a
Control Condition	5	48.85	8.99	n/a	4	48.99	2.07	n/a
MacBrain Faces 08, 19								
Experimental Condition	5	60.17	6.52	n/a	4	56.62	4.88	n/a
Control Condition	5	38.48	1.83	n/a	4	49.38	3.98	n/a
MacBrain Faces 02, 16								
Experimental Condition	5	52.88	4.64	n/a	4	49.14	2.64	n/a
Control Condition	5	46.40	3.93	n/a	3	43.13	4.43	n/a
JACNeuf Faces 25, 48								
Experimental Condition	4	59.54	7.00	n/a	4	57.54	1.30	n/a
Control Condition	5	58.07	3.91	n/a	4	49.00	1.19	n/a
Overall Preference								
Experimental Condition	18	57.49	2.85	2.62*	16	55.35	1.96	2.73*
Control Condition	20	47.95	2.94	-.70	15	48.75	1.35	-.93

* $p < .02$, two-tailed; significantly different from the chance level of 50%





A

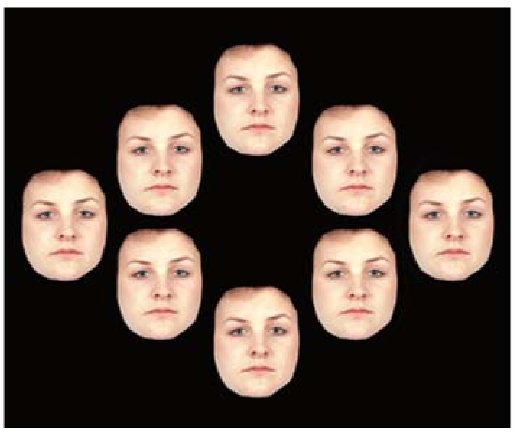
Asian Among Caucasian

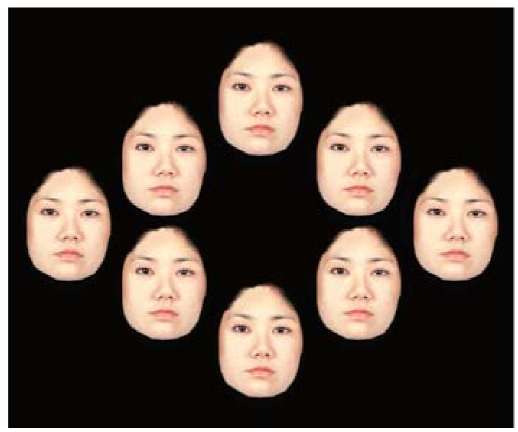
Face Display

B

Caucasian Among Asian

Face Display





C

Caucasian Face Display

D

Asian Face Display

Figure 2.1. Example of Experiment 1 test stimuli. Infants in the experimental condition were tested with a display containing a single Asian face among 7 Caucasian faces (Panel A) paired with a display containing a single Caucasian face among 7 Asian faces (Panel B). Infants in the control condition were tested with a display containing 8 Caucasian faces (Panel C) paired with a display containing 8 Asian faces (Panel D).

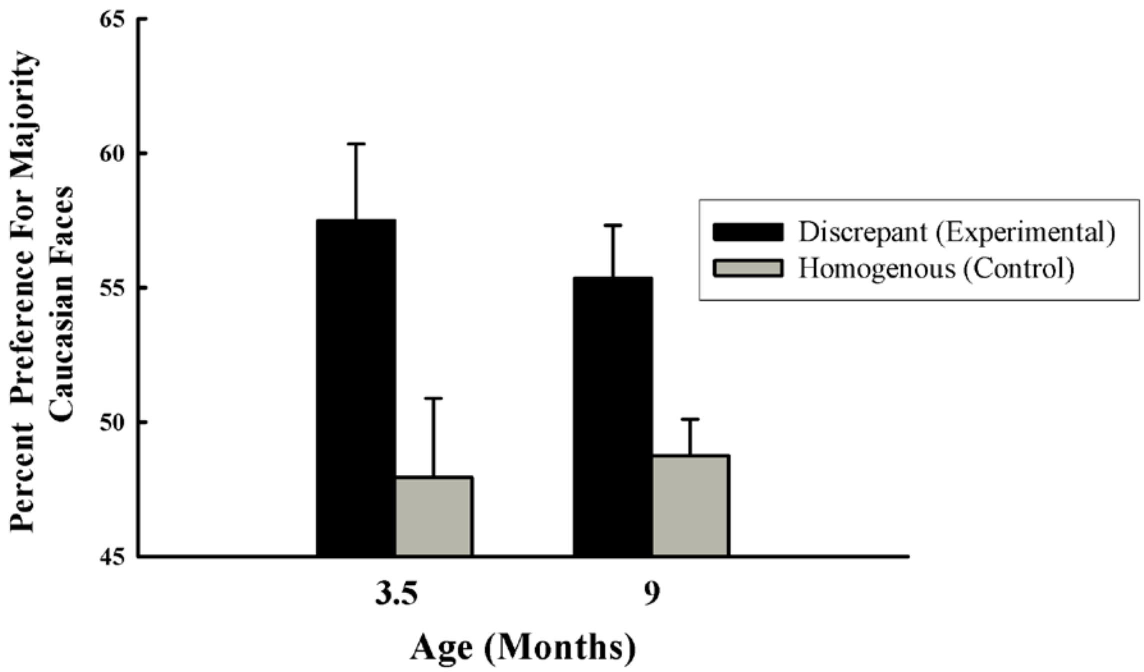


Figure 2.2. 3.5- and 9-month-olds’ mean preferences for the Caucasian majority display in experimental and control conditions of Experiment 1.

Chapter 3

Experiment 2A

Given that Experiment 1 suggested that the other-race feature is evident early in life, I wanted to investigate whether the presence of this feature disrupts the processing of other types of face information. Experiment 2a addressed this issue by examining the influence of other-race information on the processing of emotion information (what researchers call the in-group advantage—IGA) in infancy. I capitalized on the attentional asymmetry generated by emotional faces versus neutral faces (i.e., the faster detection of emotion among neutral faces than the reverse; see Introduction) to explore this phenomenon. If the IGA is present in infancy, then infants should exhibit an attentional asymmetry with Caucasian faces but not with Asian faces such that a Caucasian emotional face among Caucasian neutral faces should draw more attention than a neutral Caucasian face among Caucasian emotional faces, but there should be no such asymmetrical pattern of preference with Asian faces. I chose to study 9-month-olds in Experiment 2a because the research by Kelly et al. (2007) suggested that the ORE may not be robust until 9 months of age. An additional reason for studying 9-month-olds is that processing of emotional information is also fairly well-developed at 9 months (see discussion below).

I used fearful faces (as opposed to other expressions) because studies suggest that the IGA for happy or angry faces is not as strong as the IGA for fearful faces (Elfenbein & Ambady, 2002). In addition, studies (e.g., Fox, Russo, & Dutton, 2002) have found that fearful expressions may use more cognitive resources than other expressions because negative expressions are vital to the assessment of threat (a fearful expression may signal imminent danger to the perceiver [Palermo & Rhodes, 2007]). Fear may similarly draw attention in infancy and childhood. For example, LoBue (2009) asked 5-year-olds to locate (by touching the screen) a target emotional face among eight distracter faces depicting different emotions. LoBue found that expressions indicative of threat (anger and fear) were located faster among distracter faces than non-threat-relevant facial expressions (happy and sad). In addition, several studies investigating fearful face processing in 7-month-old infants suggest not only that it is more difficult to disengage from a fearful face than other emotional expressions (Peltola, Leppänen, Palokangas, & Hietanen, 2008), but that it is the entire fearful face rather than eyes alone that captures attention (Peltola, Leppänen, Vogel-Farley, Hietanen, & Nelson, 2009b). In addition, fear is distinguishable from happy expressions at the neurological level at this age (Nelson & de Haan, 1996). Seven-month-old infants in Nelson and de Haan's (1996) study exhibited differences in several ERP components when viewing happy and fearful faces, including a middle-latency negative component (Nc) normally associated with attention. Fearful faces elicited a significantly larger negative component than happy faces, suggesting that fearful expressions capture attention to a greater degree than non-threat-relevant facial expressions. Thus, cognitive resources used to attend to fearful expressions are difficult to disengage and reengage elsewhere for infants, children, and adults, which should make it likely that infants detect a fearful expression among neutral expressions (at least when processing own-race faces).

Infants in the Caucasian experimental condition viewed a pattern containing a single Caucasian face exhibiting a fearful expression among 7 images of the same face exhibiting a neutral expression, paired with another pattern containing a single Caucasian neutral face among 7 Caucasian fearful faces. Infants in the Asian experimental condition viewed the same pairings in terms of emotional expression, but saw Asian faces instead of Caucasian faces (see Fig. 3.1). Given that discrepancies attract infants' attention (e.g., Bhatt, 1997; Bhatt et al., 1998; Quinn & Bhatt, 1998; Rovee-Collier et al., 1992), if a Caucasian fearful face amid Caucasian neutral faces attracts attention but not vice versa, then infants should look longer at the former image than at the latter image. It is also possible, of course, that infants could look longer at the fearful among neutral expressions display than at the neutral among fearful expressions display because of the 7 neutral faces in the former display versus the 7 fearful faces in the latter display (i.e., fearful faces may be aversive to infants, and thus they may look to the side with a greater number of neutral faces than to the side with a greater number of fearful faces). In other words, performance may be driven by the majority of faces in the displays rather than by the singleton discrepant faces. To examine this possibility, control conditions of infants in the Caucasian and Asian conditions were tested for their preference between a pattern containing all fearful faces and a pattern containing all neutral faces (see Fig. 3.1). If infants in the Caucasian experimental condition exhibited a preference for the single fearful Caucasian face among neutral Caucasian faces pattern, and this preference was significantly different than the preference for the homogeneous neutral pattern in the Caucasian control condition, then it would be strong evidence that fearful faces among neutral faces attracted the infants' attention to a greater degree than the neutral faces among fearful faces pattern. In addition, if the preference for the fearful among neutral faces was significantly different from the homogeneous neutral display in the Caucasian group but not in the Asian group (resulting in an interaction between race of face [Asian versus Caucasian] and condition [experimental versus control]), then it would indicate that, in infancy, as in adulthood, emotions exhibited by own-race faces are more salient than emotions exhibited by other-race faces and that the fundamental feature of other-race information disrupts emotion processing from other-race faces.

Method

Participants.

Sixty-four 9-month-old Caucasian infants (mean age = 273.19 days, *SD* = 7.64, 27 females) participated in this experiment. They were recruited in the same manner as in Experiment 1. Data from 5 additional infants were excluded due to position preference (95% or more looking to one side).

Materials.

Stimuli were color photographs of four female Asian faces and four female Caucasian faces. These faces were the fearful and neutral versions of the faces taken from the MacBrain face bank used in Experiment 1. Two of these Asian faces and two Caucasian faces were the same as those used in Experiment 1; two additional Asian and two additional Caucasian faces from the MacBrain face bank were added (see Fig. 3.1). I am unable to publish one of the additional Asian faces and both additional Caucasian faces. The unpublished additional Asian face was listed as face 17 on the MacBrain website, and the additional unpublished Caucasian faces were listed as face 06 and face 07. The Asian face that I have permission to publish is listed as Asian face 18 on the MacBrain website. I chose to use faces from the MacBrain face bank but not the JACFEE face bank due to the restrictive range of emotional expressions in the latter set. Some researchers claim that early reports of infants' sensitivity to emotions may have been artifactual in that infants may have responded to low-level features (such as ‘toothiness’ or an open versus a closed mouth) rather than emotion per se (Caron, Caron, & Myers, 1985; Field, Woodson, Greenberg, & Cohen, 1982; Kestenbaum & Nelson, 1990). The JACFEE set does not control for either ‘toothiness’ or open versus closed mouths; fearful expressions in this set are generally ‘toothy’ and open-mouthed, whereas neutral expressions are ‘non-toothy’ and close-mouthed. These low-level featural differences would be especially detrimental in a visual discrimination task, and could result in an outcome that would be difficult to explain. The MacBrain set, on the other hand, addresses the issue of both ‘toothiness’ and open versus closed mouth by including a ‘close-mouthed’ and an ‘open-mouthed’ version of the same expression. While the amount of ‘toothiness’ is not precisely equivalent, the MacBrain set makes an attempt to address this low-level ‘toothiness’ issue, and it directly addresses the issue of open versus closed mouth. I chose to use the open-mouthed versions of the neutral and fearful facial expressions because open-mouthed fearful faces were rated as exhibiting fear more often than closed-mouthed versions of the same faces. It was important to choose faces (both Asian and Caucasian) that were clearly identified as ‘fearful’ because, in order to determine the effect of other-race information on emotion processing, the emotions should be able to be detected fairly easily, at least for adults. Tottenham et al. (2009) published overall ratings of validity and reliability for each emotion (open versus closed mouth); those that had already downloaded the face bank received a copy of the manuscript in 2008 (when this study was started) that included validity and reliability ratings for each individual face. The average validity, defined as proportion correctly identified by adults for each individual stimulus, for the Caucasian fearful faces was .70, and the average validity for the Asian fearful faces was .74. The average validity for the Caucasian neutral faces was .66, and the average validity for the Asian neutral faces was .77. Thus, there were no significant differences in validity ratings of emotion for the Asian and Caucasian faces from the MacBrain face bank on which infants in the current study were tested. Ratings for validity and reliability were gathered from participants in two locations: undergraduates from a Midwestern liberal arts college and volunteers from metropolitan New York. The ratings were made by participants from a variety of ethnicities, although the vast majority were European-American.

The same 4 Asian and 4 Caucasian faces were used in the experimental and control conditions. As in Experiment 1, I removed the hair from each photograph using Adobe Photoshop and equated for tint, size, and attractiveness so that any differences in performance in the two race groups would be based on physiognomic properties. In addition, I attempted to equate for eye-widening in Asian and Caucasian faces (eye-widening, and the subsequent enlargement of the area of the whites of the eyes, is an indication of fear for adults). Eye widening was defined as the *change* in distance from the bottom of the eyelid to the top of the eyelid between the neutral and fearful faces. The eyes were widened an average of .50 mm for Asian faces (distance subtended .06˚), and .38 mm for the Caucasian faces (distance subtended .05˚).

The faces were arranged as in Experiment 1 (see Fig. 3.1). Each display in the discrepant conditions contained 7 identical distracter faces and one face of the alternate emotion. One of these displays contained 7 fearful distracter faces with a single neutral face, while the other display contained 7 distracter neutral faces with a single fearful face. The fearful and neutral emotions were portrayed by the same actor across trials. Thus, the only difference between the singleton and distractor faces was the emotion portrayed. The singleton fearful face was in the same position on the display within face pairings, but varied between face pairings. The homogeneous displays contained 8 of the same face expressing the same emotion, and, as described above, infants in the homogenous conditions viewed a homogeneous display of fearful faces paired with a homogeneous display of neutral faces.

Procedure.

The procedure used in the present experiment was identical to that of Experiment 1 in that infants were seated in a darkened chamber with a computer monitor in front of them, and were tested with a spontaneous preference procedure of the kind used in Experiment 1 (consisting of 2 8-s test trials). Infants were randomly assigned to one of four conditions for this experiment: two groups were tested with Caucasian faces and two were tested with Asian faces. Within each of the Asian and Caucasian groups, one condition (experimental) was tested with the discrepant patterns and the other was tested with the homogeneous patterns (control). The right-left locations of the neutral homogeneous display/fearful homogeneous display or the neutral among fearful target display/fearful among neutral target display patterns (depending upon the condition to which infants were assigned) were randomly determined and counterbalanced across the set of infants in each condition; this location was changed from one trial to the next to avoid side bias. In addition, within each racial group, infants were randomly assigned to one of the four fearful-neutral female face pairings.

Coding of infant performance was identical to the method used in Experiment 1. The Pearson correlation between the two observers' scores was .96.

Results

Preference was determined in the same manner as in Experiment 1: it was assessed by computing a percentage score that measured preference for the display in which the majority of the pattern was neutral faces (i.e., the homogeneous neutral display in the control condition, and the fearful face among neutral faces display in the experimental condition). This score was computed by dividing the total duration of looking to the neutral majority display by the total duration of looking time to both displays and multiplying this ratio by 100 to obtain a percentage. It determined the overall preference for the fearful among neutral faces versus the neutral among fearful faces display in the experimental condition, and the preference for the homogeneous neutral versus the homogeneous fearful displays in the control condition.

An analysis of outlier status based on box plots (Tukey, 1977; using SPSS version 17.0) revealed that the preference score of one infant in the Caucasian control condition was an outlier. The final analyses were conducted without the preference score for this infant. See Tables 3.1 and 3.2 as well as Fig. 3.2 for preference scores for the Asian and Caucasian conditions. In order to investigate group differences, I conducted an ethnicity (Asian, Caucasian) X condition (experimental condition, control condition) ANOVA. The results of this ANOVA indicated a significant main effect of condition, $F(1, 61) = 7.23$, $p < .01$, indicating that infant preference was significantly different in the experimental versus control conditions (see Tables 3.1 and 3.2 as well as Fig. 3.2). There was also, however, a significant main effect of ethnicity, $F(1, 61) = 5.11$, $p < .03$, indicating that there was an overall difference in performance on Asian versus Caucasian faces. Interestingly, the interaction between ethnicity and condition was not significant, $F(1, 59) = .41$, $p > .50$, indicating that, although there was a significant difference in performance based on ethnicity of the face, the significant effect of condition was not differentially affected by the ethnicity of the face. This suggests that, regardless of the face ethnicity, infants in the experimental condition preferred the fearful among neutral display significantly more than infants in the control condition preferred the neutral display. Thus, the discrepant fearful face, rather than the surrounding neutral faces, drove attention in the experimental condition for both Asian and Caucasian face displays.

I conducted separate pre-planned face (Face 1, Face 2, Face 3, Face 4) X condition (experimental condition, control condition) ANOVAs for the Asian and Caucasian groups, respectively. This allowed us to explore performance separately for each race group. In addition, I examined whether there were differences in performance on the four individual faces in the respective Asian and Caucasian groups.

Performance on the Caucasian faces

The ANOVA for the Caucasian group failed to reveal a main effect for face, $F(3, 27) = .12$, $p > .90$ or an interaction between face and condition, $F(3, 23) = .09$, $p > .90$. However, the condition main effect was significant, $F(1, 29) = 5.57$, $p = .03$. These results indicate that face pair did not influence infant performance (see Table 3.1 and Fig. 3.2). In addition, it is clear from the condition main effect that infants tested with Caucasian faces exhibited a significantly greater preference for the fearful among neutral display in the experimental condition than the neutral display in the control condition. Also, *t*-tests against the chance level of 50% indicated that infants tested with Caucasian faces exhibited both a marginally significant preference for the fearful display in the control condition, $t(14) = -1.81$, $p = .09$, two-tailed, and a marginally significant preference in the opposite direction for the fearful-among-neutral display in the experimental condition, $t(15) = 1.90$, $p = .08$, two-tailed.

In the Caucasian face group, a fearful discrepant face engaged infants' attention when surrounded by neutral faces. This conclusion follows from the fact that preference was significantly higher for this display than for the corresponding neutral display in the control condition, suggesting that preference was driven by the discrepant face. This significantly *greater* preference for the fearful among neutral display over the neutral display in the control condition also indicates that preference for the neutral among fearful faces was significantly *less* than the fearful display in the control condition, indicating that attention was drawn *away from* the discrepant neutral face and *towards* the discrepant fearful face in the experimental condition. This outcome clearly indicates that infants exhibited a visual asymmetry such that fearful faces drew attention among neutral faces to a greater degree than vice versa. The results from the individual sample *t*-tests against the chance level of 50% suggest that infants prefer fearful faces over neutral faces in the control condition, albeit not to a significant degree (this preference for fearful faces is to be expected based on previous research suggesting that fearful stimuli, including faces, hold infants' attention; Peltola et al., 2008; Peltola et al., 2009b). The marginally significant results of the *t*-test in the experimental condition suggest that, despite the presence of seven fearful distracter faces in the neutral among fearful face display, infants (nearly significantly) preferred the display with the singleton fearful face among seven neutral faces. This preference for the fearful among neutral display over the neutral among fearful display once again supports the argument that infants exhibited a visual asymmetry such that fearful faces drew attention among neutral faces to a greater degree than vice versa.

Performance on the Asian faces.

The face (Face 1, Face 2, Face 3, Face 4) X condition (experimental condition, control condition) ANOVA for the Asian group suggested that there were no main effects for face, $F(3, 28) = .69$, $p > .40$, or condition, $F(1, 30) = 2.49$, $p > .10$. There was, however, a significant interaction between face and condition, $F(3, 24) = 4.75$, $p = .01$. Thus performance in the different conditions depended upon the test face. An examination of the preference scores exhibited by infants tested on different individual faces indicates that one face (Asian face 4 [MacBrain face 19]) is driving this interaction (see Table 3.2). For all other faces, the score in the experimental condition (i.e., preference towards the fearful among neutral display) was higher than the score in the control condition (i.e., preference towards the neutral display). Preferences in these conditions were reversed for Asian face 4: infants preferred the neutral among fearful face in the experimental condition and the neutral display in the control condition. Adults' ratings of validity reported in the MacBrain stimulus set did not predict this outcome: Face 4 was not the lowest rated of the Asian faces that I used in terms of validity ratings.

Given that the pattern of performance on a single Asian face was different from the other faces, I conducted the ethnicity (Asian, Caucasian) X condition (experimental condition, control condition) ANOVA without Asian face 4. Once again, there was a main effect for condition, $F(1, 53) = 14.77$, $p < .001$, and no significant ethnicity X condition interaction, $F(1, 51) = .40$, $p > .50$. More importantly, the significant main effect for ethnicity became only marginally significant, $F(1,53) = 3.47$, $p = .07$. Thus, although there are indications that infants in the Asian and Caucasian groups were performing differently, this difference has become non-significant.

I then analyzed performance in the Asian group with the remaining three faces using a face (Face 1, Face 2, Face 3) X condition (experimental condition, control condition) ANOVA. Performance on the three Asian faces was similar to performance on the Caucasian faces: A highly significant main effect for condition emerged, $F(1, 22) = 7.53$, $p < .02$, the main effect of face was not significant, $F(2, 21) = .84$, $p > .40$, and, most importantly, the significant face X condition interaction obtained with 4 faces was no longer significant, $F(2, 18) = .93$, $p > .40$. Thus, the performance on 3 of 4 Asian faces suggests that, as in the case of Caucasian faces, fear among neutral discrepancies in Asian faces engage infants' attention (see Table 3.2 and Fig. 3.2).

The conclusion that performance on Asian faces is similar to performance on Caucasian faces was bolstered by single-sample *t*-tests of infants' scores on the three faces against the chance level of 50%: infants exhibited a strong significant preference for the fearful display in the control condition, $t(11) = -3.02$, $p < .02$, but no preference in the experimental condition, $t(11) = .63$, $p > .50$. If one examines only the data from the experimental condition, it would seem that infants are failing to exhibit any sort of preference or perceptual asymmetry with Asian faces. However, if one takes into consideration the strong preference for the fearful display in the control condition and the fact that the ANOVA discussed above revealed a significant difference in the scores in the control versus experimental conditions, then it becomes clear that the preference in the experimental condition is not due to a failure to detect the fearful face among neutral faces, but instead due to the strong competition from the seven fearful faces in the neutral among fearful face display. Infants tested with Asian faces clearly did not prefer neutral over fearful faces in the homogeneous condition (they exhibited a 39.32% preference for the neutral face display), yet they devoted over half of their looking (51.70%) towards the display containing seven *neutral* faces and *one* fearful face and less than that towards the display containing *seven* fearful faces and *one* neutral face. In other words, the strong preference for fearful over neutral faces exhibited by infants when they were presented in homogenous patterns in the control condition was overshadowed by contrasts between fearful and neutral faces in the experimental condition, such that a pattern containing a majority of fearful faces did not attract infants' attention any more than a pattern containing a majority of neutral faces. This indicates that the fear among neutral contrast was potent enough to neutralize infants' normal tendency to look at fearful faces. Therefore, it seems more reasonable to conclude that 9-month-old infants exhibit emotion asymmetry with Asian faces, and thus perform similarly as on Caucasian faces, than to conclude that race disrupts Caucasian infants' processing of emotions in Asian faces.

Discussion

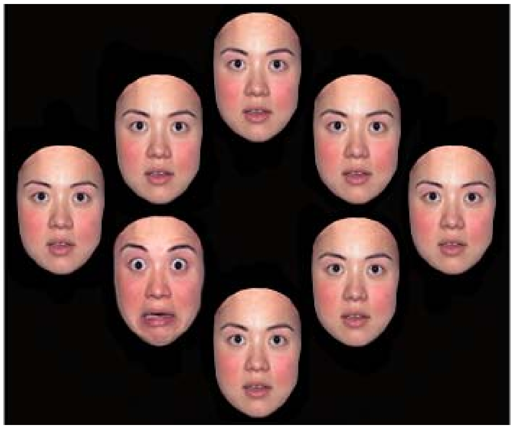
Experiment 2a examined whether the presence of the other-race feature, demonstrated in Experiment 1, disrupts processing of emotion by 9-month-olds. The results suggested that other-race information did not disrupt emotion processing by 9-month-olds, although this conclusion is based on data from only 3 of 4 Asian faces with which I tested infants. The conclusion that other-race information does not disrupt fear processing for 9-month-old infants is important to note because, although there is significant evidence that infants exhibit the ORE at 9 months (Anzures et al., in press; Hayden et al., 2007; Kelly et al., 2007; Sangrigoli & de Schonen, 2004b), and that infants detect and react appropriately to fear by 9 months (e.g., Hoehl & Striano, 2008; LoBue, 2007; Nelson & de Haan, 1996; Peltola et al., 2008; Peltola et al., 2009b), no study that I am aware of has tested disruption of fear detection when other-race information is present.

Not only did infants exhibit evidence of emotion processing in other-race faces, but they also exhibited detection of emotion in an asymmetrical fashion for both Caucasian and Asian faces. This asymmetry in emotion processing has not been tested with young infants previously. Caucasian infants tested on both Caucasian and Asian faces exhibited preferences indicating that a fearful face, when embedded among neutral faces, holds attention to a greater degree than a discrepant neutral face among fearful faces. This asymmetry was clear in both Asian and Caucasian test groups when preference for the fearful among neutral face display was compared to preference for the neutral display in the control condition. In Experiment 2b, I attempted to extend these findings to 3.5-month-olds.

Table 3.1. Overall Preference Scores for the Majority Caucasian Neutral Display in the Experimental and Control Conditions for 9-month-olds in Experiment 2a

	Preference for the Majority Neutral Display			
	n	*M*	*SE*	*t*
MacBrain Face 02				
Experimental Condition	4	53.64	2.34	n/a
Control Condition	3	44.06	4.40	n/a
MacBrain Face 06				
Experimental Condition	4	57.92	4.22	n/a
Control Condition	4	45.98	4.73	n/a
MacBrain Face 07				
Experimental Condition	4	53.98	6.93	n/a
Control Condition	4	46.51	2.07	n/a
MacBrain Face 08				
Experimental Condition	4	54.83	8.29	n/a
Control Condition	4	47.80	6.16	n/a
Overall Preference				
Experimental Condition	16	55.09	2.68	1.90*
Control Condition	15	46.22	2.09	-1.81*

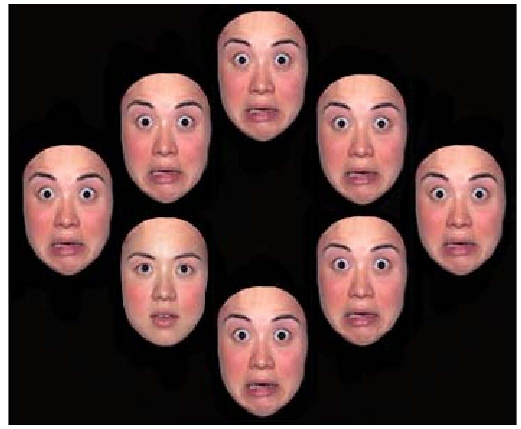
* $p < .05$, one-tailed; significantly different from the chance level of 50%



E

Asian Fearful Among Neutral

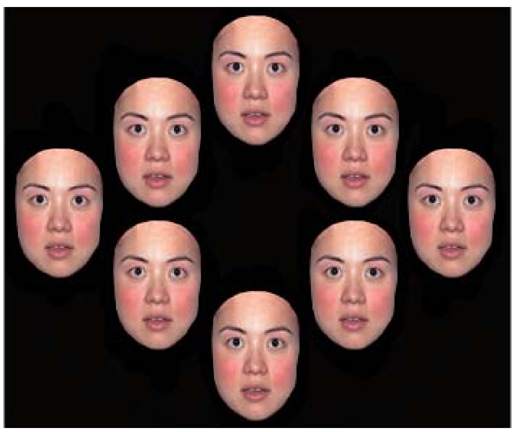
Face Display



F

Asian Neutral Among Fearful

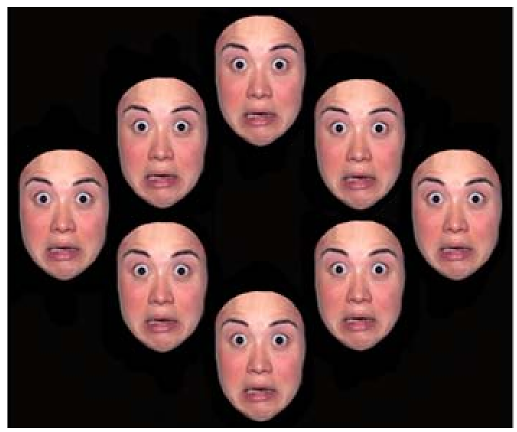
Face Display



G

Asian

Neutral Face Display



H

Asian

Fearful Face Display

Figure 3.1. 9-month-olds in the Asian experimental condition were tested with a pattern containing a single fearful face among 7 neutral faces (Panel I) paired with a pattern containing a single neutral face among 7 fearful faces (Panel J). Infants in the Asian control condition were tested with a pattern containing 8 neutral faces (Panel K) paired with a pattern containing 8 fearful faces (Panel L).

Table 3.2. Overall Preference Scores for the Majority Asian Neutral Display in the Experimental and Control Conditions for 9-month-olds in Experiment 2a

	Preference for the Majority Neutral Display			
	n	*M*	*SE*	*t*
MacBrain Face 16				
Experimental Condition	4	53.34	4.38	n/a
Control Condition	4	35.40	4.72	n/a
MacBrain Face 17				
Experimental Condition	4	51.41	3.64	n/a
Control Condition	4	47.62	3.17	n/a
MacBrain Face 18				
Experimental Condition	4	50.36	6.64	n/a
Control Condition	4	34.95	8.62	n/a
MacBrain Face 19				
Experimental Condition	4	34.37	2.35	n/a
Control Condition	4	49.62	1.95	n/a
Overall Preference (with MacBrain Face 19)				
Experimental Condition	16	47.37	2.84	-.92
Control Condition	16	41.90	2.90	-2.79*
Overall Preference (without MacBrain Face 19)				
Experimental Condition	12	51.70	2.72	.63
Control Condition	12	39.32	3.54	-3.01*

* $p < .02$, two-tailed; significantly different from the chance level of 50%

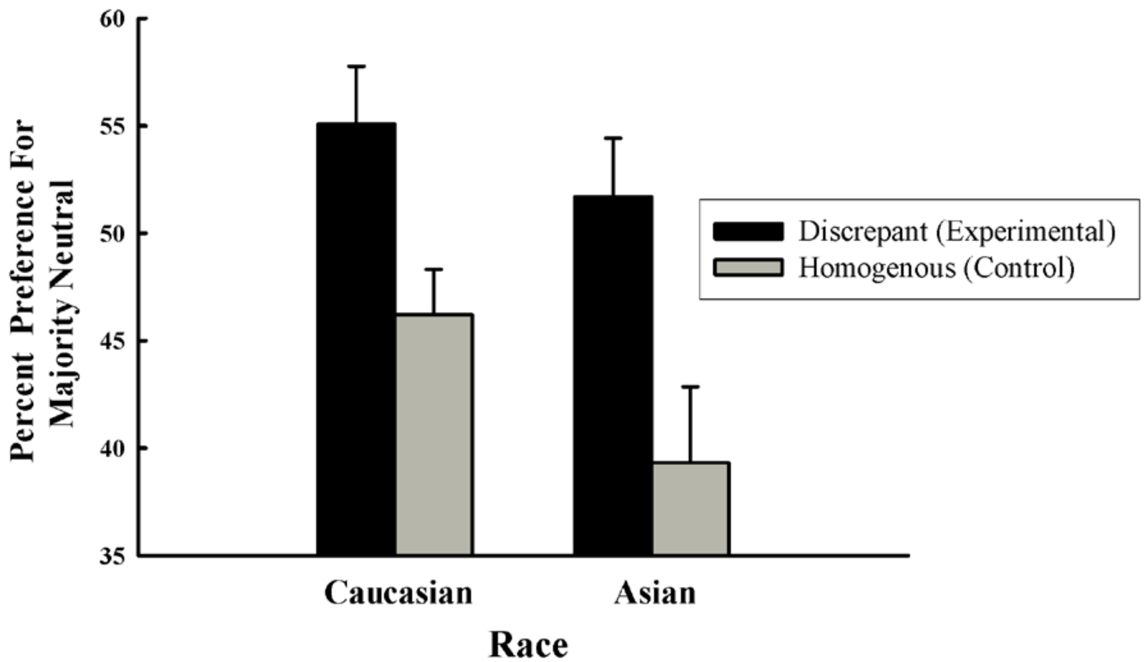


Figure 3.2. 9-month-olds' mean preference for the Asian or Caucasian neutral majority display in experimental and control conditions in Experiment 2a.

Chapter 4

Experiment 2b

As Experiment 2a suggested that the presence of other-race information does not disrupt emotion processing (at least fear) by 9-month-old infants, Experiment 2b sought to extend this finding to 3.5-month-olds. It is possible that other-race information has a greater impact on emotion processing at younger ages than at older ages. Overall, research suggests 3.5-month-olds may not have a well-developed system for detecting emotional valence, especially detecting the emotional valence exhibited by static faces portraying fearful expressions. Haviland and Lelwica (1987) suggested that infants as young as 10 weeks respond differentially to their mothers' verbally and facially expressed emotions (sad, happy, and neutral). However, this outcome occurred with a familiar face (i.e., the mother's face), with multimodal forms of emotional expression (i.e., facial expression and vocal expression of emotion occurring at the same time), and with sad, happy, and neutral faces rather than fearful faces. Four- and 9-month-olds in Serrano, Iglesias, & Loeches (1995) responded appropriately to emotional faces also and exhibited a novelty preference following habituation to neutral, angry, or happy faces (and tested with a novel expression). Again, however, fearful faces were not tested with young infants. Montague and Walker-Andrews (2001) tested 4-month-olds with a peekaboo procedure in which the experimenter replaced the typical happy/surprised response with an angry, fearful, or sad response. The typical happy/surprised response was replaced both in the verbal expression of 'peekaboo' as well as the emotion portrayed by the face. The experimenter held the emotional expression for 7 seconds in order to be able to measure infant looking patterns as well as affective response. Infants exhibited a unique pattern of looking to each of the novel expressions displayed. Specifically, infants looked longer at angry and fearful expressions than sad expressions. In addition, the pattern of looking was significantly different between angry and fearful expressions. Infants did not, however, display a unique affective response to the fearful expression. These result suggests that, in a realistic setting with multiple information modalities (i.e., auditory as well as visual information), young infants may be able to discriminate fearful expressions from other emotional expressions and even look longer at fearful expressions than other expressions.

Research investigating young infants' discrimination of static fearful expressions from other categories of emotional expression portrays a less clear picture of infant discrimination, especially in terms of the ability of a fearful expression to mobilize attention. A study conducted by Serrano, Iglesias, & Loeches (1992) indicated that 4- to 6-month-old infants may be able to categorically discriminate static fearful expressions. Serrano et al. (1992) habituated 4- to 6-month-old infants to photographs of 3 different models expressing the same emotion (fear, anger or surprise). Infants were tested with two new models: one model expressed the familiar emotion, and the other model expressed a novel emotion. Infants exhibited discrimination for all three emotional expressions, including fear. The authors suggest that infants can discriminate among each of these emotions with static faces, although they caution that this may not mean that infants perceive the emotional valence of these expressions; especially fear. This can clearly be seen by the fact that looking time to the fearful expressions during habituation was significantly less than looking time to the two other emotional expressions; suggesting that infants may discriminate fearful expressions from other expressions, but that static fearful expressions may not mobilize attention at 4 to 6 months in the manner that they do at older ages. In addition, although the authors habituated infants with three different models partially in order to control for low-level differences such as eye and mouth wideness, a perusal of the images suggests that there were clear differences in terms of wideness of mouth-opening between categories of expression despite attempts to control for this factor. Thus, infants may have discriminated based on low-level image differences rather than categorical differences in emotion. For instance, it is very possible that anger could be discriminated from fear because the angry faces were generally closed-mouthed and the fearful faces were open-mouthed.

Studies conducted by Nelson, Morse, and Lewitt (1979) and Nelson and Dolgin (1985) suggested that at 7 months, infants exhibit clear evidence of categorical processing of happy faces, but less clear categorical processing of fearful faces. When infants were habituated to various smiling posers, they exhibited a novelty preference for a novel poser exhibiting a fearful expression over the same novel poser exhibiting a happy expression. However, they failed to show a preference when habituated to various posers exhibiting a fearful expression and tested with a novel poser exhibiting a happy expression over the same novel poser exhibiting a fearful expression. One explanation is that Nelson et al. (1979) and Nelson and Dolgin (1985) tested young infants with a unimodal visual presentation of static faces, and it is possible that young infants need multiple modes of information in order to discriminate fearful expressions. This may suggest that processing of fearful faces, even at 7 months, is not fully developed. It is likely, however, that infants' failure to exhibit a preference for happy faces after being habituated to fearful faces may have been due to the attention-holding nature of fearful faces discussed above.

It is therefore possible that infants can detect static fearful faces and can discriminate fear from other expressions, but that infants younger than 7 months of age cannot detect the emotional valence conveyed by static fearful faces. If infants younger than 7 months cannot detect the 'fear' in fearful faces, they may not mobilize increased attention to fearful faces relative to other emotional expressions the way that older infants do. There is some research suggesting that very young infants exhibit a 'positivity bias,' preferring static faces displaying positive emotions over faces displaying static negative emotions (Vaish, Grossmann, & Woodward, 2008; Wilcox & Clayton, 1968). At 5 months of age, infants exhibit an equivalent preference between happy and fearful faces (Bornstein & Arterberry, 2003; Peltola, Leppänen, Mäki, & Hietanen, 2009a). At 7 months, infants prefer fearful faces over happy faces (Peltola et al., 2009a). According to research conducted by Peltola et al., this increased preference for fearful faces at 7 months occurs because sensitivity to threatening stimuli is enhanced between 5 and 7 months of age. These authors investigated the development of the attentional component (Nc) that has been found to be more negative with the presentation of fearful faces than happy faces for 7-month-old infants (Nelson & de Haan, 1994). They found that 5-month-old infants do not exhibit a more negative Nc component with the presentation of static fearful faces relative to static happy faces. In line with previous studies (i.e., Nelson & de Haan, 1994), seven-month-olds did exhibit evidence of this enhanced Nc component. Thus, enhanced mobilization of attention to static fearful facial expressions over other static facial expressions develops between 5 and 7 months of age.

In totality, these studies indicate that emotion-processing in 3.5-month-old infants may be less well-developed than emotion-processing for 9-month-old infants, especially in the case of fear. Studies on infants' detection of static expressions of fear prior to 5 months of age are scarce. It may be the case that fear is an emotion that is not detectable, or at least not salient thus does not mobilize attention, for 3.5-month-old infants even within own-race faces. For this reason, I conducted a study to examine whether 3.5-month-old infants exhibit evidence of emotion processing even with own-race faces with the procedure used with 9-month-olds in the previous experiment.

Method

Participants.

Thirty-two 3.5-month-old Caucasian infants (mean age = 114.63 days, *SD* = 4.20, 18 females) participated in this experiment. Infants were recruited in the same manner as in previous experiments. Data from 8 infants were excluded, 4 due to position preference (95% or more looking to a side), 3 due to stimulus preference (90% or more looking to a stimulus), and 1 due to a failure to look at the stimuli during the second trial.

Materials.

Materials were identical to those discussed in Experiment 2a, except that infants were tested with Caucasian faces only (see Fig. 3.1).

Procedure.

The procedure was identical to the procedure used in Experiment 2a. Infants were randomly assigned one of four Caucasian faces in either the experimental condition or the control condition. Coding of infant performance was identical to the method used in Experiment 1. The Pearson correlation between the two observers' scores for 8 infants was .95.

Results

An analysis of outlier status based on box plots (Tukey, 1977; using SPSS version 17.0) revealed that the preference score for one 3.5-month-old infant in the experimental condition was an outlier. The final analyses were conducted without the preference score for this infant. Preference scores were computed in the same way as in Experiment 2a. See Table 4.1 as well as Fig. 4.1 for preference scores. In order to explore group differences, as well as to examine performance across different faces, I conducted a face (Face 1, Face 2, Face 3, Face 4) X condition (experimental, control) ANOVA. None of the main effects or interaction effects were significant; face main effect: $F(3, 27) = 1.03$,

$p > .30$; face by condition interaction: $F(3, 23) = 1.14$, $p > .35$; condition main effect: $F(1, 29) = .05$, $p > .83$. This outcome suggests that infants at this age do not exhibit asymmetry in terms of emotion processing, even with Caucasian faces. These results indicate that 3.5-month-olds in this experiment either failed to detect the fearful faces in the display, or failed to show a preference because fear does not mobilize attention in the same way that it does with older infants and adults.

Discussion

Despite a very simple procedure that required no memory processes, 3.5-month-olds failed to exhibit evidence of a perceptual asymmetry towards fearful faces, even when they were tested on own-race faces. In fact, preference scores for the control and experimental conditions were 47.59% and 48.57%, respectively, suggesting that infants at this age may not be able to detect fear when it is expressed in static faces. Alternatively, fear may not be as salient to 3.5-month-old infants as it is to 9-month-olds infants in the sense that although they can detect fear in faces, they do not exhibit asymmetrical attention to fearful faces because fear does not mobilize attention at 3.5 months of age. The results of the current experiment are consistent with the Peltola et al. (2009a) findings that the presence of static fearful expression does not elicit enhanced attention in infants that are 5 months of age younger. The perceptual asymmetry in which a fearful face among neutral faces draws attention to a greater degree than vice-versa appears therefore to develop between 3.5 months and 9 months.

Due to 3.5-month-olds' failure to exhibit a preference with this procedure even with Caucasian faces, I decided not to test infants at this age on Asian faces because it is highly unlikely that infants would process fear in these other-race faces given that they failed even on own-race faces.

Table 4.1. Overall Preference Scores for the Majority Caucasian Neutral Display in the Experimental and Control Conditions for 3-month-olds in Experiment 2b

	Preference for the Majority Neutral Display			
	n	*M*	*SE*	*t*
MacBrain Face 02				
Experimental Condition	4	53.86	7.25	n/a
Control Condition	4	45.29	2.87	n/a
MacBrain Face 06				
Experimental Condition	4	45.08	3.78	n/a
Control Condition	4	57.93	8.11	n/a
MacBrain Face 07				
Experimental Condition	3	50.95	6.26	n/a
Control Condition	4	48.84	8.33	n/a
MacBrain Face 08				
Experimental Condition	4	44.38	4.78	n/a
Control Condition	4	38.33	7.52	n/a
Overall Preference				
Experimental Condition	15	48.41	2.21	-.72#
Control Condition	16	47.59	3.94	-.61#

$p > .40$; not significantly different from the chance level of 50%

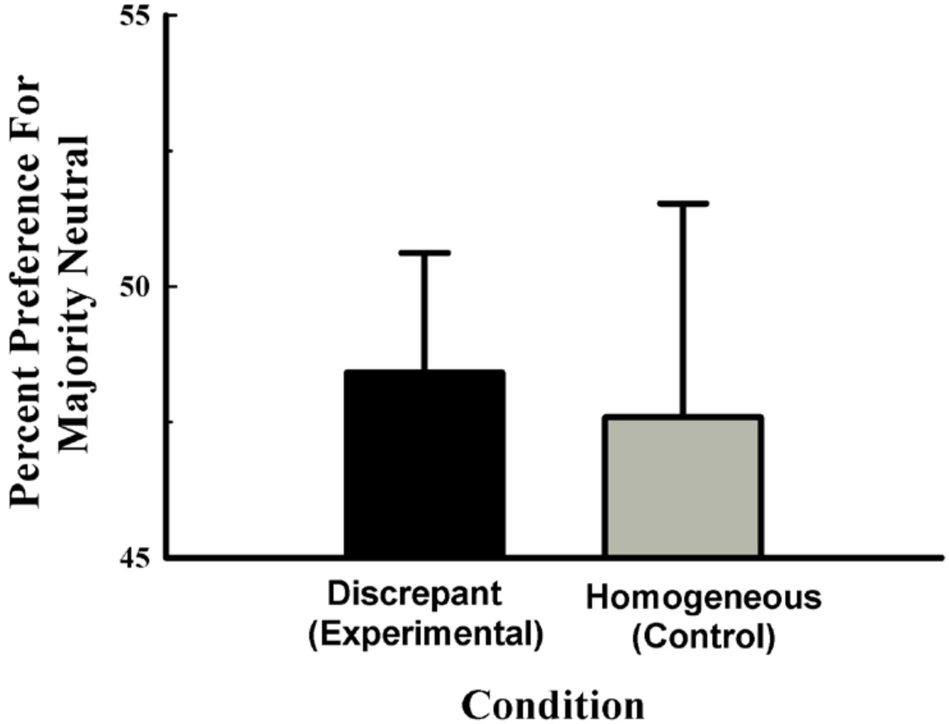


Figure 4.1. 3.5-month-olds' mean preference for the Caucasian neutral majority display in experimental and control conditions.

Chapter 5

General Discussion

The current series of experiments investigated the nature of other-race versus own-race face processing in infancy. The results give us a better understanding of how Caucasian infants perceptually process other-race faces. They also provide a window into the more general issue of the development of face-processing expertise. In Experiment 1, I investigated whether the presence of other-race information elicited a perceptual asymmetry in 3.5- and 9-month-olds, such that an Asian face surrounded by Caucasian faces draws attention to a greater degree than a Caucasian face surrounded by Asian faces. This experiment yielded clear evidence of perceptual asymmetry: infants at both ages exhibited a significant preference for the Asian among Caucasian face display across four Asian-Caucasian face pairings, and, more importantly, preferred this discrepant display in the experimental condition significantly more than the homogeneous display of Caucasian faces in the control condition, indicating that the discrepant Asian face, not the surrounding Caucasian faces, drew attention. This outcome suggests that, as for adults, other-race face information acts as a fundamental feature for infants, which is consistent with Levin's race coding mechanism (1996, 2000).

Experiment 2a tested whether the presence of this other-race feature disrupted emotion processing by 9-month-old infants. I found that infants detected a fearful face among neutral faces to a greater degree than a neutral face among fearful faces in the case of both Asian and Caucasian faces, suggesting that (a) like race, the emotion of fear is a fundamental "feature" of faces for infants, and (b) the presence of other-race information does not disrupt emotion processing (at least of fear) in infancy. However, 3.5-month-olds in Experiment 2b failed to show evidence of emotion asymmetry even for own-race faces, suggesting that this asymmetry in terms of emotion develops between 3.5 and 9 months. Given the younger infants' failure to exhibit emotion asymmetry even with own-race faces, I did not test them with other-race Asian faces. Taken together, this series of experiments suggests that an other-race feature may serve as a perceptual filter in the differential processing of own- versus other-race faces, but the presence of this feature does not disrupt emotion processing by 9-month-old infants. Three-and-a-half-month-olds, on the other hand, failed to detect, or failed to treat as salient, fearful expressions in the current experiment.

The ORE in Infancy

Previous studies suggest that infants discriminate among own-race faces better than among other-race faces (Hayden et al., 2007; Sangrigoli & De Schonen, 2004b), even when the own- and other-race faces are matched in terms of discriminability (Hayden et al., 2007). While these previous studies investigated differences in the discrimination of other- and own-race faces, the current study investigated the mechanism involved in differential processing of these faces; more specifically, Levin's proposed race-coding mechanism (1996, 2000). Therefore, while previous experiments have suggested that infants are better at discriminating among faces of their own race than faces of other races, the current experiment sought to answer *how* faces of other races are differentially perceived in relation to own-race faces. As predicted by Levin's race-coding mechanism, both 3.5-month-old infants and 9-month-olds exhibit a perceptual asymmetry with own- and other-race faces. This indicates that, like adults, infants perceive other-race information as a fundamental feature that draws attention when detected among own-race information more so than when own-race information is detected among other-race information. According to Levin's theory (which has been integrated into Sporer's more recent In-Group/Out-Group model [Sporer, 2001]), this other-race feature serves as a 'filter.' When other-race information is detected, the perceptual system categorizes the face as 'other-race' and subsequently does not process the face in the same manner as own-race faces; when the other-race feature is not detected, typical face processing functions such as individuation ensue. I can conclude from the current results only that infants categorically process other-race faces differently than own-race faces, and that infant attention is drawn to the other-race feature. It is possible that, as one of the typical face processing functions is individuation, infants individuate own-race faces but categorize other-race faces based on race. However, further research is necessary to link Levin's race coding mechanism with individuation in infancy.

It is important to add that our findings, although consistent with Levin's (1996, 2000) findings, are not exactly the same because I did not measure infants' speed of processing (which was the measure used by Levin to assess his adult participants' performance). However, our findings are strongly indicative of featural asymmetry in other-race versus own-race, because they not only are consistent with Levin's findings, but are also consistent with previous research indicating that featural discrepancies attract infants' attention (e.g., Bhatt, 1997) and that a feature-positive element among feature-negative elements attracts infants' attention but not vice versa (Bhatt et al., 2006).

The ORE is an example of a perceptual narrowing processing. At birth, infants have an equivalent potential to develop expertise with own- and other-race faces, i.e., to process all human faces at the subordinate level of processing. Over time, however, and with greater exposure to own-race faces (and little to no exposure with other-race faces), infants apparently 'lose' this potential. This is not to say that they can never regain this ability; it is simply a more effortful process; much like discriminating among sounds that fall outside of one's own language (Kuhl, Stevens, Hayashi, Deguchi, Kiritani, & Iverson, 2006; Werker & Tees, 1984). There are differing ideas as to when these perceptual narrowing processes are complete. Some studies suggest that the ORE is fully developed by 3 months of age (Hayden et al., 2007; Sangrigoli & de Schonen, 2004b). These studies do not rule out the possibility that the ORE develops earlier than 3 months, as well. Others studies suggest that this perceptual narrowing process is complete by 9 months of age and narrowing occurs in a systematic fashion such that infants can discriminate among all faces at 3 months, own-race and some other-race faces at 6 months, and only own-race faces at 9 months (Kelly et al., 2007). Kelly et al. claim that perceptual narrowing of the capacity to process other-race face information mirrors the perceptual narrowing of the capacity to process other-species information, which is found to be robust at 9 months (Pascalis et al., 2002; Pascalis et al., 2005). I have found in Experiment 1 that Levin's proposed other-race feature is present at both 3.5 and 9 months of age. This feature seems to show no evidence of development between these two age groups. This outcome may suggest that the ORE is fairly well-developed at 3.5 months of age. Alternatively, it may suggest that the other-race feature is present at 3.5 months of age, but that the ORE itself develops more slowly over time, becoming robust at 9 months. These alternatives illustrate two possible functions of this other-race feature in infancy: a) The other-race feature is the mechanism that drives the development of the

ORE, or b) the other-race feature is a mechanism that develops separately from the ORE, but becomes associated with the ORE, such that the two mechanisms work together to enable the efficient processing of own- and other-race faces.

Levin (1996, 2000) claims that the other-race feature is the basis for the ORE in adulthood; this feature leads to the rapid detection of other-race information and thus designates the information as unnecessary for individuation. The first possibility, therefore, is that the other-race feature is the basis for the ORE in infancy as well. In this scenario, infants develop this other-race feature in the first few months of life due to lack of exposure to faces of other races (and the great amount of exposure to own-race faces). Once this feature is well-developed (and this experiment suggests that the feature develops by 3.5 months), infants exhibit the ORE because the feature serves as a perceptual filter in own- versus other-race face processing very early in life. Studies that suggest that infant perceptual narrowing processes are not complete until 9 months may be employing more difficult procedures and different kinds of stimuli (see below), which gives the impression that the ORE develops later than it actually does. Alternatively, the race feature could be fully developed at 3.5 months in that other-race information draws attention when surrounded by own-race information, but its function as a filter—Levin's mechanism which determines that other-race information be processed at a more basic level of processing than own-race information—could continue to develop until it is robust at 9 months of age. This would allow for the differential outcomes of studies investigating the ORE, even though the perceptual asymmetry in terms of race information is well-developed at 3.5 months. In both instances given (i.e., the concurrent development of perceptual asymmetry and the perceptual filtering based upon the presence of other-race information, and the dissociated development of the two phenomena), the other- race feature is assumed to drive the development of the ORE (possibility [a] listed above).

A second possibility (possibility [b] listed above) is that the ORE and the other-race feature are different and independently developing mechanisms. In this case, infants can discriminate own-race faces but fail to discriminate other-race faces based on differences in level of exposure to own and other race faces. A separate mechanism (i.e., Levin's feature) may develop in which other-race information exhibits a perceptual asymmetry in that other-race information draws attention to a greater degree among own-race information than vice-versa. This attentional difference may initially be based on the novelty of other-race facial features (Strayer & Johnson, 2000; Wang, Cavanagh, & Green, 1994). As suggested, this perceptual asymmetry develops due to differential levels of exposure to own- and other-race faces, but it may not drive the ORE at first. Eventually, the other-race feature and the ORE in infancy become intertwined in that the infant perceptual system 'learns' that detection of other-race information based on this other-race feature means that the other-race face in front of them is unnecessary to process because they cannot discriminate other-race faces at the level they can discriminate own-race faces anyway. Thus this feature becomes a perceptual filter in that the detection of other-race information signals to the infant that it is unnecessary to individuate the other-race face. This scenario would again allow room for the increased robustness of the ORE over time found with 3-, 6-, and 9-month-old infants in Kelly et al. (2007) even though infants in Experiment 1 of the current study exhibited evidence of the other-race feature. Therefore, Levin's race coding feature could be well-developed by 3.5 months, and also allow the ORE to increase in robustness between 3.5 and 9 months.

Levin's theory favors possibility (a) (i.e., a direct and causal connection between ORE and the feature). In fact, it specifically states that the feature enables designation of an other-race individual as belonging to a socially constructed 'out-group. It is probable, as discussed above, that the race feature initially develops not because of the out-group status of people of other races, but because infants are exposed to individuals of their own race to a greater degree than those of other races. It is possible to argue, however, that the own-race individuals (including family members) that infants are most likely to feel attachment towards could serve as a nascent 'in-group,' because one purpose of an 'in-group' is to provide feelings of safety and belonging (which could be seen initially in attachment relationships). In fact, 3-month-old infants, but not newborns (Bar-Haim et al., 2006, Kelly et al., 2005) prefer own-race faces over other-race faces (when tested with a single exemplar of each kind). In addition, very young children exhibit preferences for own-race children over other-race children (Finkelstein & Haskins, 1983), suggesting that association with in-groups develop fairly early in life. While the social ramifications of in-group/out-group status relationships are absent in perception of other-race faces for infants, the development of this other-race feature may be a way to 'fast-track' differential discrimination of those salient in the infants' life (i.e., own-race individuals) versus those individuals not salient in the infants' life (i.e., other-race individuals).

The ORE Controversy

The results of Experiment 1 support the idea that infants exhibit differential processing of own- and other- race faces in infancy (and thus perceptual narrowing processes may be fairly advanced) as early as 3.5 months of age. This outcome is in line with other studies that have found that infants as young as 3 months exhibit the ORE (Hayden et al., 2007; Sangrigoli & De Schonen, 2004b). The 3.5-month-olds and 9-month-olds tested in Experiment 1 of the current study performed similarly, thus there were no developmental differences in terms of other-race information being coded as a feature for infants. Other studies investigating the ORE have found developmental differences that suggest, as mentioned above, that the ORE develops later than 3 months and is not robust until 9 months of age (Kelly et al., 2007, 2009). These studies suggest that infants can discriminate among own- and other-race faces to an equivalent extent prior to 6-9 months of age, but that greater experience with own-race faces leads to greater ability to discriminate among these faces to increasingly greater detriment to other-race face processing. Thus, according to these studies, perceptual narrowing processes are not advanced until 9 months of age.

The difference between the studies that have found that 3-month-olds exhibit the ORE (Hayden et al., 2007; Sangrigoli & de Schonen, 2004b) and those that have found that the ORE emerges between 6 and 9 months of age (Kelly et al., 2007, 2009) seems to rest upon discrepancies in procedure and stimuli. Studies that have found the emergence of the ORE to take place between 6 and 9 months tested infants with colorful photographs depicting Caucasian and other-race individuals with all of the external features present (e.g., hair, ears, etc.). They also habituated infants to adults either in a ¾ face pose or a full-frontal face pose, and tested them with the opposite pose. In contrast, studies that have found that the ORE emerges at around 3 months used black and white photographs in order ensure that infants discriminated solely on the basis of physiognomic facial characteristics rather than skin tone characteristics. In addition, these studies removed the external features of the face such as hair and ears in order to prevent these external features from interfering with the processing of internal facial features; also, these studies habituated and tested infants with faces in frontal poses. The current study resembles the latter studies to a greater degree than the former studies.

An effort was made in the current study to equate for skin tone so that infants would not exhibit preferences based on low-level skin-tone differences. This was a departure from the black and white images tested in previous studies, but also an improvement because the skin tone was the natural color of the face for one of the two faces in each fair pair. In addition to equating for skin tone, external characteristics such as hair and ears were removed. It was important that hair be removed because it and the way it is styled could potentially provide superficial racial markers and affect performance (MacLin & Malpass, 2001). An additional compelling reason for removing the hair which was more germane to infant face processing considerations was that I felt that removing hair would lessen distractions from external facial characteristics. Infants at younger ages tend to process faces less configurally (Bhatt et al., 2005; Cashon & Cohen, 2004; Cohen & Cashon, 2001; Schwarzer & Zauner, 2003; but see Quinn & Tanaka, 2009) and rely more on superficial external characteristics. Thus, it was important for us to remove easily distinguishable features of the posed individual.

The removal of hair and other external features described above may have contributed in two different ways to the differences in the outcomes of the current study (and of Sangrigoli and de Schonen [2004b] and Hayden et al. [2007]) versus studies by Kelly and his colleagues (Kelly et al., 2007, 2009) in which the ORE was not found until after 6 months of age. The first way is that removing external features as well as the natural skin tone (in Hayden et al. and Sangrigoli & de Schonen) made detecting own-race and other-race information as well as discriminating own- and other-race information more difficult for both Asian and Caucasian faces, resulting in infants' failure to discriminate Asian faces in Hayden et al. and Sangrigoli and de Schonen. However, even if this were the case, infants discriminated Caucasian faces, which reinforces the idea that at some level, Caucasian faces and Asian faces are differentially processed. In addition, the removal of external facial features would not explain the results of the current series of studies, which suggest that infants not only detect other-race information, but that other-race information holds infant attention to a greater degree when surrounded by own-race information than vice-versa.

The second reason for differences between the current findings and those of Kelly et al. (2007) stems from younger infants' greater tendency to process faces based on external facial characteristics rather than internal facial characteristics with static faces (Hainline, 1978; Haith, Bergman, & Moore, 1977). It is possible that 3-month-olds in Kelly et al. focused on the external features like the hair or the ears of the test faces, and were able to identify both own- and other-race novel faces based upon these external features alone. It is plausible, as well, that changing the pose between habituation and test increased the use of featural characteristics for these infants. The recent study by Anzures et al. (in press) hints at the latter possibility: 6-month-old infants in this study exhibited evidence of the ORE with Asian faces, an ethnicity that Kelly et al. found did not elicit the ORE in 6-month-olds. There were differences in procedure between these studies, but a main difference was that infants in Anzures et al. were habituated and tested with frontal-view faces, thus lessening the need for reliance on featural information for discrimination.

It is clear that further research is necessary in order to truly gauge the timeline for the emergence of the ORE. The current study presents evidence that Caucasian faces and Asian faces are categorized differently and differentially perceived even by 3.5 months of age. As suggested above, however, the development of this other-race feature may not correspond directly with the development of the ORE (although Levin [1996] argues that the other-race feature is the mechanism for the ORE). Whether the other-race feature and the ORE are directly related or not, however, the other-race feature may make the differential processing of own- and other-race faces more efficient for the perceptual system. While the presence of this other-race feature suggests that own- and other-race faces are categorized differently, this differential categorization failed to affect detection of emotion in Experiment 2a.

The ORE and Emotion Processing

The presence of the other-race feature, which suggests differential processing of own- and other-race faces, failed to elicit differences in emotion processing. Nine-month-old infants performed equally well whether presented with an Asian or Caucasian face in a visual discrimination task in which they were tested with a display containing a fearful face among neutral faces paired with a display containing a neutral face among fearful faces. Infants in both the Asian face and the Caucasian face groups exhibited a preference for the display with the majority neutral faces that was significantly different in the experimental versus control conditions (at least when one of the four Asian faces was removed). Given that the discrepant fearful face in the experimental condition display was the sole difference between the two displays, this outcome suggests that the discrepant fearful face drove attention for this group of infants. This preference towards the discrepant fearful face drove preference away from the patterns containing discrepant neutral faces and surrounding fearful distracter faces (fearful faces that were undoubtedly competing for infant attention: the fearful face display in the control condition elicited a highly significant preference over the neutral display for infants tested with Asian faces, and a marginally significant preference over the neutral display for infants tested with Caucasian faces). Infants tested with Caucasian faces exhibited a marginally significant preference for the discrepant fearful face display over the discrepant neutral face display, providing additional evidence that an emotional face drives attention when it is among neutral faces. Those tested with the Asian faces did not exhibit a significant preference for the fearful among neutral face display (although the mean for the experimental condition was in the predicted direction), but this was most likely due to the strong preference for the Asian fearful faces in general, as suggested by the significant preference for the fearful face display in the control condition. In effect, the fearful faces surrounding the discrepant neutral face in the experimental condition were competing with the single discrepant fearful face in the experimental condition. It is clear, however, that this discrepant fearful face drew attention in the experimental condition; preference for this display was strongly and significantly different from preference to the display containing 8 neutral faces in the control condition.

These results are not consistent with the in-group advantage for emotion processing (IGA) exhibited by adults, suggesting that the IGA may not develop until childhood or adulthood. The fact that 9-month-old infants, who have been shown to exhibit a fairly robust ORE as well as the ability to detect the other-race feature described by Levin (1996, 2000) as the mechanism for the ORE, fail to exhibit differential processing of emotion based on the race of the face suggests that detection of this other-race feature does not drive the IGA (at least for 9-month-old infants). The IGA predicts that infants would exhibit this perceptual asymmetry for fearful faces with Caucasian faces, but would fail to show perceptual asymmetry with Asian faces. Instead, while there were slight differences in emotion processing with Asian and Caucasian faces, it is fair to conclude that infants in both conditions exhibited a perceptual asymmetry such that fearful faces surrounded by neutral faces drew attention to a greater degree than neutral faces surrounded by fearful faces.

These results support models suggesting that stable facial characteristics based on social categories such as gender, race, etc., are processed separately and in parallel to changeable characteristics such as emotion (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000; Kubota & Ito, 2007). The results also are in line with research indicating that, although emotions are expressed differently in different cultures, emotion detection does not reliably vary along cultural lines (Beaupré & Hess, 2005; Matsumoto et al., 2009), at least with Caucasian infants tested with Caucasian and Asian faces.

However, several studies, including Elfenbein and Ambady's (2002) meta-analysis, suggest that the IGA is a fairly robust phenomena for adults (e.g., Elfenbein & Ambady, 2003; Thibault et al., 2006), and fear especially is an emotion that elicits differential processing based on the race of the face expressing the emotion (Chiao et al., 2008, Elfenbein & Ambady, 2002), although other emotions do, as well (Elfenbein & Ambady, 2002; Elfenbein et al., 2007; Lee et al., 2008). Elfenbein and Ambady (2002) and, to a greater degree, Thibault et al. (2006) maintain that the IGA is a function of in-group/out-group bias, such that a person will be more motivated to detect emotion information when this information is conveyed by someone in their in-group rather than someone that is considered to be 'out-group.' This explanation resembles Levin's (1996, 2000) race coding hypothesis in that he suggests that the mechanism driving other-race feature detection is the 'out-group' status of individuals of other races. I have found in the current experiment that this race-coding feature, however, is available to infants as young as 3.5 months of age, suggesting that it develops well before social aspects of in-group/out-group status develop. Thus, emotion may be disrupted by this other-race feature in adulthood because of the added weight of the 'out-group' social label given to those of other races. This is, of course, speculative. At this point, the most conservative explanation for the current results in terms of emotion-processing with 9-month-olds is that race and emotion are processed separately by infants, and that the IGA and the ORE originate at different ages with different mechanisms.

A hotly debated issue in the literature concerning the presence or absence of the IGA is the issue of the degree to which faces are posed. Matsumoto et al. (2009) claim that researchers find the IGA when they use posed expressions. These researchers used images of un-posed emotional displays from the 2004 Olympic Games and found that happy, sad, and surprised faces of Americans and Japanese contenders failed to elicit the IGA for either American or Japanese participants. However, Matsumoto et al. did not test emotions that have been found to elicit the IGA strongly in other studies: fear and disgust. Also, these faces were more than likely extreme versions of these emotions due to the nature of the event. Exaggerated emotions may elicit less of an IGA. At the other end of the spectrum, Elfenbein et al. (2007) found that ‘naturally’ posed faces elicited the IGA, whereas ‘stereotypically’ posed faces, based on Ekman and Friesen’s (1977) face action coding system, failed to elicit the IGA. Thus, it seems that faces that elicit the strongest IGA are those that depict posers expressing his or her own version of the facial expression. Fortunately, the researchers that constructed the MacBrain face bank (from which the stimuli used in the current study were drawn) instructed posers to express the emotion the way that they naturally would. Thus, these naturally posed facial expressions had a good chance of eliciting the IGA if the IGA was present at 9 months.

In addition to using “natural” as against stereotypically posed faces, I also ensured that faces were well-matched in terms of ‘toothiness.’ An early study that examined emotion detection in infancy failed to equate for ‘toothiness’ (Caron et al., 1985). A later study showed that infants in this earlier study were discriminating emotional faces (especially happy) from neutral faces not because of the emotional valence of the face, but because the emotional faces showed a greater amount of the person’s teeth (Kestenbaum & Nelson, 1990). Also, all expressions were open-mouthed, which was an additional concern (Field et al., 1982). In the event that infants exhibited the IGA in the current study by demonstrating a perceptual asymmetry with own-race faces but not with other-race faces, it was important to ensure that infants exhibited this differential processing due to differences in the race of the faces, rather than due to differences in 'toothiness' levels or open versus closed mouths between Caucasian and Asian fearful and neutral faces. Although I was limited in terms of Asian faces (there were only 5 female Asian faces available), the amount of 'toothiness' was relatively equivalent for own- and other-race faces. I also attempted to equate in terms of eye-whiteness in the fearful faces. Despite these controls, 9-month-old infants failed to exhibit evidence of the IGA. While the IGA was not a factor in emotion detection for 9-month-old infants, the results of the study do give us an insight into the nature of emotion processing for 9-month-olds.

Nine-month-olds' Processing of Fearful Faces

As described above, 9-month-olds in Experiment 2a exhibited a perceptual asymmetry such that a fearful face among neutral faces was attended to to a greater degree than a neutral face among fearful faces. This was true for both Asian and Caucasian faces. This perceptual asymmetry in terms of fear corresponds to studies with adults and children on this subject. This literature suggests that, for both adults (LoBue, 2009; Williams et al., 2005) as well as 5-year-olds (LoBue, 2009) threat-relevant emotions (including anger and fear) draw attention among neutral faces more rapidly than vice-versa in a visual search paradigm. LoBue & DeLoache (2008) in fact found that 5-year-olds located fear-relevant stimuli faster than non-fear-relevant stimuli, which suggests that the mobilization of attention to fear may be more important for young children than mobilization of attention to other emotions.

Other studies indicate that fear mobilizes attention to a greater degree than other expressions in infants as young as 7 months of age (Nelson & de Haan, 1996; Peltola et al., 2008). The current study further suggests that, not only does fear mobilize attention, but that it elicits a perceptual asymmetry such that a fearful face draws attention to a greater degree among neutral faces than a neutral face among fearful faces. This is important because infant attention is apparently primed to locate a single fearful face among neutral faces, which will inform them of danger in their surroundings. This is likely to be beneficial for infants at 9 months because they are crawling, cruising, and exploring at this age. It is evolutionarily advantageous for them to pick up on fearful expressions exhibited by those around them in order to navigate their world successfully without danger by either avoiding danger or by alerting the caregiver. At this age, the person's race that is conveying emotion (although noticeable as indicated by Experiment 1) is apparently not as salient as the emotion that is conveyed (especially if it is fear). It remains to be seen whether race will interfere with the processing of other less attention demanding emotions such as sadness.

There is a possibility that infants exhibited this perceptual asymmetry because fearful faces are more novel than neutral faces (as opposed to the threat-relevant emotional valence of the face). Novelty is one of many aspects of perception that elicit perceptual asymmetries (Strayer & Johnson, 2000; Wang, Cavanagh, & Green, 1994). However, there are two arguments against this claim. The first argument is the fact that, in general, the prototypically neutral expression is one in which a person has his or her mouth closed (the people posing neutral expressions in JACFEE- the face bank on which the facial action coding system described above was based on- for example, all exhibited closed-mouth neutral expressions, Matsumoto & Ekman [1988]). Therefore, it is likely that infants would find the neutral expressions used in the current study (with open mouths) to be novel as well. The actors were asked to pose a 'neutral' emotion naturally, but, as with every other emotion, they were asked to pose the expression with an opened mouth and a closed mouth. I chose to use the open-mouthed version of these stimuli in order to equate for toothiness and to avoid low-level preferences based on open versus closed mouths, but a potential additional advantage of using these stimuli was the relatively novel nature of the stimuli for infants. The second argument against the hypothesis that infants' attention to fearful among neutral faces was driven by novelty is based on the growing literature suggesting that infants treat fearful faces both behaviorally and physiologically different from other facial expressions (Nelson & de Haan, 1996; Peltola et al., 2008). This literature concentrates on 7-month-old infants, but the findings can be extended to 9-month-olds. These studies, as discussed above, have found that 7-month-olds show an increased latency to disengage from fearful expressions than other expression (and that this is due to the configuration of the face rather than just the widening of the eyes), and that fearful faces elicit a larger attentional engagement than happy faces (Nelson & de Haan, 1996). All of these studies suggest, therefore, that by 9 months of age, fearful faces mobilize infant attention to a greater degree than other expressions. Thus, while it is possible that infants in the current study exhibited this perceptual asymmetry due to the novelty of the fearful face, it is unlikely given the reasons mentioned above.

3.5-Month-Olds' Detection of Fearful Expression

In Experiment 2b, 3.5-month-olds failed to exhibit systematic preferences in either the experimental or control conditions with Caucasian faces. Thus, they did not exhibit the perceptual asymmetry that 9-month-olds exhibited in Experiment 2a, and, in addition, did not show evidence that fear mobilizes attention at this age. This could have at least been shown by a significant preference for the fearful display in the homogeneous condition. However, this was clearly not the case because all preference scores were at chance. This indicates that infants either failed to detect fear information in these static faces, or that fear is not a salient emotion for infants at this age.

Previous studies of fear detection at or prior to 5 months of age have been scarce. Peltola et al. (2009a) used static faces in a study that suggested that a fearful expression mobilizes more attention than a happy expression at 7 months of age, but not at 5 months. In contrast, Montague and Walker-Andrews (2001) found that infants who were tested with a peekaboo procedure exhibited differential looking to expressions of sadness, fear, and anger, and looked longer at threat-relevant negative expressions (i.e., anger and fear) than non-threat-relevant negative expressions (i.e. sadness), possibly suggesting increased mobilization of attention to threat-relevant stimuli at 4 months of age. Montague and Walker-Andrews, however, tested infants with live models (as against photographs), and infants were also exposed to verbal emotion cues. Fearful expressions were therefore presented bimodally. Thus, with enough information, 3.5-month-old infants may detect fear, but with unimodal visual presentation of static expressions in the current study, 3.5-month-olds failed to attend to fearful faces. The use of static expressions as well a single mode of presentation of the emotion was a necessary limitation to our study (although, as described below, a supreme effort was made to simplify the procedure in order to compensate for the use of static facial expressions). Montague and Walker-Andrews also tested infants at 4 months of age (as against 3.5 months in Experiment 2b), which introduces the possibility that their infants' superior performance was due to the slight difference in age.

The current experiments suggest that there is clear development of both fear detection in static faces as well as the development of a fear feature that leads to perceptual asymmetry in terms of fearful versus neutral faces between 3.5 and 9 months. This developmental difference is apparent even though the procedure was tailored to be simple for both 3.5-month-olds and 9-month-olds: infants were tested on just two 8-second spontaneous-preference test trials, and there were no memory demands because all of the necessary information was presented in the test trials and infants could directly compare the test displays.

As mentioned above, fearful expressions most likely gain greater and greater salience to the infant as he/she becomes mobile. At 3.5 months, expressions of fear may not be salient because the infant experiences little danger of falling and becoming injured. As such, the infant likely experiences very little fear affect from others.

Importance of Race and Emotion Information in Relation to Face Expertise

The results of the current series of studies give an indication of how expertise in face-processing develops in infancy. Specifically, they provided insight into how race information fits into the development of face expertise. At birth, an infant's perceptual system is primed to respond to the stimuli surrounding the infant. Faces are some of the most important visual stimuli to infants. The mother's face is associated with warmth, food, and safety. Other faces also become important to the infant. The infant must learn to distinguish among these faces in order to be able to identify people who are salient to them. The results of the current study suggest that other-race faces are processed differently from own-race faces at least by 3.5 months of age. This suggests that, early in life, race has become a facial characteristic that allows the infant to distinguish among faces that are salient and non-salient to them. If infants are not exposed to other-race faces, the presence of other-race information may indicate that this person is 'unknown,' and that their behavior is not personally relevant or important.

Levin's (1996, 2000) race coding mechanism suggests that infants may be processing other-race faces at the basic level, and thus other-race face processing would be based on categorical other-race facial characteristics rather than individuating information, although this claim is beyond the conclusions that can be made in regard to infants based on the results of the current study. By developing an ability to detect other-race information among own-race information, infants can separate people that have the potential to be salient to them from those that are not. They can then go on to develop expertise with salient own-race faces that surround them, indicated by detection of second-order information as well as the inversion effect (Diamond & Carey, 1977; Friere et al., 2000; Itier & Taylor, 2004).

In addition to race information, the development of expertise in face processing also includes increasing detection of emotion information. Emotion information is important for successful navigation in the world. It is important that infants respond appropriately to positive expressions by smiling, for example, as this promotes further smiling on the part of the adult and builds attachment relationships (DeMulder & Radke-Yarrow, 1991; Waters, Wippman, & Sroufe, 1979). Threat-relevant expressions, on the other hand, warn of danger, whether it be from the person expressing the emotion (in the case of anger) or of an imminent outside threat (in the case of fear). The ability to detect fear-relevant stimuli is adaptive, as it allows humans to avoid harm (LoBue & DeLoache, 2008; Peltola et al., 2008, 2009b). According to the current results, at 3.5 months, fear is either not detected or is not a salient emotion for infants, even when portrayed by own-race posers. This suggests that fear may be an expression that infants seldom see at this age, and that fear is not an important facial expression for 3.5-month-olds. As suggested above, this may be due to infants' lack of ability to self-locomote. The ability to detect fear in a robust fashion seems to develop between 3.5 and 9 months. At the older age, the ability to detect fearful expressions does not seem to be disrupted by the presence of other-race information.

Although race is a salient characteristic in infancy, the results of Experiment 2a indicate that the presence of racial characteristics do not interfere with the processing of fearful expressions. Thus, at 9 months, race and emotion may be processed separately, although both seem to be important characteristics in face processing at this age. As there was no evidence of the IGA with fearful own- and other-race faces, it is probable that the processing of both emotion and race are facial characteristics that are still developing for 9-month-olds. It is also possible that race and emotion processing are fairly well-developed at 9 months, but fear is an emotion that becomes especially salient to infants at around 9 months due to the danger involved in mobility. Infants may look to others for guidance on whether situations are dangerous or not. Fear could therefore be one of the few emotions at 9 months that would overcome the presence of racial information. Future studies should investigate this possibility.

Limitations

One of the major limitations of the current series of studies is the fact that only Caucasian infants were tested. The use of at least two races (in the present case, Asian in addition to Caucasian) would allow the demonstration of perceptual asymmetry in both directions in Experiment 1 and, thus, rule out the possibility that some low-level nonracial feature associated with Asian faces and not the Caucasian faces used in the present series of studies led to the perceptual asymmetry exhibited in Experiment 1. It is telling, however, that both 3.5- and 9-month-old infants in the control condition, who were tested with homogeneous arrays of faces, failed to exhibit a preference. Thus, any low-level nonracial feature that may have led to the present pattern of performance must be akin to the other-race feature in attracting attention when embedded in an array of discrepant elements, rather than when presented in homogeneous arrays. The probability of the presence of such a nonrandom fundamental feature in the Asian faces is likely not very high, although the present research cannot rule out the possibility. Moreover, two of the face pairs used in Experiment 1 (those from the JACFEE set) are part of a stimulus set in which adults exhibited cross-cultural performance differences based on race (Beihl et al., 1997). These factors provide some confidence that the infants' performance in the present study was based on racial differences.

Testing Asian and Caucasian infants in Experiment 2a would also rule out the possibility that the emotions expressed by Asian faces that were chosen were of the same level of intensity as that of the Caucasian faces (although validity ratings that guided the choice of stimuli in the current study should be a good indicator of level of intensity). It is possible that the Asian faces chosen displayed a higher level of fear than the Caucasian faces chosen. Thus, Caucasian infants may have failed to exhibit differential processing with Asian and Caucasian faces because of the greater intensity of fear displayed by the Asian faces. If this were the case, then Asian infants would exhibit evidence of differential processing of Caucasian and Asian faces; showing a perceptual asymmetry for fearful faces in the Asian face group and no evidence of perceptual asymmetry for the

Caucasian face group. It is possible that this is the case, as infants exhibited a highly significant preference for the fearful display in the control condition. The preference in the Caucasian group was only marginally significant. Thus, the Asian faces may be exhibiting fear more intensely. However, if the other-race feature was disrupting emotion processing for Asian faces (and thus disrupting the perceptual asymmetry elicited by a fearful expressions), it would seem that the preferences for the fearful face display in the control condition would be more equivalent. Therefore, while testing a group of Asian infants may be helpful, it is fairly clear that the Caucasian infants in the current study did exhibit strong evidence of emotion processing and perceptual asymmetry with fearful Asian faces (at least with three of the four faces); so it seems reasonable to conclude that the presence of other-race information does not disrupt emotion processing (at least of fear) by 9-month-old Caucasian infants.

It is also possible that the spontaneous-preference procedure that I used in order to explore whether infants differentially process emotion information in own- versus other-race faces was less than ideal for finding *differences* in emotion processing of own- and other-race faces for 9-month-olds because it required no memory processing, and the fearful and the neutral faces could be directly compared to one another on the display. If the fearful and the neutral faces were presented separately and required memory on the part of 9-month-olds (through a habituation or familiarization task), I may have found a difference in emotion processing. However, one could argue that it is important to give infants every opportunity to perform to their capabilities, which this task seemed to do. In addition, the procedure also provided valuable information into perceptual asymmetries involved in emotion processing- a question that had yet to be asked in the infant developmental literature. In follow-up studies, however, experimenters may wish to use habituation or familiarization procedures in which one emotional expression at a time is presented to the infant in order to allow potential differences in emotion processing between own- and other-race faces to present themselves.

One other limitation that was briefly mentioned above is the fact that I tested infants with static photographs of faces. Infants gain a greater amount of information from dynamic images (Kellman & Spelke, 1983; Otsuka & Yamaguchi, 2003; including moving faces when testing for face recognition: Otsuka, Konishi, Kanazawa, Yamaguchi,

& O'Toole, 2009). Motion is an especially salient cue for younger infants (e.g., Johnson & Aslin, 1996; Kellman & Shipley, 1991; Kellman & Spelke, 1983). Therefore, especially in Experiment 2b, motion and perhaps realistic faces may have improved 3.5-month-olds' detection of emotion. Unfortunately, the hypotheses that I was testing lent themselves more towards static face displays, as studies investigating perceptual asymmetry require several distracters and at least one target. However, the use of dynamic faces as stimuli in studies is more likely to provide an accurate picture of facial emotion processing by young infants.

Potential Applications for and Implications of the Current Research

The current research suggests that infants differentially process own- and other-races faces as early as 3.5 months of age. More specifically, infants develop an other-race feature such that other-race faces draw attention when among own-race faces to a greater degree than own-race faces among other-race faces. It is this perceptual asymmetry, according to Levin (1996, 2000), and the filtering mechanism associated with it in adulthood, that drives the basic-level processing of other-race faces, and thus is the mechanism responsible for the ORE. While Levin's claim cannot be substantiated by the results of this series of experiments for infants, the presence of this other-race feature so early in life, prior to social notions of in-group/out-group status, suggests that the ORE most likely originates with differences in perceptual encoding of own- and other-race faces. This suggests that a possible way to mitigate the ORE, at least to some extent, would be to expose infants to other-race faces early in life (Sangrigoli & de Shonen, 2004b). This way, the perceptual other-race feature will never have a chance to develop, and the development of social in-groups and out-groups may not be demarcated along racial lines to the same extent because there is no initial differentiation based purely on amount of exposure to own- and other-race faces. In effect, the social constructs of in-group/out-group would not have a readily available perceptual differentiation mechanism to build upon.

In addition to knowledge that has the potential to aid in mitigating the ORE, this series of experiments also provides an illustration of behavior of a normally-developing infant. Knowledge concerning the point at which race becomes a factor in infant face processing, as well as when infants develop the ability to detect cues related to emotion, can serve as a baseline for normal development in testing infants for disorders that affect social functioning such as Autism. An important sign and symptom of Autism is an inability to develop expertise in terms of facial processing (e.g., Hobson, Ouston, & Lee, 1988; Klin, Sparrow, Bildt, Cicchetti, Cohen, & Volkmar, 1999). The knowledge gained from this research and other research along these lines can help to delineate the normal course of the development of sensitivity to social cues. Deviations from this course could then be used to ascertain pathologies like Autism.

Conclusions

The current series of studies investigated whether Levin's (1996, 2000) proposed race coding mechanism is involved in the processing of race information in infancy. In addition, I investigated how this proposed mechanism affects emotion processing. I found that, in accordance with the race coding mechanism, infants located an Asian face among Caucasian faces more rapidly than vice-versa, indicating that infants as young as 3.5 months have developed the race feature that is central to this mechanism. Thus, infants differentially process own- and other-race information at an early age. It is possible that the presence of this other-race feature is the basis upon which later in-group/out-group dynamics evolve.

Experiment 2a indicates that race does not interfere with the processing of fearful expressions at 9 months. Emotion and race may therefore be processed separately at 9 months of age, although it remains to be seen whether this lack of interference is due to the salience of fearful expressions at this age. If emotion and race are processed separately for all emotions in infancy, then it may be an indication that the IGA is a socially-based phenomenon, in that people choose whether or not to discriminate the emotions of others based on their status as an in-group member or an out-group member. The dialect theory (Elfenbein et al., 2007) most likely also contributes to the IGA with emotions other than fear, in that different cultures express facial emotions in different ways, and those outside of a particular culture may find it difficult to 'read' the emotion correctly. Testing 9-month-olds with emotional expressions other than fear will give a clear picture of the extent of the separation of emotion and race processing at this age. At this point, I can only conclude that the presence of other-race information does not interfere with the processing of fear in infancy.

In the final experiment, 3.5-month-olds failed to process a fearful expression when among neutral expressions with own-race faces. Thus, infants at 3.5 months may either fail to detect static emotional expressions such as fear, or fear may not be a salient expression for this age group. This outcome suggests that development of emotion processing is more protracted than the development of race processing. Alternatively, infants may be capable of detecting expressions of fear, but fear may not be ecologically salient at this age and thus may fail to induce asymmetrical processing. If the latter is true, future research will have to investigate why racial information in faces is elevated to a salient status earlier than fear information.

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Academic Excellence Scholarship | August 1999 - May 2003

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Professional Publications

Published Papers

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, 169-181.

Bhatt, R. S., Hayden, A., Kangas, A., Zieber, N., & Joseph, J. (in press). Part representation in infancy: Sensitivity to the short-cut rule. *Attention, Perception, and Psychophysics*.

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