Two of the Same? Infants' Conceptual Representation of Faces Based Upon Gender, Race, and Kind Information

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TWO OF THE SAME? INFANTS’ CONCEPTUAL REPRESENTATION OF FACES
BASED UPON GENDER, RACE AND KIND INFORMATION

A Dissertation Presented

By

CHARISSE B. PICKRON

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

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Psychology
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DEDICATION

To Mom, Dad, and Marita

For your endless love, emotional, physical, and mental support.
Thank you for showing me how to see it through.
ACKNOWLEDGEMENTS

First, I want to thank my advisor, Erik Cheries, for taking me on and welcoming me into his lab as a 4th year graduate student who needed a new home. I thank Erik Cheires for his patience as we developed a new mentee-mentor relationship. His constant support, positive attitude, and mentorship kept me motivated through some of the most challenging experiences of graduate school. Thank you to my committee members, Neil Berthier, Maureen Perry-Jenkins, and Denise Ives, for their helpful comments and suggestions on this work. A special thank you to Maureen Perry-Jenkins who I’ve sought mentoring from throughout graduate school and who I see as a role model as a researcher who cares deeply for the work she does and the changes she makes in the communities that she studies and serves.

I thank Lisa Scott (University of Florida) for being my first advisor in graduate school. I thank her for the training, support, motivation, and lessons learned in becoming a developmental scientist. Lisa Scott embraced my multiple interests and showed me how to connect them into meaningful research questions. Her fearlessness in conducting research, promoting diversity, giving back, and sharing her work was inspiring to see and learn from. I want to thank Kirby Deater-Deckard for his unstoppable energy to conduct research in Springfield and for introducing me to what it means to do community-relevant work. I want to acknowledge the staff of the Psychological & Brain Sciences department; without their tireless work and support, conducting research and completing graduate school would have been much more difficult.

I extend a huge thank you to Sandra Petersen and Vanessa Hill for their never ending support, family dinners, endless hugs, and their presence as scientific role models.
for myself and many others in the NEAGEP/PREP family. Their dedication to diversity and excellence in science has been extremely inspiring to me.

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Thank you to Hillary Hadley and Eswen Fava for their years of friendship, mentorship, research support, and passion for having a good time in and outside of lab. Thank you to the executive board members of the Graduate Students of Color Association: Tina Chen, Ashley Carpenter, Raquel Bryant, Nigel Golden, and Korka Sall. Their friendship and community has been invaluable. Thank you to the many members of writing support and accountability groups that I have been a part of. Thank you to Shereen El Mallah for being the best parallel play writing buddy I could have asked for.
Infants’ perceptual abilities allow them to distinguish faces of different races and genders from an early age (for a review, see Pascalis et al., 2011). However, it is still unknown when infants begin using these perceptual differences to represent faces in a conceptual, kind-based manner. The current dissertation examined this issue by testing whether 12- and 24-month-old infants represent faces of different races and genders as distinct ‘kinds’ or instead as variations of a single broader category (e.g., ‘human face’). The current dissertation included two experiments each with a different type of violation-of-expectation individuation paradigm. Experiment 1 used a passive viewing looking-time measure to establish infants’ baseline response to human- vs. non-human faces as well as their response to male versus female faces. Results from Experiment 1 replicated previous looking time measures and found evidence that 12-month-old infants have a representation for an ontological or ‘human’ kind. Using a manual search paradigm, infants’ face individuation based on gender and race was assessed in Experiment 2. Twenty-four-month-old infants, but not younger infants, displayed reaching behaviors
that indicated they individuated faces based on the kind ‘human’ as well as face gender.

There was no evidence of individuation based on a face’s race group. The current
findings help to determine how infants begin to conceptually represent gender and race
differences as identity-defining variations that might serve as a starting point for socio-
cognitive biases observed later in development.
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CHAPTER I

INTRODUCTION

The human face is arguably the richest source of social information that we can directly observe. Investigations have extensively focused on when, how, and what information is perceived and processed from faces at an early age. From birth (and even prenatally e.g., Reid et al., 2017) infants display a visual attention bias for faces and face-like configurations that supports early learning and allows for infants to readily perceive differences in face identities (see Reynolds & Roth, 2018 for a review). Infants’ perceptual differentiation capabilities are quickly fine-tuned to the faces they most frequently see. For example, the development of face perception is molded by the early and frequent experiences infants have with primary caregivers (for a review, see Pascalis et al., 2011). Our face perception abilities sharply tune to the faces of individuals who share the gender and race of our primary caregivers (e.g., Kelly et al., 2007; Pascalis, de Haan, & Nelson, 2002). Although much is known about infants’ ability to perceptually distinguish faces, relatively few studies have examined how these perceptual abilities develop into the meaningful conceptual distinctions about people or groups that children eventually possess. The goal of the current study is to examine when the perceptual differences infants observe between faces are used to conceptually differentiate people into distinct groups. For instance, infants may readily distinguish between the perceptual features of different gender faces, but do infants then conceptually represent these differing faces as belonging to distinct ‘kinds’ or categories of people? The current studies address this open question by examining whether infants represent faces as conceptually distinct along three different dimensions: ontological kind (human vs. non-
human), gender (male vs. female), and race (Caucasian vs. African-American). Bridging this gap between early perceptual abilities and higher-level representations is a critical step in understanding the development of social categories and biases more generally.

**Face Perception during Infancy**

**Visual Preferences**

Infants between 3 and 9 months of age exhibit perceptual biases for the faces they most frequently see (for reviews see Lee, Anzures, Quinn, Pascalis, & Slater, 2011; Pascalis et al., 2011; Scherf & Scott, 2012). Perceptual biases for faces have been measured behaviorally using spontaneous looking time preferences (e.g., Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002) as well as discriminating between novel and familiarized faces (e.g., Kelly et al., 2007). Infants’ earliest perceptual biases for faces are displayed by looking longer towards one face compared to another. This perceptual bias is found when comparing faces between gender and different race groups. For example, 3- to 4-month-olds as well as 10-month-old infants look longer towards female compared to male faces (Hillairet de Boisferon, Uttley, Quinn, Lee, & Pascalis, 2014; Kim, Johnson, & Johnson, 2015; Quinn et al., 2002; Tham, Bremner, & Hay, 2015). Young infants also look longer towards images of a prototypical girl versus boy face (Quinn et al., 2010). Interestingly when male and female faces are compared within different race groups, infants only display a female face bias for the race group that is most familiar (Kim et al., 2015; Liu, Xiao, Quinn, et al., 2015; Quinn et al., 2008). These looking preferences indicate that infants’ perceptual biases for female faces generalize across age (children & adults), but are specific to a familiar race group. In sum, infants may be building a
perceptual representation of faces based on gender prototypes and this is influencing how they begin to attend to and navigate their social world.

The evidence for and against the presence of race-based perceptual biases is less clear. The primary finding is that as early as 3 to 4 months (but not neonates), infants spontaneously look longer towards faces of the race they are most familiar with (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005). A recent eye-tracking study provides evidence that when infants see side-by-side female faces, infants’ spontaneous looking time preferences shift from own-race faces at 3 month to other-race faces at 9 months (Liu, Xiao, Xiao, et al., 2015). Furthermore, 11-month-old Caucasian and Hispanic infants looked longer toward African-American and Hispanic relative to Caucasian female faces (Singarajah et al., 2017). Authors suggest that race-based perceptual biases are in part influenced by the infants’ caregivers, but is also shaped by the infants’ ability to isolate features that mark stark differences between an in-group and an out-group member (Singarajah et al., 2017). Specifically, longer looking to other-race faces may indicate that older infants are assessing the racial composition of their broader community and directing their attention toward members of a novel group. In contrast, other behavioral studies provide evidence that infants between 4 and 12 months do not display biased looking duration toward faces based on race (Gaither, Pauker, & Johnson, 2012; Liu et al., 2011; Montoya, Westerlund, Troller-Renfree, Righi, & Nelson, 2017; Wheeler et al., 2011). Infants’ discrepant performance in these studies might be explained by methodological differences or possibly the different demographics of each study’s sample. Recently researchers provide evidence that qualities such as size and racial homogeneity of a community shape infants’ developing face processing capabilities (Ellis,
Xiao, Lee, & Oakes, 2017) and determine which cues are most salient to mark in-group and out-group members (Singarajah et al., 2017). These findings seem to indicate that perceptual biases do not uniformly develop. Biases are shaped not only by caregivers, but also infants’ greater environment. This research provides motivation for understanding how infants think about the different groups of people that are either represented or absent from their environment.

**Perceptual Discrimination**

Being able to differentiate one face identity from another is an ability that is highly valuable to successfully navigating one’s social world (see Scherf & Scott, 2012 for a review). We use face discrimination capabilities to quickly determine if someone is family, a friend, a co-worker or a stranger. It is hypothesized that through almost exclusive experience with caregivers and the amount of social learning that occurs in the first year infants’ face discrimination capabilities are shaped (for reviews see Hadley, Rost, Fava, & Scott, 2014; Pascalis et al., 2014; Scherf & Scott, 2012; Scott & Fava, 2013). Infants display better discrimination capabilities for familiar gender and race faces. For example, neonates can differentiate their mother’s face from a similar looking female face (Bushnell, Sai, & Mullin, 1989; Pascalis, Schonen, Morton, Deruelle, & Fabre-Grenet, 1995) and reliably discriminate among two similar looking female faces by 3 months of age (e.g., Barrera & Maurer, 1981). In the second-half of their first year, infants begin to display reliable differentiation capabilities for male faces (Rennels, Kayl, Langlois, Davis, & Orlewicz, 2016; Righi, Westerlund, Congdon, Troller-Renfree, & Nelson, 2014). By 7 months infants display visual behavioral evidence that they can discriminate between two male faces as well as two female faces (Righi et al., 2014).
However electrophysiological responses from the same 7-month-old infants indicated that they have differential neural sensitivity to female faces relative to male faces, suggesting that the early and frequent exposure primarily to females results in long lasting perceptual biases for female faces (Rennels et al., 2016; Righi et al., 2014). Easily discriminating between two female or male faces could relate to infants’ developing attachment or social relationships with their caregivers versus strangers (Scherf & Scott, 2012). Once again, this female face perceptual bias is present early and appears to last throughout the first year of life. This seems to indicate that the perceptual features that differentiate faces along gender are highly salient for infants and could lead to differences in how infants think about or relate to people of differing face genders.

Unequal perceptual discrimination capabilities for faces of different races are shown when infants demonstrate robust perceptual capabilities for differentiating among own-race faces and a poorer ability for other-race faces (for reviews see Lee, Anzures, Quinn, Pascalis, & Slater, 2011; Scherf & Scott, 2012). Researchers consistently presents evidence that between 3 and 9 months of age infants’ capability to differentiate between two faces tunes to the race they are most familiar with, this is known as the ‘other-race effect’ (Kelly et al., 2007, 2009; Tham et al., 2015; Vogel, Monesson, & Scott, 2012). These findings have traditionally been tested with a visual-paired comparison paradigm (VPC). This test of discrimination familiarizes or habituates infants to a single face identity, at test infants are presented with the familiarized face and a novel face side-by-side. Infants’ looking time toward each test face is recorded and compared (Kelly et al., 2007; Scott, 2011; Scott & Monesson, 2009; Vogel et al., 2012). If infants look significantly longer toward one of the two faces, researchers interpret this evidence that
infants’ are able to discriminate between the familiarized and novel face identities. For example, 3-month-olds readily respond to novel compared to familiarized face regardless if the two faces are from the infants’ own-race or other-race group. In contrast, 9-month-olds only respond to novel faces at test when the familiarized and novel face are both from their own racial category (Kelly et al., 2007, 2009).

Other research indicates that the presence of the other-race effect is moderated by the gender of the presented faces. Specifically, at 3 to 4 months infants appear to display an own-race female face discrimination bias, however by 9 months infants can reliably discriminate own-race faces among both female and male face pairs (Tham et al., 2015). Even when low-level perceptual cues such as skin color were controlled for, 9-month-old infants maintained differential processing for own- relative to other-race faces (Anzures, Pascalis, Quinn, Slater, & Lee, 2011; Balas, Westerlund, Hung, & Nelson, 2011; Hayden, Bhatt, Zieber, & Kangas, 2009; Vogel et al., 2012). This suggests that skin color is not the only driving factor for infants’ face discrimination biases. Infants’ own-race biases may be more broadly related to better perception of in-group members as a result of the quantity and quality of early experiences with particular groups of people or caregivers (for reviews see Pascalis et al., 2011; Scherf & Scott, 2012; Scott & Fava, 2013; Scott, Pascalis, & Nelson, 2007). In particular, infants spend the majority of their time with adults who are of the same gender, race, and age as their primary caregivers (Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014). This increase in experience may make faces matching the gender and race of their caregiver appear more familiar, making it easier to detect and process distinguishing features between two individuals within an infants’ in-group (Liu, Xiao, Quinn, et al., 2015; Liu, Xiao, Xiao, et al., 2015).
Perceptual Categorization of Faces

Infants’ early perceptual biases for differentiating faces within familiar groups may reflect the development of perceptually categorizing these faces. Categorization reflects the representation of multiple exemplars that are both distinctive and have shared common features (for a review see Ramsey et al., 2005) and face categorization for both human and nonhuman biological groups begins to develop early in infancy (Anzures, Quinn, Pascalis, Slater, & Lee, 2010; Quinn, Doran, Reiss, & Hoffman, 2009; Quinn, Lee, Pascalis, & Tanaka, 2015; Ramsey et al., 2005; Scott & Fava, 2013). Infants build prototypes of different types of faces that allow them to efficiently determine if a newly encountered exemplar should be included in a particular category (for a review see Ramsey et al., 2005). This process may be similar to how adults categorize a novel stimulus based on how close in perceptual space it is to a stored prototype (Nosofsky, 1986). Infants might construct such perceptual categories for female versus male, or own- and other-race, to efficiently differentiate identities among novel and familiar faces.

Just as face gender is one of the earliest features infants display looking biases for, young infants also seem to first form a perceptual category for female faces (for a review, see Ramsey, 2005). For example, following familiarization to several different female faces, infants looked longer toward one of these familiar faces compared to a face that was an average of all the female faces. Authors suggested that infants’ experience with female faces facilitates infants’ ability to form a ‘female face’ prototype or category (de Haan, Johnson, Maurer, & Perrett, 2001; Rubenstein, Kalakanis, & Langlois, 1999; Waxman & Grace, 2012). Other research shows that by 7 months of age infants can form
a perceptual category for female faces that includes faces of different races (Waxman & Grace, 2012). However it is not until 11 months that infants do the same for male faces.

Infants also appear to include vocal cues to their female face category. For example, infants between 6 to 9 months of age look longer toward a female relative to a male talking face when they hear a female voice (Hillairet de Boisferon et al., 2015; Poulin-Dubois, Serbin, Kenyon, & Derbyshire, 1994; Richoz et al., 2017). These past studies did not find evidence for male face-voice matching. Although there is some evidence that 9-month-olds can match male faces and voices (Walker-Andrews, Bahrick, Raglioni, & Diaz, 1991), it seems this effect is not reliably displayed until 18 months of age (Poulin-Dubois, Serbin, & Derbyshire, 1998). In sum, by 6 months infants’ primary experience with women appears to support a category that groups female looking faces with female voices.

Recently, studies have demonstrated that infants also build different perceptual categories of own- and other-race faces (Anzures et al., 2010; Quinn et al., 2015; Uttley et al., 2013; Waxman & Grace, 2012). For example, 6- and 9-month-old Caucasian infants were familiarized to either three Black or three Asian female faces. At test infants were presented with two new faces, one that represented the familiarized race category and the other that represented a novel race category. Six-month-old infants looked longer toward the face from the novel race category versus the novel face identity from the familiarized category. This finding indicates that 6-month-old infants can form distinct perceptual categories for Black and Asian face groups. Nine-month-olds did not display greater looking than chance when presented with a face of a novel race category relative to a novel identity of the familiarized race. These findings indicate that 9-month-old
infants did not perceptually distinguish between the two other-race face groups. To further examine this null finding researchers had a second group of 9-month-olds who were either familiarized to three own-race Caucasian faces or three other-race (either Black or Asian) faces. At test, infants looked longer towards the face representing the novel race category (Quinn et al., 2015). For example, 9-month-olds familiarized with own-race Caucasian faces looked longer toward the other-race Black or other-race Asian faces relative to an own-race face of a novel identity. One conclusion that can be drawn from these findings is that perceptual face categorization appears to follow the same developmental trajectory as infants’ face discrimination capabilities. That is, at 6 months infants have distinct other-race categories for different race groups (Quinn et al., 2015) and have robust abilities to differentiate individuals within these categories (Vogel et al., 2012). By 9 months, infants have narrowed their categorization for own-race faces and formed a general or broader other-race face category. Therefore, 9-month-olds do not seem to be categorizing faces of unfamiliar races into separate race-specific groups, such as separate categories for Black faces and another for Asian faces.

Similar to findings from female face-voice matching research, there is evidence that infants also differentiate specific audio input with own-relative to other-race faces. For example, 6-month-old infants displayed visual attention differences that suggested they associated other-race faces with non-native languages (Uttley et al., 2013). Authors suggested that 6-month-olds have perceptual categorical representation of non-native language from other novel non-language sounds and are starting to build representations between face groups and language. Recently, researchers found that 9-month-old, but not 3- or 6-month-old infants raised in a monoracial environment display visual associations
between own-race faces and happy sounding music and other-race faces with sad
sounding music (Xiao et al., 2017). These results provide further evidence that infants are
starting to organize faces based on properties such as race (and language) in a meaningful
way. Although the formation of categories and associations between own- and other-race
faces may not be as salient as gender, depending on home or community environment,
race can be a salient marker for determining in-group and out-group membership.

**Perceptual categories vs. kinds.** The previously described research provides
clear evidence that infants develop and fine-tune perceptual categories and discrimination
capabilities based on social experiences. Perceptual categorization distinctions can be
made based on grouping similarly shared features. Infants could group faces together
using various types of perceptual feature differences, such as eye or hair color, freckles,
skin complexion, or gendered features. However these perceptual categories may not
further group faces beyond what is superficially observed. In contrast, individuals that
belong to the same ‘kind’ category share properties that make them more conceptually
similar, sometimes despite how superficially different they may appear on the surface
(for reviews see Xu, 1999, 2005). For example, a short, squat, and ceramic black mug,
and a tall, plastic, red cup could be assigned to different perceptual categories (e.g., ‘red
things’ vs. ‘black things’ etc.) while retaining membership to the same ‘kind’ category
(i.e., ‘cup’). The face perception literature reviewed thus far has not determined if and
when infants possess such kind categories for faces.

Distinguishing faces on the basis of perceptual features that correlate with gender
and race make it plausible that infants possess kind concepts around the first year of life.
Indeed, Quinn and Eimas (2000) suggest that kind concepts for objects develop from
infants’ combining perceptual learning with language learning. However the methods that are primarily used to test face processing during infancy, such as the match-to-sample habituation task or VPC tasks (e.g., Anzures et al., 2010; Quinn et al., 2015; Rennels et al., 2016) are not designed to differentiate perceptual vs. kind-based processing performance. These tasks require infants to hold perceptual features of a familiarized face in memory, but infants are not required to demonstrate any deeper understanding of how these properties relate or whether the faces share anything in common beyond their surface features. For instance, infants might register the perceptual similarity between an object presented twice in a row without necessarily representing it as the same one.

Representing the number of individuals involved in a particular event or scene is called ‘individuation’ (for a review see Xu, 1999) and researchers have used individuation tasks to test for the presence of kind category representations (e.g., Xu & Carey, 1996).

**Object Individuation**

Representing objects as distinct entities as they move through changes in time and space is a process known as individuation (Cohen & Cashon, 2007; Xu, 2005, 2007, 2010). This process is vital for resolving the many ambiguities that exist in our everyday experience. For example, the ordinary experience of seeing someone walk through an open door and then returning through a different door moments later leaves the observer needing to infer the number of individuals involved. Whether the observer interprets this event as involving one person or two people is a question of individuation. There are a variety of cues that our minds might use in order to conclude how many objects or people are involved in a scenario such as this, ranging from the perceptual (e.g., the corresponding hair color, height, and clothing between the two people) to more
conceptual distinctions (e.g., the ‘kind’ or category the two people belong to). The process of individuation is a common topic of study across development, from young infants to adults and the connections between them (for reviews see e.g., Carey & Xu, 2001; Cheries, Mitroff, Wynn, & Scholl, 2009; Scholl & Leslie, 1999).

**Individuation by Perceptual Information**

Some of the earliest evidence for object individuation examined infants’ use of so-called ‘spatiotemporal cues’ in an object tracking task (e.g., Krojgaard, 2007; Spelke, Kestenbaum, Simons, & Wein, 1995). For example, infants were tested to see if they understood that an object travels in a constant path and cannot be perceived in two places at the same time. If they have this knowledge, then they would interpret a spatiotemporally discontinuous appearance of an object as an instance of a different individual (Spelke et al., 1995). Four-month-old infants were assigned to one of three testing conditions, varying the appearance and disappearance of an object constantly moving across a presentation stage. In the Continuous Condition, infants habituated to an object traveling behind two separate screens visibly passing through an open space between each screen. Infants in the Discontinuous Condition were habituated to an object moving behind two separated screens *without* visibly passing through the middle space. Following habituation, the occluders were removed and infants’ looking time was measured during the presentation of one and two objects moving across the stage. If infants expect objects to travel on continuous pathways through the visible space then their looking times towards one and two object outcomes will differ across the continuous and discontinuous motion conditions. Indeed, infants in the Continuous Condition looked significantly longer toward two objects traveling across the stage. This
finding indicates that infants familiarized to a continuously moving object perceived this event as involving a single object. In contrast, infants in the Discontinuous Condition looked longer towards one object traveling across the stage, indicating these infants perceived the discontinuous disappearance and reappearance of an object as involving two distinct objects. Spelke and colleagues (1995) concluded that the 4-month-olds’ object individuation was due to an implicit awareness of the spatiotemporal ‘rules’ of object continuity, namely that an object cannot appear in two distinct locations without moving on a continuous trajectory between them.

The experiments by Spelke and colleagues (1995), suggest that very young infants are capable of individuating objects based on perceptual cues like continuous or discontinuous spatial movement. Other studies have explored when infants begin using different types of perceptual cues to individuate objects. For example, from 4.5 to 12 months of age infants gradually use more complex surface features to track and individuate objects (Tremoulet, Leslie, & Hall, 2000; Wilcox, 1999). Wilcox (1999) conducted a series of experiments with 4.5- to 11.5-month-old infants testing object individuation based on shape, size, pattern, and color. First, infants were familiarized to a screen wide enough to hide two objects behind it. At test, infants saw objects pass behind a new screen that was either the same width or a narrower screen just wide enough to hide a single object. Four and half-month-old infants displayed longer looking during test trials when they saw an object’s shape or size change after passing behind a narrow screen. Object pattern individuation was displayed at 7.5 months of age and by 11.5 months infants displayed longer looking (i.e., individuation) when an object changed color after passing behind a narrow screen (Wilcox, 1999).
Interestingly, infants use pattern and color information much earlier when these features are presented in combination with an object’s function (Wilcox & Chapa, 2004; Wilcox, Woods, & Chapa, 2008). For example, when 7- and 9-month-old infants are primed to associate color with an object’s function, infants later use color as an individuating feature of novel objects (Wilcox & Chappa, 2004). Infants’ object individuation based on function and color information was not due to simply seeing multiple objects moving in different ways, instead infants were able to generalize that color was significant to the representation of the object. This finding suggests that the type of experience infants have with objects can make surface features more meaningful and be used to track distinct objects across different contexts and time. Might the same be true for perceptual features of human faces? Overall, the specific type of property that infants use to individuate objects (e.g., color, shape, pattern, function) progresses gradually over the first year of life.

**Individuation by Kind**

Infants are also capable of individuating objects based on conceptual information, such as the type or ‘kind’ of entity something is. For example, adults may categorize a cat and dog as both being ‘animals’, with common features such as being animate and furry, or perhaps they would categorize them more specifically as objects that belong to the category ‘cat’ and ‘dog.’ In the latter case, the two objects would be represented as two distinct individuals because of the fact that they are examples of two different types or ‘kinds’ of things. In the second half of their first year of life, infants display similar kind-based object individuation abilities (for reviews, see Xu, 1999, 2007). The seminal study by Xu and Carey (1996) used a violation-of-expectation paradigm with stimuli that
represented different conceptual kinds of objects (e.g., duck, ball, truck). Across a series of 5 experiments, Xu and Carey (1996) examined whether 10- or 12-month-old infants used kind-based representations to individuate objects. Authors first replicated previous findings (Spelke et al., 1995) that infants use spatiotemporal information as a salient cue for individuating objects. Then, authors removed the spatiotemporal information so that objects separately appeared and disappeared from either sides of a single screen. For example, infants observed a duck appear from one side of the screen and a truck appear from the other. Following several repetitions the screen was removed to reveal either a single object (e.g., a truck) or two objects (e.g., a duck and a truck). This single object presentation was identified as the unexpected outcome and the two object presentation was described as the expected outcome. The authors predicted that if infants perceived the two objects as distinct individuals then longer looking to the single object presentation would be displayed relative to baseline. Twelve-month-olds, but not 10-month-old infants displayed longer looking towards the unexpected, single object outcome (Xu & Carey, 1996). Ten-month-old infants did not display a significant change in looking for one- versus two- object outcomes even when fully habituated to the presentation (Xu & Carey, 1996) and when working memory requirements were reduced (Xu, Carey, & Welch, 1999). Critically, this result was not based upon the younger infants failing to notice the perceptual difference between the two objects (e.g., the duck and truck); an analysis of their habituation curves indicated that they could perceptually discriminate the two objects. Instead, the fact that 10-month-olds did not individuate the two objects suggests that they might have ignored the perceptual differences between the objects and represented them in a more conceptual manner as belonging to the same
category ‘object’. By 12 months of age infants may be biased to individuate objects on the basis of their belonging to different kinds (Xu & Carey, 1996). This interpretation was bolstered by the finding that 12-month-olds who possess labels for different kinds (e.g., knowing the words ‘duck’ and ‘truck’) succeeded in the individuation task.

These language findings resulted in researchers hypothesizing that language acquisition is one particularly powerful mechanism driving kind-based object individuation early in development (for a review see Xu, 2007). Research that explicitly tested this hypothesis confirmed that infants’ word-object knowledge is related to kind concept individuation (Dewar & Xu, 2007; Rivera & Zawaydeh, 2007; Xu, 2002; Xu, Cote, & Baker, 2005). For example, Rivera & Zawaydeh (2007) found 10- and 11-month-old infants who knew the word for each presented object that appeared sequentially from behind a screen looked longer toward a one object outcome compared to two, a pattern reflecting successful individuation. However, infants in the same study who only knew the word for one of the two objects did not show evidence of object individuation (Rivera & Zawaydeh, 2007). Xu (2002) found 9-month-old infants displayed longer looking to a single object outcome if they had heard distinct nonsense labels for each novel object presented during the familiarization phase. Infants looking patterns did not differ when they heard the same label, two distinct tones, or two different emotion sounds for each object (Xu, 2002). These null findings further support the hypothesis that unique labels are one important factor underlying kind-based individuation. A possible explanation for the relationship between word learning and individuation is that by already knowing words for each object, infants have distinct conceptual representations for those objects. Hearing two distinct words may be leading
infants to formulate two distinct representations of objects during the task (Dewar & Xu, 2007). Furthermore a recent proposal suggests that label-learning re-organizes infants’ information processing system from being stimulus driven (i.e., bottom-up), to something top-down or more conceptually driven (Hadley et al., 2014). Hearing a label during an individuation task may divert infants’ attention away from perceptual information and towards more meaningful or conceptual representations of the presented objects (Ferguson & Waxman, 2017; Fulkerson & Waxman, 2007; Havy & Waxman, 2016; Waxman & Markow, 1995).

Changes in infants’ kind-based individuation of objects with the support of word knowledge is to some extent reflected in changes to infants’ perceptual discrimination capabilities for objects and faces (Hadley, Pickron, & Scott, 2015; Pascalis et al., 2005; Scott, 2011; Scott & Monesson, 2009). For example, after three months of seeing images of monkey faces and hearing their individual names, 9-month-old infants were tested on a new set of monkey faces in a visual paired comparison task. Nine-month-old infants who heard the individual names displayed longer looking to the novel relative to the familiarized monkey face (Pascalis et al., 2005; Scott & Monesson, 2009). Nine-month-old infants who only saw the monkey faces or heard the word “monkey” for all of the faces showed no evidence of perceptual discrimination at test (Scott & Monesson, 2009). Although it cannot be concluded that these 9-month-old infants had a conceptual representation for monkey faces, they did demonstrate better differentiation capabilities compared to infants who had not received individual-level label training. Therefore, if label learning supports infants’ kind-based individuation, then this may suggest that as infants learn unique names for faces, they are also developing some types of conceptual
representations for face kinds based on those faces they most frequently experience. One finding indicates that over 90% of typically developing 8-month-old infants comprehend words for their primary caregivers such as mommy and daddy (Fenson et al., 1994). Might this mean that, as a result of name learning, infants begin to represent faces that are similar to their caregivers as members of distinct kinds?

Other results illustrate the relative independence of kind-based individuation processes from lower-level perception. Researchers test how dissociable these two processes are by pitting property and kind information against one another in different manners. For example, in one such study infants represented two different objects of the same color (e.g., a yellow duck and yellow truck) as two distinct individuals (Xu, Carey & Quint, 2004). Therefore even when objects are perceptually more similar, 12-month-old infants with distinct kind representations for objects (e.g., duck and truck) are still able to display object individuation (Xu, Carey, & Quint, 2004). Conversely, infants who observe two objects that are perceptually very different (a red cup vs. a black mug), but represent them as the same kind of object (‘cup’), do not display individuation.

The manual search box task method provides converging evidence for kind-based object individuation (Feigenson & Carey, 2003; Van de Walle, Carey, & Prevor, 2000; Xu & Baker, 2005; Xu et al., 2005). In this task, infants were familiarized with the process of reaching inside a box to retrieve an object. After either one or two objects were removed and then replaced back inside a box, infants were invited to reach and retrieve the object(s). Reaching time was measured as an index of infants’ interest or attention for the contents of the box. Van de Walle and colleagues (2000) tested object individuation under two conditions, spatiotemporal and property-kind. Infants in the
spatiotemporal condition observed two objects appearing at the same time on top of the box prior to being placed inside. Similar to Spelke and colleagues (1995), the reasoning was that when infants perceive two items at the same time they will represent these objects as distinct individuals. The property-kind condition involved infants seeing each object appear one at a time from inside the box and were tested on whether they represented the objects as distinct individuals. If infants successfully individuated the objects, after being allowed to retrieve one object, they should reach back in a second time and for a longer duration than when they only see a single object enter the box. The results from this task mirrored prior studies using looking-time procedures (e.g., Xu & Carey, 1996); 10-month-old infants individuated objects based on spatiotemporal information (i.e., when they saw 2 objects simultaneously) but did not do so based solely on property/kind differences (i.e., seeing a duck and truck one at a time) whereas 12-month-old infants displayed spatiotemporal and property-kind based object individuation (Van de Walle et al., 2000). Another example of the manual search task testing for individuation is with the use of labels (Xu et al., 2005). Specifically, Xu and colleagues (2005) used either one or two distinct verbal labels to identify hidden contents within a box. When infants heard two different labels for items hidden within a box, they reach for a greater amount of time when they only found 1 object. In contrast when infants only heard a single label their reaching was diminished once they had found one object (Xu et al., 2005). These findings further present evidence that manual search tasks can test infants’ individuation of objects. Furthermore these labeling findings provide additional evidence that individuation of object kinds is supported by word-object information.
Individuation of Natural Kinds

Infants’ possession of kind concepts for several rudimentary objects (e.g., book, duck, truck, ball, etc.) coincides with the time when they understand noun labels for such objects. However, there is reason to believe that infants possess concepts for even more basic kinds even without having word knowledge. For example, Surian and colleagues (2010) found 10-month-old infants can individuate based on the kind property of agency. Agency was defined as a property of an object that had self-propelled motion instead of aided motion. Ten-month-old infants saw objects sequentially move out from behind a screen; one object (e.g., a cup) was picked up and moved by a hand while the other object (e.g., caterpillar) started moving on its own without any contact from the reaching hand. Infants’ looking duration was recorded during the test phase, which included the infants seeing the sequential object presentation followed by the removal of the screen. If infants represented the objects during the sequential presentation phase as two distinct individuals (e.g., one ‘animate’ and one ‘inanimate), it was predicted that they would look longer towards the unexpected one-object outcome versus a two-object outcome following the removal of the screen. Indeed, 10-month-olds looked significantly longer towards the unexpected, one object outcome compared to baseline levels of looking (Surian & Caldi, 2010). Critically, infants did not individuate objects in the display that belonged to the same kind category. For example, two animate objects that displayed very different motion patterns and physical characteristics (e.g., a bee vs. a caterpillar) were represented as a single object (Surian & Caldi, 2010). This suggests that 10-month-old infants have a conceptual category based on animacy that allows them to distinguish self-propelled objects from those that only move with external assistance. Even without
word knowledge, or spatiotemporal information, 10-month-old infants demonstrate conceptual representations for basic, yet highly salient ecological processes.

From face perception research it is clear that human faces are one of the most fundamentally salient stimuli for infants. Infants quickly formulate perceptual categories believed to be in-part shaped by caregiver experience (Anzures et al., 2010; de Haan et al., 2001; Rubenstein et al., 1999; Uttley et al., 2013; Waxman & Grace, 2012; Xiao et al., 2017). This early categorization raises the question of whether infants also possess conceptual, kind-based, representations for human faces. Limited research has begun to examine infants’ possession of kind distinctions related to people. Recent research indicates that infants as young as 6 months of age are found to have improved working memory capabilities when tested on tracking a doll’s face compared to a non-face object (Kibbe & Leslie, accepted for publication). Authors argue that concept knowledge for human faces aided infants to accurately remember the presented events. This may indicate that infants as young as 6 months of age have the beginnings of a kind-representation for human faces, however there have been no individuation studies that have directly tested this. Thus far there have only been two kind-based individuation studies with faces (Bonatti, Frot, & Mehler, 2005; Bonatti, Frot, Zangl, & Mehler, 2002). Bonatti and colleagues (2002, 2005) found that 10-month-old infants individuate objects based on the biological kind ‘human.’ This was tested by presenting infants with a humanlike doll and an animal doll (e.g., a dog) sequentially emerging from behind a screen (Bonatti et al., 2002). In this scenario infants looked longer towards an unexpected outcome of a single doll revealed from behind a screen. Moreover, 10-month-old infants looked longer to a one versus two object outcome after being familiarized to an upright
and an inverted human doll head, suggesting that normal face processing is important for triggering the representation of ‘human-kind’ (Bonatti et al., 2005). Finally, in order to test whether infants possessed more specific human-kind representations, these researchers presented subjects with two dolls that differed by gender (e.g., a female doll in a blue dress versus a male doll head with dark hair). In this case infants did not individuate the two dolls suggesting that they viewed the male doll and female doll as the same general kind (Bonatti et al., 2002).

In summary, by 10 months of age infants possess kind concepts related to agency and human-likeness (Bonatti et al., 2005, 2002; Surian & Caldi, 2010). According to these studies, infants do not appear to possess subordinate-level kinds for humans such as gender. One important consideration for the null gender effects found by Bonatti and colleagues (2002) is that the stimuli used were only caricatures of human faces. The dolls varied in surface material (e.g., rubber and porcelain), skin color, length of hair, and clothes (e.g., presence of a hat) making it difficult to determine if the null results were due to the stimulus not being realistic. Therefore it is possible that infants’ sensitivity to gender could be more effectively revealed using more detailed and realistic images of faces. Although perceptual biases for different types of faces are present as early as 3 months of age and persist into adulthood, it is unclear whether infants are developing more refined conceptual properties for human faces based on race. This question may be more effectively addressed using individuation techniques with real human faces instead of unnatural dolls that have previously been used.
Current Study

Face gender and race are highly salient perceptual markers in infants’ environment. The current dissertation investigated if and when these perceptual cues are used to represent people as individual members of distinct kind categories. Specifically, we examined whether infants use facial features that vary across gender and race to distinguish one individual as conceptually distinct from another individual. The current dissertation included two experiments each with a different type of individuation measure to test this open question. Each task familiarized infants to an ambiguous number of perceptually distinct faces that appeared one at a time from behind an occluder or from inside a box. Test trials examined whether infants used these perceptual differences to infer how many individuals were involved in the event.

Experiment 1 used a passive viewing looking time measure to test for individuation of faces. Experiment 1 consisted of two different face comparison conditions: 1) the superordinate category distinction human vs. non-human (a conceptual replication of previous violation-of-expectation studies but with photo-realistic human faces; Bonatti et al., 2002), and 2) gender (male vs. female). Experiment 2 used a manual search task to test infants’ individuation of faces to further test for individuation of gender (male vs. female) face kinds and contrasted this to individuation of race (Caucasian vs. African-American) face kinds.

If infants interpret the perceptual differences between faces as reflecting different ‘kinds’ of individuals it was predicted they would expect 2 faces to exist in the event and show greater behavioral responses (i.e., longer looking or reaching) to an unexpected outcome of 1 face versus 2. Alternatively, if infants represent facial features of
humanness, gender or race as malleable expressions of a single individual, then it was predicted that infants should display a greater response to 2 faces being presented. It was predicted that infants would individuate human faces from non-human face. This prediction is consistent with pervious individuation findings with artificial doll heads (Bonatti et al., 2005, 2002). Based on previous research we also predicted that infants would individuate faces based on gender differences. For example, female face processing biases appear very early and form a female face category prior to male faces (Quinn et al., 2002; Waxman & Grace, 2012). Additionally, in social preference tasks, children make gender in-group biases before making race-based biases (e.g., Shutts, Kinzler, Katz, Tredoux, & Spelke, 2011). These early gender biased findings both from perceptual development and social preference could suggest a ‘gender-first hypothesis.’

No previous individuation studies have examined differences based on race. Extensive research suggests that infants’ perceptual processing systems tune to face stimuli of a familiar race, such that by 9 months infants respond differentially to own-race vs. other-race stimuli (Quinn et al., 2015). Therefore, like gender, it is possible that infants’ performance will reflect a deeper conceptual distinction based upon race and reason that an individual of one race group is distinct and cannot change to another race group. However, other work suggests that the perceptual differences between people of varying races may be seen as relatively superficial until much later in development (Kinzler & Dautel, 2012; Kinzler, Shutts, DeJesus, & Spelke, 2009; Kinzler & Spelke, 2011; Kurtz-Costes, Defreitas, Halle, & Kinlaw, 2011; Shutts et al., 2011). For example, 5-year-old children have been found to preferentially choose an own-race individual to have as a playmate compared to an other-race individual. In the same study 10-month-old
and 2.5-year-old infants did not show race-based preferences when offered to take a toy from two different individuals (Kinzler & Spelke, 2011). Thus, there is no clear evidence that infants and toddlers conceptualize race in a way that would guide their social preferences. These considerations for gender- and race-face kind individuation were further investigated across Experiments 1 and 2.
CHAPTER II

EXPERIMENT 1

Experiment 1 was conducted to further investigate infants’ individuation of human faces. Infants participated in a classic violation-of-expectation looking-time task (e.g., Xu & Carey, 1996; Xu et al., 2004). Infants participated in 1 of 2 stimuli conditions. Condition 1 was to test individuation of human versus non-human faces. Condition 2 tested infants’ individuation of male and female faces.

Methods

Condition 1: Human vs. non-human faces.

Participants. All procedures were approved by the Institutional Review Board at the University of Massachusetts. The present study included two age groups of infants, 11- to 12-month-olds and 19- to 27-month-olds. The younger age group was chosen based on previous findings that by about 11 to 12 months infants reliably display kind-based object individuation (e.g., Bonatti et al., 2002; Xu & Carey, 1996). The older age range was chosen as infants begin to have a larger vocabulary of words related to people, both comprehension and productions (Fenson et al., 1994). Infants in both experiments were recruited from the Western Massachusetts area using multiple recruiting techniques. Families were recruited through the Developmental Science research recruitment database maintained by our lab, posting Facebook ads online, making in-person announcements to teachers and parents at daycare facilities in Springfield, MA, the Holyoke Children’s Museum, and T.V./radio talk-shows. Data was collected at two infant lab locations; the Infant Cognition Lab at UMass, Amherst and the Healthy Development Initiatives in the UMass Center in Springfield, MA. The goal of using multiple recruiting
methods and testing locations was to increase the diversity represented in the infant participant sample, including the range of race, ethnicity, and socioeconomic status background of families.

All primary caregivers completed an in-depth demographics questionnaire. This questionnaire served two purposes. The first was to maintain a record of infants’ social experiences prior to participating. Questions were related to the type and frequency of experience their infant shares with male and female people of different races (i.e. Caucasian, African-American, and East Asian). The second purpose was to gather language development information. This was important information to gather because past research indicates word-object knowledge supports kind-concept individuation (Dewar & Xu, 2007; Rivera & Zawaydeh, 2007; Xu, 2002; Xu & Carey, 1996). Parents responded to word comprehension and expression questions that provided data on which gender-related words infants knew (for the complete questionnaire, see Appendix A).

Younger age group (12 months). A total of 23 younger infants participated in Condition 1. Of these infants, 16 were included in the final sample. The remaining 7 were not included due to fussiness and not completing the minimum number of 7 out of 9 trials (5), experimenter error (1), and computer error (1). The final sample included 16 eleven-to 12-month-old infants ($M_{age} = 367.83$ days, $SD = 9.51$) with 8 males and 8 females.

Based on reported demographic data, 13 infants were reported to be racially White or Caucasian and 3 were Multiracial. There were 13 non-Hispanic or Latino, 2 were Hispanic or Latino and 1 infant whose ethnicity was not reported. Infants came from families with an average education level of some graduate school. Education levels ranged from completing some high school to completion of a professional degree. The
average household income was 55 – 65, thousand per year and ranged from less than 15, thousand per year to over 75, thousand per year.

**Older age group (24 months).** A total of 20 nineteen- to 27-month-old infants participated in Condition 1. Of these infants, 18 were included in the final sample. The remaining infants were excluded due to becoming fussy and not completing the minimum of 7 out of 9 trials (1) and computer error (1). The final sample included 18 older infants ($M = 693.06$ days, $SD = 81.64$) with 9 males and 9 females.

Based on reported demographic data, 15 infants were reported to be racially White or Caucasian, 1 was African-American or Black, 1 was Asian, 1 was Multiracial, 0 were Middle Eastern, Native Hawaiian/Alaskan Native. There were 16 infants who were *not* Hispanic or Latino and 2 who were Hispanic or Latino. Infants came from families with an average education level of some graduate school. Education levels ranged from completing some high school to completion of a professional degree. The average household income was 55 – 65, thousand per year and ranged from less than 15, thousand per year to over 75, thousand per year.

**Stimulus & Apparatus.** Photographs of human faces were included as stimuli for this task. Faces were chosen from the *Chicago Face Database* (Ma, Correll, & Wittenbrink, 2015) which consist of approximately 158 individual face identities who were between the ages of 18 and 40 years of age. Ma and colleagues (2015) had over 1,000 adults verify racial and gender identities rate faces on a range of features. Most critical to the present study, was that all faces were categorized based on race, gender, and rated for friendliness and attractiveness. All faces used in Experiment 1, Condition 1, were racially Caucasian and expressed a happy closed mouth smile. Approximately 10
undergraduate research assistants from our lab individually picked the 10 “best” looking male and female faces. These sets of faces were then presented to the entire lab group where we selected 8 male and 8 female faces (see Figure 1). Faces were selected based on clarity of the friendly facial expression, visibility of the eyes and no apparent makeup, body piercings, or physical abnormalities. All male faces included in the final set had hair length that did not extend past their ears. All finalized female faces had hair length that reached to at least their chin. Five non-human shape faces were created in Photoshop CS5 12.0.x64 and PowerPoint (see Figure 1). The non-human shape stimuli were edited versions of the human faces. In Photoshop, the internal features of a Caucasian human face were smoothed over and replaced with non-human shapes. Therefore, the skin color and texture was consistent with the human faces, however there were no human-like features. The internal shape features were added in PowerPoint and consisted of two shapes stacked on top of each other.

Two female, two male, and two non-human shape faces were used in the puppet show. Face stimuli were printed and then affixed to puppet doll bodies to allow for a more realistic presentation. The puppets’ bodies were identical and they possessed the same shirt, pants, and shoes with only the face trait of “humanness” varying between faces. During the show puppets were seated on their bottoms, the heads were 7.25 inches tall by 4.5 inches wide. Puppets were presented on a stage that was painted black with a curtain that moved up and down during the presentation. The stage was 48 inches wide, 29 inches tall, and 20 inches deep. Infants saw a blue screen that an experimenter raised and lowered. The blue screen was 22 inches wide and 29 inches tall. The screen was used as an occluder that the puppets passed behind throughout the presentation.
Figure 1. Caucasian Female & Male Face Stimuli. Caucasian human face stimuli used in both conditions of Experiments 1 and 2. Non-human shape faces were used in Condition 1 of Experiments 1 and 2.

**Procedure.** Infants sat on their parent’s lap approximately 40 inches from the stage in a dimly lit room. Classical music quietly played in the background. Before the puppet show began, parents were instructed to remain neutral and refrain from talking, pointing, or responding in any way throughout the presentation. Infants’ face, body, and verbalizations were recorded throughout the puppet show. The puppet show consisted of three phases: a baseline, familiarization, and test phase (see Figure 2).

The **baseline phase** was used to measure infants’ spontaneous looking towards one versus two puppets prior to the start of the test trials. During the baseline phase infants saw 4 trials of a blue screen being lowered to reveal either one or two puppets. One puppet had a human face and the other had the non-human shape face.
Experimenters cued infants’ attention to the stage by saying “Look here Name of infant” as the blue screen was lowered. Trials lasted until infants looked away for 2 consecutive seconds. In-between the baseline and familiarization trial the face identity of the two puppets used was changed to two new face identities, but still maintained that one was human and the other non-human. The familiarization phase served as an opportunity for infants to see the movement of the puppets which reduced the likelihood of the novelty of the puppets to influence looking behavior at test. Infants saw a sequential presentation of puppets emerging from behind the centrally located blue screen. A puppet appeared to the side of the screen, paused for 4 seconds, and then moved back behind the screen, 1 second later a second puppet moved out from behind the screen towards the opposite side of the stage, paused for 4 seconds, and then moved back. This pattern was repeated for a total of 4 puppet presentations (2 per side). The test phase assessed infants’ representation of how many individuals they believed were behind the screen. During the test phase infants once again saw faces sequentially move out from either side of a screen. After a total of 4 puppet face presentations (2 per side), the screen was lowered and revealed either one or two puppets and infants’ looking-time towards the stage was recorded. The puppets remained visible until infants looked away for 2 seconds. The presentation of faces followed by the screen removal was repeated for a total of 4 test trials.

Three components of the puppet show task were counterbalanced between infants across 8 different conditions. First, half of the infants saw female faces paired with the non-human faces and half saw male faces paired with the non-human faces. Second, face identity pairings were counterbalanced. Specifically, there were two face identities for each type of face (i.e., two female faces, two male faces, and two non-human faces).
Male and female faces were never paired together during Condition 1. However individual face identities within each gender group were equally paired together with the non-human faces. For example, female face A was equally paired with non-human faces A and B during the baseline and test phases as was female face B equally paired with non-human faces A and B. Third, the pattern of face outcomes being revealed from behind the blue screen of one face versus two faces during the baseline and test phases was counterbalanced within a single testing session as well as across infants. During the baseline phase, puppet presentation outcome followed either a pattern of 1, 2, 2, 1 (i.e., 1 face, 2 faces, 2 faces, 1 face) or 2, 1, 1, 2 (i.e., 2 faces, 1 face, 1 face, 2 faces). At test, puppets were presented in either a 1, 2, 1, 2 or 2, 1, 2, 1 pattern (Surian & Caldi, 2010; Xu & Carey, 1996; Xu et al., 2004).

**Coding.** Infants’ looking behavior was viewed through a video camera on a computer monitor outside of the testing room. Looking duration was coded by an experimenter during the presentation of the puppet show using the program *jHab* (Casstevens, 2007). After the infant had left the lab, a second experimenter recoded the video. This second experimenter was not involved in any part of the original puppet show presentation. Primary and secondary video coders achieved a reliability of at least .90 for all included participant data.
Figure 2. Experiment 1 Looking Time Task. Depiction of the passive viewing puppet show used in Experiment 1 Conditions 1 and 2. The puppet show included 9 trials: 4 baseline, 1 familiarization, and 4 test trials.

**Condition 2: Male vs. Female Faces.**

**Participants.**

Younger age group (12 months). A total of 18 younger infants participated in Condition 2. Of these infants, 17 were included in the final sample (8 females, 9 males). One infant was not included due to becoming fussy and not completing a minimum of 7 out of 9 trials. The average age for the 11- to 12-month-old infants was 366.53 days ($SD = 13.75$) with 9 males and 8 females included in the final analyses.

Based on reported demographic data, 12 infants were reported to be racially White or Caucasian, 2 were Multiracial, 1 was African-American or Black, 1 was Asian, and 1 whose race was not reported. There were 13 infants ethnically identified as not Hispanic or Latino and 4 who were Hispanic or Latino. Infants came from families with
parents who have completed an average of some graduate-level education with a range from completing high school to a professional degree. The average household income was 55 to 65 thousand per year and ranged from less than 15 thousand per year to over 75 thousand per year. On average infants were reported to know 4.18 ($SD = 1.38$) out of 13 possible gendered words.

*Older age group (24 months).* A total of 19 older infants participated in Condition 2. Of these infants, 16 were include in the final sample. The remaining infants were excluded due to becoming fussy and not completing the minimum of 7 out of 9 trials (3). The mean age of the final sample for the 19- to 27-month-old infants was 718.56 days ($SD = 77.50$), there were 8 males and 8 females.

Based on reported demographic data, 12 infants were reported to be racially White or Caucasian, 1 was African-American or Black, 2 were Asian, and 1 was Middle Eastern. There were 11 infants ethnically identified as not Hispanic or Latino, 2 were Hispanic or Latino, and 3 whose ethnicity was not reported. Infants came from families whose parents completed some graduate-level education with a range from high school completion to professional degree. The average household income was 65 – 75 thousand per year and ranged from less than 15 thousand to over 75 thousand per year. On average infants were reported to know 7.44 ($SD = 3.20$) out of 13 possible listed gendered words.

*Stimuli & Apparatus.* The same 2 male and 2 female Caucasian faces from Condition 1 were used in Condition 2. However the non-human faces were not included in Condition 2’s puppet show. All other testing materials and apparatus were identical to Condition 1.
**Procedure.** The testing procedure was identical to Condition 1, with the only difference being that infants only saw male and female faces. All counterbalance conditions were also identical to Condition 1.

**Analyses**

For each condition, infants’ looking duration to one compared to two faces during the baseline and test phase was analyzed. Separate 5-way 2 x 2 x 2 x 2 x 2 mixed measures analysis of variance was conducted separately for each infant age group within Conditions 1 and 2. Within-subject factors included trial phase (baseline, test), face outcome (1 face, 2 faces) and trial pair (first pair, second pair). Between-subject variables were the order of face presentation during baseline trials (1 face first, 2 faces first) and the order of face presentation during the test trials (1 face first, 2 faces first). For each experiment a third, more targeted ANOVA was conducted to analyze whether infants’ looking behavior was statistically different between age groups. This ANOVA included the within-subject variables of trial phase (baseline, test) and face outcome (1 face, 2 faces) and had infant age as a between-subjects variable (younger, older).

**Secondary Analyses.** Prior studies that have presented evidence for a link between language and kind-based object individuation analyzed data by categorizing infants’ word knowledge and comparing their duration of looking to one versus two object presentations during test trials (Rivera & Zawaydeh, 2007; Xu & Carey, 1996). The current study also assessed possible differences in infant performance based on word knowledge. This was done specifically for Condition 2, which tested for the individuation of male versus female faces. We used questionnaire data related to infants’ comprehension and expression of words related to people in gendered roles (e.g.,
mommy, daddy, girl, and boy). We created a ‘gendered word’ variable for both comprehension and expression for each infant. This variable represented the sum of reported gender related words infants comprehended and separately that they expressed. We used a linear regression to assess whether there was a relationship between infants’ word knowledge and their looking time during the puppet show.

Results

**Condition 1: Human versus Non-human faces.**

*Younger age group (12 months).* The 5-way repeated measures ANOVA included within-subject variables of phase (Baseline, Test), outcome (1 face, 2 faces), trial pair (first pair, second pair), face presentation order at baseline (2,1,1,2; 1,2,2,1), and face presentation test order (1,2,1,2; 2,1,2,1). This analysis revealed a significant main effect of trial pair $F(1, 12) = 11.79, p = .005, \eta^2 = .50$ due to infants looking significantly longer during the first trial pair ($M = 12.63$ seconds, $SD = 5.12$) compared to the second trial pair ($M = 8.66$ seconds, $SD = 2.54$). There was a significant interaction between phase and outcome $F(1, 12) = 6.48, p = .026, \eta^2 = .35$. However, there were no significant follow-up paired sample t-tests found.

This interaction was further qualified by the second significant interaction between phase, outcome, and trial pair $F(1, 12) = 8.11, p = .015, \eta^2 = .40$. Follow-up paired sample t-tests revealed that during the first trial pair, infants looked longer at two faces ($M = 18.49$ seconds, $SD = 14.91$) compared to one face ($M = 7.29$ seconds, $SD = 2.45$) during baseline $t(15) = -3.04, p = .008$, Bonferroni corrected $p = .064$, but this difference in looking was not found for the first test trial pair (see Figure 3). Additionally, infants looked longer at test for the first single face presentation compared to the first
single face presentation at baseline $t(15) = -2.22, p = .042$, Bonferroni corrected $p = .336$.
No other follow-up paired sample t-tests comparisons were significant. Lastly, to check
whether the differences found between 1 face versus 2 faces at the first baseline was
different than what was found during the first test trial paired sample t-tests were
conducted between the difference scores. The difference between the first baseline pair
between 1 versus 2 faces ($M = 11.20$ seconds, $SD = 14.75$) was marginally greater than
the difference between 1 versus 2 faces during the first test trial ($M = 1.71$ seconds, $SD =
8.84$) $t(15) = 2.00, p = .068$. Differences in looking between 1 versus 2 faces during the
second baseline compared to the second test trial were not statistically or marginally
different.

**Older age group (24 months).** The same 5-way repeated measures ANOVA was
used to analyze the looking duration toward one and two faces for the older infants. There
was a significant main effect of paradigm phase $F(1, 14) = 10.46, p = .006$, $\eta^2 = .43$ with
infants looking longer during the baseline ($M = 19.32$ seconds, $SD = 9.30$) compared to
the test phase ($M = 14.67$ seconds, $SD = 5.80$). A second significant main effect was
found for trial pair $F(1, 14) = 9.28, p = .009$, $\eta^2 = .40$, with infants looking longer during
the first trial pairs ($M = 19.38$ seconds, $SD = 8.40$) compared to the second trial pairs ($M =
14.61$ seconds, $SD = 7.28$).

There was a significant interaction of paradigm phase and baseline trial order $F(1,
14) = 6.91, p = .020$, $\eta^2 = .33$. Second, there was a significant interaction of trial pair,
baseline trial order, and test trial order $F(1, 14) = 7.18, p = .018$, $\eta^2 = .34$. These
interactions did not include primary variables of paradigm phase and face outcome and
thus were not further examined.
There were 3 significant interactions that included the primary variables of interest, paradigm phase and face outcome. First, we obtained a significant 3-way interaction of phase, outcome, and test trial order $F(1, 14) = 4.79, p = .046, \eta^2 = .26$. Looking duration to 1 versus 2 faces was compared. When infants saw 1 face presented at test, there were no significant differences in looking toward 1 face versus 2 faces at baseline or at test. When infants saw 2 faces presented first at test, there were no significant follow-up paired sample t-tests found between looking duration toward 1 versus 2 faces at either the baseline or test phase.

We also found a significant 4-way interaction of paradigm phase, face outcome, baseline trial order, and test trial order, $F(1, 14) = 5.28, p = .038, \eta^2 = .27$. Paired sample t-tests revealed that when infants saw 1 face presented first at baseline and at test, they looked significantly longer toward 1 face ($M = 19.02$ seconds, $SD = 10.07$) compared to 2 faces ($M = 11.83$ seconds, $SD = 5.83$) during the test trial $t(4) = 3.13, p = .035$, corrected $p = .07$ compared to the expected two faces outcome. This effect was only found for a condition that contained 5 infants and so these findings do not appear very robust and will not be further discussed. There were no other significant paired sample t-tests following this 4-way interaction. There was a second significant 4-way interaction between paradigm phase, face outcome, trial pair and baseline trial order $F(1, 14) = 4.68, p = .048, \eta^2 = .25$. There were no significant follow-up paired t-tests. Figure 4 reflects the non-statistically significant differences between infants’ looking to 1 versus 2 faces outcome across the baseline and test phases.
**Condition 2: Face Gender Male versus Female.** The same 5-way repeated measures ANOVA was conducted for the second group of younger and older infants tested in the puppet show task.

**Younger age group (12 months).** There were two significant main effects found from these analyses. There was a significant main effect of face outcome $F(1, 13) = 6.08$, $p = .028$, $\eta^2 = .32$, such that infants looked longer toward two faces ($M = 11.05$ seconds, $SD = 4.07$) compared to one face ($M = 9.46$, $SD = 3.81$). There was also a significant main effect of trial pair $F(1, 13) = 8.10$, $p = .014$, $\eta^2 = .38$, such that infants looked longer during the first trial pair ($M = 11.61$ seconds, $SD = 5.21$) compared to the second trial pair ($M = 8.90$ seconds, $SD = 2.85$).

A significant 2-way interaction of face outcome and baseline trial order was found $F(1, 13) = 11.03$, $p = .006$, $\eta^2 = .46$. A second 2-way interaction was found between paradigm phase and trial pair $F(1, 13) = 6.72$, $p = .022$, $\eta^2 = .34$. These interactions did not include the primary variables of paradigm phase and face outcome and therefore were not followed-up.

A significant 3-way interaction between paradigm phase, face outcome and baseline order was also found $F(1, 13) = 7.36$, $p = .018$, $\eta^2 = .36$. Follow-up paired sample t-tests revealed that when infants saw 2 faces first during the baseline phase, they looked significantly longer toward 2 faces ($M = 14.86$ seconds, $SD = 5.37$) compared to 1 face ($M = 10.27$ seconds, $SD = 4.93$) during baseline $t(7) = -3.78$, $p = .007$, corrected $p = .014$ as well as looked longer toward 2 faces ($M = 11.99$ seconds, $SD = 4.14$) versus 1 face ($M = 9.14$ seconds, $SD = 2.08$) at test $t(7) = -2.91$, $p = .023$, corrected $p = .046$. 
**Older age group (24 months).** There were no significant main effects found from the ANOVA conducted for the older infants’ looking time during the puppet show. However there was one significant 3-way interaction between, face outcome, baseline trial order, and test trial order $F(1, 12) = 7.62, p = .017, \eta^2 = .39$. This interaction was not further investigated because it did not include the critical variables of interest, paradigm phase and face outcome. There were no other significant interactions found for these data. Although there were no statistical differences found for the older age group, Figure 4 provides a visual depiction of looking time to 1 versus 2 faces during each trial pair during the baseline and test phase.

![Figure 3](image)

**Figure 3.** Experiment 1: Individuation of Human & Gender Faces Younger Age Group. The two graphs depict 12-month-old infants’ looking time (in seconds) to a 1 face outcome compared to a 2 faces outcome at the baseline and test phase, for each trial pair. The graph on the left reflects findings from Condition 1 and the graph on the right
reflects findings from Condition 2. Error bars are the standard error of the mean and * reflects $p < .05$.

Figure 4. Experiment 1: Individuation of Human & Gender Faces Older Age Group. The two graphs depict 24-month-old infants’ looking time (in seconds) to a 1 face outcome compared to a 2 faces outcome at the baseline and test phase, for each trial pair. The graph on the left reflects findings from Condition 1 and the graph on the right reflects findings from Condition 2. Error bars are the standard error of the mean there were no statistically significant differences between looking times.

**Secondary Analyses: Demographic data.** Prior research has provided evidence that infants’ kind-based individuation is supported by word-object knowledge (e.g., Rivera & Zawaydeh, 2007; Xu, 2002; Xu & Carey, 1996). In the present study parents reported on a series of person-related words that they believed their infant comprehended as well as expressed. To better understand the possible relation between
word knowledge and kind-individuation, we created two separate word knowledge scores, gendered word comprehension and gendered word expression. Each score reflects the sum of words either comprehended or expressed related to people with a gendered identity (e.g., mommy, daddy, boy, girl). To test the effect of gendered word comprehension on the difference on looking duration, we regressed infants’ looking duration toward 1 puppet at test on the number of gendered words the infant was reported to understand and the duration of looking toward two puppets at test. We found that there was a significant relationship between gendered word comprehension and looking duration during the test trial with 1 unexpected puppet face, while controlling for looking duration on the expected two puppet faces test trial; the more gendered words that an infant knew the longer their looking duration to 1 unexpected face ($b = .64, t(30) = 2.50, p = .018$). Furthermore we regressed infants’ looking duration toward 1 puppet at test on the number of gendered words the infant was reported to understand and the duration of looking toward 1 puppet during baseline. We found that there was a significant relationship between gendered word comprehension and looking duration during the unexpected 1 face test trial while controlling for looking time during 1 face at baseline; the more gendered words that an infant knew, the longer their looking duration to 1 unexpected puppet face ($b = 1.00, t(30) = 2.45, p = .032$). We found no significant relationship between gender word comprehension and infants’ looking time toward 2 faces while controlling for their looking time toward a 1 face outcome at baseline or at test ($b = .21, t(30) = .52, p = .607., b = -.555, t(30) = -1.31, p = .199$ respectively).

A similar relationship was found between infants’ looking duration toward the unexpected 1 puppet face at test and the number of gendered words infants expressed
controlling for their looking duration toward the expected two faces test trial. We found that the more gendered words an infant expressed, the longer their looking duration during an unexpected 1 face puppet test trial ($b = .55$, $t(30) = 2.25$, $p = .032$). Once again we regressed infants’ looking duration toward 1 puppet at test on the number of gendered words expressed and the duration of looking toward 1 puppet during baseline. We found that there was a significant relationship between gendered word expression and looking duration during the unexpected 1 face test trial while controlling for looking time during 1 face at baseline; the more gendered words that an infant expressed, the longer their looking duration to 1 unexpected puppet face ($b = 1.00$, $t(30) = 2.47$, $p = .019$). We did not find a significant relationship between gendered word expression and infants’ looking toward 2 faces, controlling for 1 face at either baseline or test ($b = .55$, $t(30) = 1.53$, $p = .137$, $b = -.317$, $t(30) = -.79$, $p = .434$ respectively).

Discussion

The goal of Experiment 1 was to replicate and extend previous findings that have examined infants’ individuation of human faces as a kind-category. The present study tested infants using the classic violation-of-expectation looking-time task using different types of human faces. In Condition 1, younger and older age groups saw a series of puppets with either human or non-human facial features. In Condition 2, younger and older infants saw puppets with female and male faces. Infants who individuated the two types of faces being presented should look longer toward the “unexpected” single face presentation compared to when two faces remained behind the screen. The behavior of younger infants in Condition 1 (i.e., human versus non-human) displayed evidence consistent with them individuating the face stimuli. Specifically, infants displayed longer
looking toward two faces versus one face during the first baseline trial pair, but not
during first test trial pair. Additionally, infants’ looking time toward one face increased
from the baseline phase to the test phase. This looking pattern supports an interpretation
of infants’ individuating the two face types. If infants had not individuated the human
from the non-human face it is likely that their bias for looking toward two faces would
have remained and that they would not have increased their looking toward one face from
baseline to test. These findings, though not as robust as past work by Xu and Carey
(1996) who found a complete switch in looking patterns at test, are consistent with
previous face individuation research (Bonatti et al., 2002, 2005). Interestingly, there was
no other evidence of individuation from the older infants in Condition 1 (i.e., human vs.
non-human) or from infants at either age in Condition 2 (i.e., male vs. female).

Based on the secondary analyses we did find a positive relation between gendered
word knowledge and looking time toward the one face outcome in Condition 2. This
finding came as a bit of a surprise because there was no evidence of individuation simply
based on the looking time data from infants in Condition 2. However, it is possible that
some of our infants, in particular those who comprehended more gendered words, did
individuate the male and female faces.

Overall the findings from Experiment 1 provide some evidence that 12-month-old
infants are individuating human faces as a distinct kind that is different from a non-
human identity. However, we did not find any evidence to suggest that older infants were
individuating human and non-human faces. Furthermore, there was no evidence that
infants individuated faces based on gender (‘maleness’ or ‘femaleness’), although it is
possible that some infants were able to do so based on their word knowledge. For older
infants in both conditions it is possible that the passive viewing looking-time task was not stimulating enough for them to fully engage and reveal a consistent pattern of response. It is also possible that the passive nature of the looking-time task did not allow for infants to gain enough information to fully individuate finer-grained features of human faces. Several studies provide converging evidence of object individuation through the use of a manual search task (e.g., Feigenson & Carey, 2003; Van de Walle et al., 2000; Xu & Baker, 2005). The act of searching for a hidden or undiscovered item is believed to provide a more direct measure of infants’ representation for the number of items or the types of items involved in a scene (e.g., Van de Walle et al., 2000; Xu & Baker, 2005). Additionally, a manual search task affords the direct comparison to two face conditions. Unlike with the puppet show where face condition was between subjects, with a manual search task we were able to use a within-subject block design (Feigenson & Carey, 2003, 2005). This allowed for more direct comparison of infants’ individuation of different types of faces. Because of our concerns related to the sensitivity of the puppet show task and the advantage of using a within-subjects block design to directly compare individuation of different face conditions we had infants also participate in an interactive manual search box task.
CHAPTER III

EXPERIMENT 2

This second experiment investigated infants’ individuation of human faces with the use of an interactive manual search task (Feigenson & Carey, 2003, 2005; Taborda-osorio & Cheries, 2018; Van de Walle et al., 2000; Xu & Baker, 2005). Infants who had participated in Experiment 1, Condition 1 also participated in Experiment 2, Condition 1. This first condition tested infants’ individuation of human versus non-human faces as well as male and female faces. These were the same face groups tested in Experiment 1, but with the use of an interactive reaching task we were able to test this face group comparison within subjects. Infants who participated in Experiment 1, Condition 2 also participated in Experiment 2, Condition 2. This second condition tested for individuation of human versus non-human faces, but with the use of African-American faces (instead of Caucasian). This was done to assess whether infants (who were primarily Caucasian) had a generalized representation of humanness that was not race specific to Caucasian faces. Additionally, infants in Condition 2 were tested on the individuation of faces that varied by race.

**Methods**

**Condition 1: Human vs. non-human faces; Male vs. Female Faces.**

**Participants.**

*Younger age group (12 months).* A total of 24 younger infants participated in Condition 1. Of these infants, 20 were included in the final sample. The remaining 4 were not included due to fussiness and not completing the minimum number of 6 out of 8 trials (2), experimenter error (1), and computer error (1). The final sample of 11- to 12-month-old infants had an average age of 370.10 days ($SD = 50.10$) with 11 males and 9 females.
Based on demographic data, 17 infants were reported to be racially White or Caucasian and 3 were Multiracial. There were 17 infants who were ethnically not Hispanic or Latino, 2 who were Hispanic or Latino, and 1 whose ethnicity was not reported. Infants came from families with an average education level of a four-year degree. Education levels ranged from completing some high school to completion of a professional degree. The average household income was 55 – 65, thousand per year and ranged from less than 15, thousand per year to 75, thousand per year. On average infants were reported to know an average of 5.25 ($SD = 1.97$) out of 13 possible gendered words.

**Older age group (24 months).** A total of 20 older infants participated in Condition 1. Of these infants, 16 were included in the final sample. The remaining infants were excluded due to becoming fussy and not completing the minimum of 6 out of 8 trials (2), experimenter error (1), and computer error (1). The average age of the final sample was 717.31 days ($SD = 81.28$) with 8 males and 8 females.

Based on reported demographic data, 13 infants were reported to be racially White or Caucasian, 1 was African-American or Black, 1 was Asian, and 1 was Multiracial. There were 14 infants ethnically identified as not Hispanic or Latino, and 2 who were. Infants came from families with some graduate-level education, but ranged from completing some high school to completion of a professional degree. The average household income was 65 to 75 thousand per year. On average infants were reported to know an average of 9.43 out of a possible 13 gendered words.

**Stimuli & Apparatus.** The remaining 6 female and 6 male face photographs as well as 3 remaining non-human shape faces were used in the search task (see Figure 1). Faces measured 3 inches (tall) by 2 inches (wide) and were affixed to a block of stiff
black foam core that were cut to the same shape as the face. The black foam core block was 1 inch thick, which allowed infants to easily grasp the faces from within the box. Faces were affixed to both sides of the foam core block so that infants had plenty of access to the faces once they removed them from the box. The box was made of black foam core and was 10 (wide) x 5 (tall) x 12.6 (deep) inches. The front of the box had an opening that was 4 inches tall and 3 inches wide. The top and bottom half of this opening was covered by two pieces of red spandex sheet so that infants could not see into the box without having to reach in or separate the fabric. These box dimensions are consistent with previous object individuation manual search box tasks (Taborda-osorio & Cheries, 2018; Van de Walle et al., 2000). Two to three additional toys (i.e., a squeaky frog, squeaky duck, and koosh ball) were used during baseline trials. These objects were similar in dimension to the faces used during the manual search task.

**Procedure.** The box task took place approximately 5 minutes after the puppet show. Once again parents were instructed to remain neutral and to not respond in any way to the events that occurred during the box task. Infants sat on their parent’s lap in front of a square table that was 33 inches wide and 45 inches tall. The individuation box task consisted of a baseline phase and a test phase (see Figure 5). Infants completed two baseline trials. These trials were used to familiarize infants to the action of removing items from within the box. The experimenter first introduced the box by showing the infant they could reach their hand in and out of the box. During this, the experimenter said “Look, Name of infant, look at this box. You can place your hand in and take it back out.” The experimenter encouraged the infant to reach into the box and even had the parent do so to show their infant that it was ok to reach inside the box. Once the infant
independently reached and retrieved a toy two times in a row the experimenter continued to the test phase.

During the test phase, the experimenter demonstrated the removal and replacement of faces from within the box. Infants completed 8 test trials, divided into two blocks of 4 trials. One block of trials was used to evaluate infants’ individuation of the kind ‘human’ relative to non-human shape faces. The other block of trials was used to evaluate infants’ individuation of male versus female human faces. Within each block infants completed two pairs of two types of test trials. The test trials either involved a single face being removed and replaced or two faces being sequentially removed and replaced inside the box. Each test trial contained a different set of face identities, for a total of 6 different faces seen throughout the manual search task.

During the single face test trials, the experimenter pulled out one face object from within the box, placed the face on the far right corner of the front of the box, said “look,” and pointed at the face for approximately 5 seconds. The experimenter then picked up the face wiggled it in front of the infant and placed it back down on the left-front corner of the box once again saying “look,” while pointing. After 5 seconds, the experimenter replaced the face back inside the box being sure the infant watched as the face went in the front. The box was then pushed towards the infant so they could retrieve the hidden face. If infants did not independently retrieve this first face, the experimenter would do so showing the baby that it was possible to find something within the box. Reaching duration data from these “failed” trails were not included in the final analyses. Infants had 10 seconds to observe or play with the face once they removed it from within the box. The experimenter then took the face away from the infant keeping the box within
reach. Infants reaching behaviors were observed during a 10 second period after the experimenter took the face away. During this 10 second pause, the experimenter did not interact with the infant and kept their eyes down toward the table. This 10 second timing to record infant reaching behavior has been used in previous manual search box tasks (e.g., Taborda-osorio & Cheries, 2018; Van de Walle et al., 2000).

For the two faces test trials, the same actions were completed as in the single face trials, however a second face was removed from the box once the first face was replaced. Infants never saw two faces come out of the box at the same time. Thus, infants first saw one face removed, placed on top of the box and the put back in. Then the experimenter removed their hand and showed the infant it was empty. The experimenter then put their hand back in the box and removed a second face. This face was once again placed on top of the box in each corner and then replaced back inside of the box. The box was then pushed forward toward the infant, as this happened the experimenter secretly removed one of the two faces out the back of the box so that the infant could only find one face. After the first face was found and infants had 10 seconds to examine the face, experimenters took the face away and allowed for a 10 second measured reaching pause. Next, the experimenter reached inside the box and removed the second face, showing the infant that there was something leftover in the box. Once again infants had 10 seconds to explore this second face, the face was then removed and a second 10 second measured reaching pause was given. The logic of having two types of test trials was to compare infants’ reaching behaviors when the box should have been completely empty (i.e., during a single face trial) to when the box was “unexpectedly” empty. If infants individuated the two different faces then it was expected that they would display greater
reaching when they could not find the second face (i.e., unexpected-empty outcome) compared to when they only saw and found a single face (i.e., expected-empty outcome).

Three components of the manual search box task were counterbalanced across 8 different conditions. First, the block order was counterbalanced such that half of the infants completed the human versus non-human face block first and the other half completed the gender, male versus female face block first. Second, the trials within each of the two face blocks that infants completed were assigned one of four types of test trial orders: 1, 2, 2, 1; 2, 1, 1, 2; 1, 2, 1, 2; or 2, 1, 2, 1. Trial orders were counterbalanced across the 8 counterbalance conditions. Infants never saw the same trial order across the two face blocks that they participated in. Third, the order of face identity presentation was randomly set across the 8 counterbalance conditions.

**Coding.** Infants’ reaching behaviors were recorded on a video camera positioned above and to the side of the infant’s position. After the task was completed experimenters coded the duration of each individual reach inside of the box with a stopwatch. Experimenters started timing once the infants’ third knuckle passed through the red curtain and into the box. Experimenters stopped timing once the fingers were fully removed from the box. Infant behaviors such as grabbing, pulling or swiping at the front of the red curtain were not counted as reaches and thus not included in the duration data.
Figure 5. Experiment 2 Manual Search Task. Experiment 2 included an interactive reaching task. Infants completed 8 trials, 4 trials per face block. There were three types of face outcomes. The image on the left depicts the expected-empty trial. Such that infants saw one face go in and only found one face within the box. The image on the right depicts the unexpected-empty and expected-empty final trials. Unexpected-empty trials included infants seeing two faces go inside of the box, but only find one face. Expected-empty final trials followed unexpected-empty trials. Infants were presented with the second face leaving the box completely empty.

**Condition 2: Human vs. Non-human; Caucasian vs. African-American.**

**Participants.**

**Younger age group (12 months).** A total of 18 younger infants participated in Condition 2. Of these infants, 17 were included in the final sample. One infant was not included due to becoming fussy and not completing the minimum number of 6 out of 8
trials. The average age of the 11- to 12-month-old infants was 370.94 days ($SD = 10.08$) with 9 males and 8 females included in the final analyses.

Based on reported demographic data, 12 infants were reported to be racially White or Caucasian, 2 were Multiracial, 1 was Asian, 1 was African-American or Black, and 1 whose race was not reported. There were 14 infants ethnically identified as not Hispanic or Latino and 3 who were Hispanic or Latino. Infants came from families with an average education of completing some graduate school, ranging from high school to professional degree completion. The average household income was 65 to 75 thousand and ranged from less than 15 thousand to over 75 thousand. Infants were reported to spend an average of 82% ($SD = 27.21$) of their weekly time with individuals of the same race as their caregivers and an average of 17% ($SD = 24.05$) of their weekly time with individuals of a different race than their primary caregivers.

**Older age group (24 months).** A total of 22 older infants participated in Condition 2. Of these infants, 18 were included in the final sample. The remaining 4 infants were excluded due to becoming fussy and not completing the minimum of 6 out of 8 trials. The average age for the final sample of 19- to 27-month-old infants was 712.50 days ($SD = 82.71$) with 9 males and 9 females.

Based on reported demographic data, 13 infants were reported to be racially White or Caucasian, 2 were Asian, 1 was African-American or Black, and 2 did not disclose race identity. There were 12 infants who were not Hispanic or Latino, 2 who were Hispanic or Latino, and 4 whose ethnicity was not reported. Infants came from families with an average education of some graduate school, but ranged from high school to professional degree. The average household income was 65 – 75 thousand per year and
ranged from less than 15 thousand to over 75 thousand per year. Infants were reported to spend an average of 78% ($SD = 24.59$) of their weekly time with individuals of the same race as their caregivers and 11% ($SD = 18.19$) of their weekly time with individuals of a different race than their primary caregivers.

**Stimuli & Apparatus.** The same 6 male and 6 female Caucasian face identities used in Condition 1 were also used in Condition 2. Additionally, 6 new male and 6 new female African-American face identities were chosen from the *Chicago Face Database* (see Figure 6). The same process used to choose the Caucasian faces in Condition 1 was used to pick the African-American faces in Condition 2. The 3 non-human shape faces from Condition 1 were also included, however the skin complexion was based off of African-American faces instead of Caucasian faces (see Figure 6). All other testing materials were identical to Condition 1.

**Procedure.** The testing procedures were identical to those used in Condition 1. The only difference was the inclusion of African-American human faces and African-American based non-human faces. All counterbalance considerations were also identical to those of the 8 conditions used in Condition 1.
Figure 6. African-American Face Stimuli for Manual Search Task. Six male and female human African-American faces were used in Experiment 2, Condition 2. There were three non-human shape faces that were also used in Experiment 2, Condition 2.

**Analyses**

For each condition, infants’ reaching duration inside of the box was used as the dependent measure. There were two test trial types: a single face presentation, and a two face presentation. During the one face test trials, reaching duration was coded when the experimenter gave the infant 10 seconds to explore the box after the first (and only) found face was taken away. This reaching duration was called the *expected-empty outcome*. For the two faces test trials, there were two separate reaching duration periods coded. The first was during the 10 second pause after the experimenter took away the
first (of two) found face, this was called the *unexpected-empty outcome*. The second coded reaching duration period was the 10 seconds following the researcher’s presentation and removal of the missing second face, this trial type was known as the *expected-empty final outcome*. The primary comparison of interest was infants’ reaching duration for expected-empty versus unexpected-empty trials. Greater reaching during unexpected-empty trials has been interpreted as evidence of individuation of the two stimuli presented because infants are “expecting” to find the second hidden face (Feigenson & Carey, 2003; Taborda-osorio & Cherrie, 2018; Van de Walle et al., 2000; Xu & Baker, 2005).

For Conditions 1 and 2 age separated 4-way mixed measures 2 x 3 x 2 x 2 ANOVAs were conducted with block type (human, non-human, face-specific), face object outcome (expected-empty, unexpected-empty, and expected-empty final), and pair (first pair, second pair) as within-subjects factors. Block order (human/non-human block first, face-specific block first) was the between-subjects variable. Next targeted 3-way 2 x 3 x 2 mixed measures ANOVA were conducted for each face block type for each infant age group. Within-subjects variables included face object outcome (expected-empty, unexpected-empty, expected-empty final), pair (first pair, second pair). Between-subjects variable were block order (human/non-human block first, specific-face block first).

**Secondary analyses.** Demographic data was used to analyze infants’ individuation of face gender and race. As with Experiment 1, we used a linear regression to assess whether there was a connection between gendered word knowledge and performance on the man versus female manual search box task (Condition 1). The same variable used in Experiment 1’s secondary analyses was used for Experiment 2,
Condition 1 analyses. Additionally, parents reported on the percentage of time infants spent with members of their own-race and other-race groups. This information was collected based on work which hypothesize exposure to gender and racially homogenous or heterogeneous groups of people influence infants’ face processing capabilities (for reviews see Lee et al. 2011; Pascalis et al. 2011; Scherf and Scott 2012). Linear regressions were conducted to assess whether the time infants spent with individuals of familiar and unfamiliar races was related to their performance on the individuation box task based on race face groups.

**Results**

**Condition 1: Humanness & Gender.**

*Younger age group (12 months).* A 4-way 2 x 3 x 2 x 2 mixed measures ANOVA was conducted with block type (humanness, gender), face outcome (expected-empty, unexpected-empty, and expected-empty final) and trial pair (first, second) as within-subjects factors. Block order (humanness first, gender first) was the between-subjects factor. The 4-way ANOVA revealed a significant main effect of trial pair $F(1, 18) = 9.18$, $p = .007$, $\eta^2 = .34$, due to greater reaching during the first trial pair ($M = 3.24$ seconds, $SD = 1.20$) compared to the second pair ($M = 2.46$ seconds, $SD = 1.30$). There was also a significant main effect of outcome $F(2, 17) = 10.62$, $p = .001$, $\eta^2 = .56$, due to infants displaying longer reaching durations during the unexpected-empty outcome ($M = 3.85$ seconds, $SD = 1.79$) compared to the expected-empty ($M = 2.68$ seconds, $SD = 1.31$) and the expected-empty final ($M = 2.03$ seconds, $SD = 1.06$) outcomes.

There was a significant 2-way interaction of block type by block order $F(1, 18) = 22.40$, $p < .001$, $\eta^2 = .55$. However because this interaction did not contain the primary variables of interest, block type and outcome, this interaction was not further examined.
From this omnibus ANOVA it is clear that infants were individuating faces, however it was not clear if they were doing this differently for each type of face comparison.

To examine whether infants were behaving differently during the ‘humanness’ and ‘gender’ blocks, two separate 3-way mixed measures $2 \times 3 \times 2$ ANOVAs were conducted, one for each block type (i.e., human versus non-human and male versus female). Within-subject variables included trial pair (first, second), and outcome (expected-empty, unexpected-empty, and expected-empty final). The between-subjects variable was block order (humanness first, gender first).

**Human versus non-human block.** A significant main effect of outcome was found $F(2, 17) = 6.53, p = .008, \eta^2 = .43$ such that infants reached significantly longer during the unexpected-empty box outcome ($M = 4.44$ seconds, $SD = 2.29$) compared to the expected-empty ($M = 2.88$ seconds, $SD = 1.82$) and expected-empty final ($M = 2.45$ seconds, $SD = 1.50$) outcomes (see Figure 7). No other significant effects or interactions were found.

**Male versus female block.** A significant main effect of trial pair was found $F(1, 18) = 8.13, p = .011, \eta^2 = .31$, such that the reaching duration was greater during the first trial pair ($M = 3.20$ seconds, $SD = 1.56$) compared to the second trial pair ($M = 2.06$ seconds, $SD = 1.55$). There was also a significant main effect of outcome $F(2, 17) = 5.76, p = .012, \eta^2 = .40$, with infants displaying longer reaching during the unexpected-empty ($M = 3.44$ seconds, $SD = 2.22$) compared to expected-empty final ($M = 1.71$ seconds, $SD = 1.14$), but not expected-empty ($M = 2.75$ seconds, $SD = 1.67$). No other significant effects or interactions were found.
Older age group (24 months). A 4-way ANOVA revealed a significant main effect of trial pair $F(1, 14) = 5.94, p = .029$, $\eta^2 = .30$, due to infants reaching longer during the first pair ($M = 2.53$ seconds, $SD = 1.54$) compared to the second trial pair ($M = 1.88$ seconds, $SD = 1.22$). There was also a significant main effect of face outcome $F(2, 13) = 12.70, p = .001$, $\eta^2 = .66$, with infants reaching longer during the unexpected-empty trials ($M = 3.25$ seconds, $SD = 1.47$) compared to the expected-empty ($M = 1.45$ seconds, $SD = 1.23$) and excepted-empty final ($M = 1.92$ seconds, $SD = 1.78$) trials (see Figure 7).

Lastly, there was a significant 2-way interaction of trial pair and block order $F(1, 14) = 13.74, p = .002$, $\eta^2 = .50$, this interaction was not further investigated because it did not include the primary variables of interest, block type and outcome.

Human versus non-human ANOVA. There was a significant main effect of face outcome $F(2, 13) = 10.04, p = .002$, $\eta^2 = .61$. From the compared means, older infants were reaching significantly longer during the unexpected-empty trials ($M = 2.92$ seconds, $SD = 1.98$) relative to the expected-empty trials ($M = 1.67$ seconds, $SD = 1.96$), but not significantly different compared to the expected-empty final trials ($M = 2.43$ seconds, $SD = 2.42$). Additionally, infants reached longer during the expected-empty final trials ($M = 2.43$ seconds, $SD = 2.42$) compared to expected-empty trials ($1.67$ seconds, $SD = 1.96$).

Male versus female ANOVA. There was a significant main effect of face outcome $F(2, 13) = 9.66, p = .003$, $\eta^2 = .60$. Older infants reached significantly longer during the unexpected-empty trials ($M = 3.57$ seconds, $SD = 2.37$) compared to both the expected-empty ($M = 1.24$ seconds, $SD = 1.96$) and expected-empty final ($M = 1.41$ seconds, $SD = 1.84$) (see Figure 7).
Figure 7. Experiment 2 Condition 1: Individuation of Faces Human & Gender.

Experiment 2, Condition 1 infants’ individuation of human and gender faces. Infants’ reaching duration (in seconds) during expected-empty, unexpected-empty, and expected-empty final are portrayed for the younger age group (left) and older age group (right) of infants. Both age groups display individuation of human versus non-human faces. Only 24-month-old infants displayed individuation of male versus female faces. Error bars represent the standard error of the mean, * represents $p < .05$.

**Secondary data analyses: Demographic data.** To test the effect of gendered word comprehension as well as expression on the difference in reaching duration, we regressed infants’ reaching time during the unexpected-empty trials on the number of gendered words the infant was reported to understand (and separately to express) and the duration of reaching for the expected-empty trials. We found no significant relationships between gendered word comprehension and reaching duration for the unexpected-empty trials.
while controlling for reaching during expected-empty trials as well as controlling for expected-empty final trials. Furthermore, we found no significant relationships between gendered word expression and infants’ reaching duration during unexpected-empty trials while controlling for expected-empty and expected-empty final trials. Lastly, we found no significant relationships between time spent with female or male individuals and infants’ reaching duration during unexpected-empty trials while controlling for expected-empty and expected-empty final trials.

**Condition 2: Humanness & Race.** Infants from Experiment 1 Condition 2 also participated in Experiment 2 Condition 2. Here, we assessed infants’ individuation on the basis of humanness with the use of African-American faces as well as individuation based on race facial differences.

**Younger age group (12 months).** A 4-way 2 x 3 x 2 x 2 mixed measures ANOVA was conducted with block type (humanness, race), face outcome (expected-empty, unexpected-empty, and expected-empty final) and trial pair (first, second) as within-subjects factors. Block order (humanness first, race first) was the between-subjects factor. This analysis revealed a significant 3-way interaction of block type, face object outcome, and trial pair $F(2, 14) = 3.97, p = .043, \eta^2 = .36$. Follow-up paired comparison t-tests were conducted between the 3 types of face object outcomes for each trial pair. There were two significant t-test outcomes (see Figure 8). The first was that infants reached significantly longer during the unexpected-empty compared to expected empty for the first human versus non-human trial $t(16) = -2.98, p = .009$, corrected $p = .054$. Second, infants’ reaching duration toward the unexpected-empty outcome was significantly longer compared to the expected-empty final trial $t(16) = 4.43, p < .001$, corrected $p < .001$. 
There were no other significant comparisons for the human versus non-human tests nor for any of the race comparisons. There were no other significant main effects or interactions found for these analyses.

We further examined infants’ reaching duration with two separate 3-way 2 x 3 x 2 mixed measures ANOVAs, one for each face block type. Within-subject factors were, trial pair (first, second), face object outcome (expected-empty, unexpected-empty, and expected-empty final) and the between-subjects factor was block order (humanness first, race first).

*Human versus non-human block (African-American faces).* There was a significant main effect of face object outcome $F(2, 14) = 5.93, p = .014, \eta^2 = .46$, with infants reaching significantly longer during the unexpected-empty trial ($M = 2.58$ seconds, $SD = 1.57$) compared to the expected-empty final trial ($M = 1.44$ seconds, $SD = 1.13$). Infants also reached longer during unexpected-empty trials relative to expected-empty, but this difference was not statistically significant. There was also a significant 2-way interaction of trial pair and face object outcome which qualified the main effect of outcome $F(2, 14) = 7.95, p = .005, \eta^2 = .53$. This 2-way interaction was followed up with paired sample t-tests between the three types of face outcomes at the two different trial pair levels. Paired sample t-tests revealed that infants’ reaching the first trial pairs was significantly longer for unexpected-empty ($M = 3.09$ seconds, $SD = 2.52$) compared to expected-empty ($M = 1.08$ seconds, $SD = 1.29$) $t(16) = -2.98, p = .009$, corrected $p = .054$ and expected-empty final ($M = 1.35$ seconds, $SD = 1.68$) $t(16) = 4.43, p < .001$, corrected $p < .001$. There were no other significant paired comparisons.
Race: Caucasian vs. African-American block. There were no significant main effects or interactions found for the 3-way mixed measures ANOVA assess infants’ reaching behavior after seeing Caucasian and African-American faces from within a box.

Figure 8. Experiment 2 Condition 2: 12-Month-Old Infants’ Individuation of Faces Human & Race. Graphs reflects 12-month-old infants’ reaching duration (in seconds) during Experiment 2, Condition 2 for the human versus non-human face block (left) and the Caucasian vs. African-American race block (right). Infants displayed greater reaching to the unexpected-empty trial relative to the expected-empty trial, but only in the first trial pair for human versus non-human block. Error bars represent the standard error of the mean, * represents $p < .05$.

Older age group (24 months). The same 4-way $2 \times 3 \times 2 \times 2$ mixed measures ANOVA used for the younger infants was used to analyze the reaching behaviors of the 24-month-old infants. Again, this ANOVA included block type (humanness, race), face outcome (expected-empty, unexpected-empty, and expected-empty final) and trial pair
(first, second) as within-subjects factors. Block order (humanness first, race first) was the between-subjects factor. There was a significant main effect of block type $F(1, 16) = 6.98, p = .018$ $\eta^2 = .30$ with infants reaching overall longer during the race face block ($M = 3.74$ seconds, $SD = 2.73$) compared to the humanness face block ($M = 2.18$ seconds, $SD = 1.38$). There was a marginal main effect of face object outcome $F(2, 15) = 3.66, p = .051$, $\eta^2 = .33$ with infants reaching significantly longer during the unexpected-empty face outcome ($M = 4.28$ seconds, $SD = 3.41$) compared to the expected-final outcome ($M = 2.16$ seconds, $SD = 1.72$) and marginally longer than expected-empty outcome ($M = 2.43$ seconds, $SD = 1.44$). There was also a marginally significant interaction of outcome and pair $F(2, 15) = 3.60, p = .053$, $\eta^2 = .32$. Although marginal, this interaction was followed up with paired sample t-tests comparing reaching duration between the three levels of face outcome for the first and second trial pair. Infants’ reaching duration during the first and second unexpected-empty outcome ($M_{first} = 5.38$ seconds, $SD_{first} = 3.82$; $M_{second} = 4.62$ seconds, $SD_{second} = 3.72$) was significantly longer compared to the first and second expected-empty outcome trials ($M_{first} = 2.75$, $SD_{first} = 1.80$; $M_{second} = 2.10$ seconds, $SD_{second} = 1.80$) $t(17) = -2.55, p = .021$, corrected $p = .126$, $t(17) = -2.91, p = .010$, corrected $p = .06$ respectively. Additionally, infants reached longer during the unexpected-empty compared ($M_{first} = 5.38$ seconds, $SD_{first} = 3.82$) to the expected-empty final ($M_{first} = 1.70$ seconds, $SD_{first} = 1.80$) in the first trial pair $t(17) = 4.31, p < .001$, corrected $p < .001$.

Two 3-way 2 x 3 x 2 mixed measures ANOVAs, one for each face block type, were conducted to further investigate infants’ reaching behavior. Within-subject factors were, trial pair (first, second), face object outcome (expected-empty, unexpected-empty,
and expected-empty final) and the between-subjects factor was block order (humanness first, race first).

*Human versus non-human block (African-American faces).* There was a significant main effect of outcome found for the 3-way mixed measures ANOVA $F(2, 15) = 9.88, p = .002, \eta^2 = .57$ (see Figure 9). This main effect revealed that infants reached significantly longer during the unexpected-empty ($M = 3.38$ seconds, $SD = 2.30$) trials compared to the expected-empty ($M = 2.15$ seconds, $SD = 1.64$) and expected-empty final ($M = 1.00$ seconds, $SD = 1.19$) trials. Additionally, infants reached longer during the expected-empty ($M = 2.15$ seconds, $SD = 1.64$) compared to the expected-empty final ($M = 1.00$ seconds, $SD = 1.19$) trials. There were no other significant main effects or interactions found for these analyses.

*Race Caucasian & African-American block.* There was a marginally significant 2-way interaction of trial pair and face object outcome $F(2, 15) = 3.48, p = .057, \eta^2 = .32$. Although only marginal, we followed up this interaction to clearly understand infants’ general pattern of reaching for the race comparison block. Paired samples t-tests were conducted for the three levels of face outcome for the first and second trial pair. Tests revealed only one significant outcome, that infants reached longer during the unexpected-empty ($M = 6.63$ seconds, $SD = 6.66$) compared to expected-empty final ($M = 2.34$ seconds, $SD = 2.57$) during the first trial pair $t(17) = 3.09, p = .007$, corrected $p = .042$. Additionally, there was a marginally significant comparison with longer reaching during unexpected-empty ($M = 6.63$ seconds, $SD = 6.66$) compared expected-empty ($M = 3.16$ seconds, $SD = 2.60$) in the first trial pair $t(17) = -1.99, p = .063$. 
Our sample was primarily racially identified as White or Caucasian, because of this we examined whether Caucasian infants performed differently than the Infants of Color in our sample. Reaching behavior for the 13 infants who were racially and/or ethnically identified as Caucasian, non-Hispanic, was separately analyzed in a 2 x 3 x 2 mixed measures ANOVA. Within-subjects variables were trial pair (First, Second) and face outcome (Expected-empty, Unexpected-empty, Expected-empty final). Block order (Humanness first, Race first) was the between-subjects variable. There were no statistically significant or marginal main effects or interactions found for the Caucasian only infants. Although we only had 5 infants who were racially identified as non-White and/or ethnically identified as Hispanic or Latino we did compare the means of these infants’ reaching duration using paired sample t-tests. Infants of Color reached marginally longer during the unexpected-empty trails ($M = 8.71$ seconds, $SD = 5.88$) relative to the expected-empty trials ($M = 2.80$ seconds, $SD = 2.43$) $t(4) = -2.54$, $p = .064$. Infants did not show statistically significant or marginal differences in reaching duration between unexpected-empty and expected-empty final trials or expected-empty compared to expected-empty final trials.
Figure 9. Experiment 2 Condition 2: 24-Month-Old Infants’ Individuation of Faces Human & Race. Graph depicts 24-month-old infants’ reaching duration (in seconds) during Experiment 2, Condition 2. Infants displayed greater reaching during the unexpected-empty trial relative to expected-empty and expected-empty final trials for the human vs. non-human face block. Although trending, the differences in the race block were not statistically significant. Error bars represent the standard error of the mean, * represents $p < .05$.

**Secondary analyses: Demographic data.** The perceptual biases for an infants’ own (or most familiar) race group are believed to be driven by extensive time spent with individuals of the same race group (Lee et al., 2011; Rennels & Davis, 2008; Sugden et al., 2014). Originally, we planned to test if infants’ time spent with individuals of either
the same or different race as their primary caregivers was related to their performance during the race face block of the manual search task. However, this was not possible to use these variables due to the extreme skewness of the data for time spent with same race and time spent with different race. We then created a difference score of time spent with same race subtracted from time spent different race as a way to adjust for skewness. To test the effect of the difference in time spent with same and different race individuals on the length of reaching, we regressed infants’ reaching duration toward unexpected-empty trials on this difference score while controlling for infants’ reaching duration during expected-empty as well as expected-empty final trials. We found no significant relationships between reaching duration for unexpected-empty and the difference score between time spent with same and different race individuals.

The parent-report questionnaire did not include race-specific descriptive words (e.g., African-American, Caucasian, White, and Black). These types of race related words were not reported as words infants at either age would know based on the research reported by Fenson and colleagues (1994), which is how we created our vocabulary list. Future work is needed to first better understand infants’ knowledge of words used to describe race and ethnicity groups and second to examine how this may influence the development kind representations.

**Across Conditions 1 & 2.** The final set of analyses conducted was to examine whether infants’ reaching behaviors varied across Conditions 1 and 2. Separate analyses were used to compare younger and older infants’ reaching for the two human versus non-human conditions as well as comparing race versus gender conditions.

*Human vs. Non-human.*
Younger age group (12 months). A 2 x 3 x 2 mixed measures ANOVA was conducted to assess differences in infants’ reaching behavior across the two types of human versus non-human face conditions. Within-subjects factors were trial pair (first, second) and face outcome (expected-empty, unexpected-empty, and expected-empty final). The between-subjects variable was block type (Condition 1 Caucasian, Condition 2 African-American). There was a significant main effect of outcome $F(2, 34) = 9.25, p = .001, \eta^2 = .35$. Infants reach significantly longer during the unexpected-empty trial ($M = 3.48$ seconds, $SD = 2.59$) compared to the expected-empty ($M = 2.21$ seconds, $SD = 1.82$) and expected-empty final trials ($M = 1.93$ seconds, $SD = 1.51$).

There was also a significant 3-way interaction of trial pair, face outcome, and block type $F(2, 34) = 3.59, p = .038, \eta^2 = .17$ (see Figure 10). This interaction was followed up with paired sample t-tests for each block type between the three levels of face outcome for each trial pair. Infants in Condition 1 who saw Caucasian human faces versus non-human faces reached significantly longer during the second trial pair for the unexpected-empty ($M = 4.59$ seconds, $SD = 4.09$) versus expected-empty ($M = 2.55$ seconds, $SD = 2.36$) and expected-empty final trials ($M = 1.74$ seconds, $SD = 1.75$) $t(19) = -2.18, p = .042$, corrected $p = .252$; $t(19) = 3.51, p = .002$, corrected $p = .012$ respectively. Additionally, they reached marginally longer during the unexpected-empty ($M = 4.30$ seconds, $SD = 3.19$) compared to expected-empty ($M = 3.20$ seconds, $SD = 2.34$) trials during the first trial pair $t(19) = -2.09, p = .050$, corrected $p = .30$. Infants in Condition 2 who saw African-American human versus non-human faces reached significantly longer during the unexpected-empty ($M = 3.09$ seconds, $SD = 2.52$) compared to expected-empty ($M = 1.08$ seconds, $SD = 1.29$) and expected-empty final (M
70 = 1.35 seconds, \(SD = 1.68\) for the first trial pairs \(t(16) = -2.98, p = .009\), corrected \(p = .054\); \(t(16) = 4.43, p < .001\), corrected \(p < .001\) respectively. There were no other significant follow-up paired sample comparisons.

Figure 10. Experiment 2 Human vs. Non-human Faces Across Conditions 1 & 2 Younger Age Group (12 Months). Experiment 2 comparison of younger age group reaching duration (in seconds) across Conditions 1 (left) and 2 (right). Infants in both conditions reach significantly longer during the first trial pair for the unexpected-empty compared to expected-empty face outcomes. Younger infants also displayed greater reaching during the second trial pair to unexpected-empty relative to expected-empty and expected-empty final trials. Error bars represent the standard error of the mean, * represents \(p < .05\).

*Older age group (24 months).* The same 3-way 2 x 3 x 2 mixed measures ANOVA was conducted for the older age group. There was a significant main effect of trial pair \(F(1, 32) = 5.14, p = .030\), \(\eta^2 = .14\) with longer reaching during the first (\(M =\)
2.74 seconds, \(SD = 2.34\) compared to second trial pair \((M = 1.94 \text{ seconds, } SD = 1.91)\). There was significant main effect of face outcome \(F(2, 31) = 10.05, p < .001, \eta^2 = .39\) with greater reaching during the unexpected-empty \((M = 3.24 \text{ seconds, } SD = 2.36)\) compared to expected-empty \((M = 1.98 \text{ seconds, } SD = 2.02)\) and expected-empty final trials \((M = 1.80 \text{ seconds, } SD = 1.99)\).

There was a significant 2-way interaction of face outcome and block type \(F(2, 31) = 6.42, p = .005, \eta^2 = .29\) (see Figure 11). This interaction was followed up with paired sample t-tests for each block type between the three levels of face outcomes. Infants in Condition 1 (Caucasian faces) reached significantly longer during unexpected-empty \((M = 3.11 \text{ seconds, } SD = 2.48)\) compared to expected-empty \((M = 1.85 \text{ seconds, } SD = 2.41)\) trials \(t(15) = -3.09, p = .007, \text{ corrected } p = .021\). Infants also reached significantly longer during expected-empty final \((M = 2.58 \text{ seconds, } SD = 2.64)\) compared to expected-empty \((M = 1.85 \text{ seconds, } SD = 2.41)\) trials \(t(15) = -2.97, p = .009, \text{ corrected } p = .027\). Infants in Condition 2 (African-American) reached significantly longer during the unexpected-empty \((M = 3.37 \text{ seconds, } SD = 2.23)\) compared to expected-empty \((M = 2.11 \text{ seconds, } SD = 1.62)\) and expected-empty final trials \((M = 1.66 \text{ seconds, } SD = 1.38)\) \(t(17) = -3.13, p = .006, \text{ corrected } p = .018; t(17) = 3.76, p = .002, \text{ corrected } p = .012\) respectively. There were no other significant follow-up paired comparisons found.
Figure 11. Experiment 2 Human vs. Non-human Faces Across Conditions 1 & 2 Older Age Group (24 Months). Experiment 2 comparison of older age group reaching duration (in seconds) across Conditions 1 (left) and 2 (right). Infants in both conditions reach significantly longer during the unexpected-empty compared to expected-empty face outcomes. Infants in Condition 2 also displayed greater reaching to the unexpected-empty relative to expected-empty final trials. Error bars represent the standard error of the mean, * represents $p < .05$.

**Gender vs. Race.**

**Younger age group (12 months).** A 3-way $2 \times 3 \times 2$ mixed measures ANOVA was conducted to assess differences in infants’ reaching behavior across the gender and race blocks. Within-subjects variables included trial pair (first, second), face outcome (expected-empty, unexpected-empty, and expected-empty final) and between-subjects factor of block type (Condition 1 Gender, Condition 2 Race). There was a significant main effect of trial pair, $F(1, 35) = 6.69, p = .014$, $\eta^2 = .16$, with infants reaching longer
during the first trial pair ($M = 2.79$ seconds, $SD = 1.73$) compared to the second trial pair ($M = 1.88$ seconds, $SD = 1.67$). There was a marginal 2-way interaction of face outcome by block type $F(2, 34) = 2.89, p = .071, \eta^2 = .14$. Although marginal we did follow-up paired sample t-tests within each block for each face outcome level. Infants in the Gender block reached significantly longer during the unexpected empty ($M = 3.17$ seconds, $SD = 2.10$) compared expected empty-final trials ($M = 1.65$, $SD = 1.21$) $t(19) = 3.42, p = .003$, corrected $p = .009$. Additionally, they reached significantly longer during the expected-empty trials ($M = 2.48$ seconds, $SD = 1.14$) compared to expected-empty final trials ($M = 1.65$ seconds, $SD = 1.21$) $t(19) = 2.20, p = .041$, corrected $p = .123$. Infants in the Race block showed no significant differences in reaching between unexpected-empty and expected-empty or expected-empty final.

*Older age group (24 months).* The same 3-way 2 x 3 x 2 mixed measures ANOVA used for the younger age group was conducted for the older age group. There was a significant main effect of face outcome $F(2, 31) = 5.90, p = .007, \eta^2 = .28$ (see Figure 12). Infants reached significantly longer during unexpected-empty trials ($M = 4.43$ seconds, $SD = 4.27$) compared to expected-empty ($M = 2.03$ seconds, $SD = 1.99$) and expected-empty final ($M = 2.39$ seconds, $SD = 2.51$) trials. There were no other significant main effects or interactions found for these data.
Experiment 2 comparison of reaching duration (in seconds) collapsed across face block types of gender and race for younger (left) and older (right) infants. The graph reflects the significant main effect found for 24-month-old infants, this was not found for 12-month-old infants. Infants in the older age group reached significantly longer during the unexpected-empty compared to expected-empty face outcomes and expected-empty final trials. Error bars represent the standard error of the mean, * represents $p < .05$.

**Discussion**

Experiment 2 examined infants’ individuation of faces along qualities of humanness, gender, and race using a manual search task. Both 12- and 24-month-old infants demonstrated reaching behaviors that suggest they individuated human faces from non-human faces. This was observed for both Caucasian faces (Condition 1) and African-American faces (Condition 2). Specifically, infants reached inside of the box for a greater amount of time when the only found 1 face, but had previously seen both a human and a non-human face go inside of the box. Relative to the 2 faces test trials, infants’ reaching
was significantly diminished during 1 face trials, such that they reached less once they had retrieved the 1 face they saw be placed within the box. Additionally, infants did not reach for very long after the second of the 2 faces was found during the 2 faces expected-empty final trials. Our findings are both consistent and extend the results from Experiment 1, Condition 1, in which only the younger aged infants displayed individuation of human faces. Using similar stimuli, but a different task, we found individuation of human versus non-human faces in both age groups. This difference further supports that manual search tasks can test for individuation and be more appropriate to use with a wider age range compared to a passive viewing measure.

Experiment 2, Condition 1 also tested for individuation of male versus female faces. We found that the 24-month-old infants individuated male and female faces. They demonstrated this by reaching longer when they could not find a second hidden face after seeing the presentation of a male and female face go inside of a box. Older infants’ reaching was significantly shorter on trials that they succeeded in finding the single face that they had seen be placed within the box. The 12-month-old infants did not show evidence of individuation for male compared to female faces, as their reaching during 1 compared to 2 faces trials were not significantly different from one another. These findings extend prior research findings that only found individuation based on humanness, but not gender (Bonatti et al., 2002). Using a more interactive task to test for individuation has provided a finer-grained perspective of when infants are starting to use features of gender to individuate people.

In addition to testing human versus non-human faces, Condition 2 was used to test for individuation of faces of different race groups. There were no significant effects or
interactions for either age group to indicate infants’ individuated African-American from Caucasian faces. Although only marginal, the older infants did display a reaching pattern which reflected individuation. Past research with children show that race is more salient for those of a marginalized group (Kinzler & Dautel, 2012). Although our 24-month-old infants were primarily Caucasian, there were 5 Infants of Color. To better understand the marginal effects found for the race face comparison block we did follow-up analyses separating infants by race group. Interestingly, when only the Caucasian 24-month-old infants’ reaching behavior was analyzed the marginal interaction that had previously been found was no longer present. In contrast, we found that the 5 Infants of Color displayed a reaching pattern that suggested individuation of faces from different race groups (i.e., Caucasian versus African-American faces). It is possible that the null effects found with only the Caucasian infants was due to a reduced sample size (n=13). However it is also plausible that race for Caucasian infants is not a salient kind-based marker for representing individuals. For the Infants of Color we present very preliminary evidence that they individuate faces based on race group membership. A larger sample of both Caucasian and Infants of Color are needed to fully understand whether there are these group differences infants’ representation of people based on race.

We tested for significant differences in reaching between Conditions 1 and 2 at each age group for the different types of face blocks. For the two types of human versus non-human face blocks both younger and older infants displayed the same greater reaching during unexpected-empty trials compared to expected-empty and expected-empty final trials. We found some age differences when we compared infants’ reaching for gender individuation compared to race individuation. Younger infants did not display
any significant differences in reaching between unexpected-empty and expected-empty or expected-empty final trials for either face block. There was however a marginal interaction of face outcome and block type. Infants in the gender comparison condition displayed some evidence of greater reaching toward unexpected-empty trials, but this was only in comparison to expected-empty final trials and thus not a robust enough effect to claim that they behaved differently compared to infants in the race comparison block. Older infants demonstrated reaching behavior that indicated individuation of faces regardless of the face comparison. This suggests that in general older infants are better at the individuation task than younger infants. Additionally, older infants equally individuated the gender and race face comparisons, which could suggest the presence of kind-based representations for gender and race.
CHAPTER IV
GENERAL DISCUSSION

The present study examined the unanswered question of whether infants possess kind-based representations for different types of faces. Specifically, two experiments were conducted to investigate whether infants use the conceptual distinctions between faces that are human versus non-human, of different genders, and different races as the basis of their individuation judgments. Twelve- and 24-month-old infants participated in a passive-viewing, violation-of-expectation task involving puppets with different facial features appear from behind a screen (Experiment 1) and completed a violation-of-expectation manual search task (Experiment 2) involving faces hidden inside of a box that they were tasked with retrieving. Overall, findings from these two experiments indicate that 12- and 24-month-old infants represent human faces as distinct from non-human faces. Twenty-four-month-old infants provided evidence in Experiment 2 (the manual-search task) that also indicated individuation of faces based on gender. Neither age group demonstrated strong behavioral evidence for the individuation of faces based on race. The findings from the present study replicate and extend prior research on the development of kind-based representations of objects and people. This study was the first to use realistic human faces to test for kind-based individuation and to find that by their second birthday, infants can use gender as a salient feature to track distinct individuals through time and space.

The current research was motivated by an interest in understanding the factors that contribute to the development of social group awareness. The human face is one of the most salient social stimuli we perceive, recognize, and categorize starting from a very
young age (Pascalis et al., 2011). Even before birth face-like stimuli attract visual attentional biases in fetuses (Reid et al., 2017). This visual attentional bias persists throughout development and is influenced by infants’ social experiences (Reynolds & Roth, 2018). Furthermore, processing social stimuli such as a face has critical consequences in learning individual identities, social cues, language and other socio-emotional capabilities. Researchers have extensively examined early perceptual biases for faces which represent the gender and race of infants’ primary caregivers (for a review, see Scherf & Scott, 2012). However there is limited work examining if and when infants have kind categories for different types of face groups. The data presented in this current dissertation begins to bridge the gap in our understanding of infant face perception and higher-order conceptualizations of gender and race.

**Individuation of Face Kinds or Identities?**

The present study provides data that infants individuated faces along different dimensions. Specifically, infants displayed a greater behavioral response when they only saw or found 1 of 2 previously presented faces. These differences in infant behavior were found under two face type conditions, human versus non-human for 12- and 24-month-old infants and male versus female for just 24-month-olds. One interpretation of these data is that infants successfully individuated the faces by representing the underlying kind category they belonged to (e.g., ‘human’ and ‘male’ or ‘female’). However an alternative interpretation of the present findings is that infants were individuating the different identities of faces that were used in our stimuli set. That is, instead of responding based on representations of different categories, infants were simply tracking the perceptual change between one faces’ featural identity to the next. After all, the face perception
literature shows that even newborn infants can perceive differences between two face identities (Field, Cohen, Garcia, & Greenberg, 1984; Pascalis et al., 1995), making it possible that infants in the present study did the same. If this were the case we would have expected infants in both age groups to have individuated all of the different types of faces we presented. That is, if infants simply used face identity then it would have been expected that younger infants individuated male and female faces just as older infants did and both age groups would have individuated faces in our race comparison condition. It is the case that all of our faces had unique identities as the stimuli included were photos of actual people with different identifying features (Ma et al., 2015). The face stimuli we employed had been validated as clear representations of the gender and race groups that each individual self-identified as. Furthermore, it is not possible to clearly argue that the differences in face identities were more distinct to infants than the differences represented across the kind categories of human, gender, and race. Thus we argue that it is more likely that the current data supports infants individuating faces using higher-order kind representations that are not strictly perceptual or based solely on differences in face identity.

**Infants’ Representation of Human-Face Kinds**

The current study replicated and extended previous findings that infants possess the superordinate kind-category ‘human’ and can individuate human faces as distinct from non-human faces. Infants as young as 6 months of age are found to have improved working memory capabilities when tested on tracking a doll’s face compared to a non-face object (Kibbe & Leslie, accepted for publication). This finding was interpreted as evidence that concept knowledge for human faces aids in the way infants remember
events. There have been only two previous studies examining individuation for human faces as a way to test for infants’ kind-based representation of people (Bonatti et al., 2005, 2002). Infants succeeded in tracking a human doll’s face as a distinct individual when paired with an animal face (Bonatti et al., 2002) as well as an inverted face (Bonatti et al., 2005). Based on these findings, the “human first” hypothesis proposes that infants distinguish human faces from other objects in their environment, and this is a primitive distinction acquired before they possess finer-grained categories.

The present findings from Experiment 1 replicate those that were presented by Bonatti and colleagues (2002, 2005). Specifically, we found that 12-month-old infants overcame their initial bias to look longer toward two faces presented side-by-side compared to one face during baseline trials. At test, following a sequential presentation of a human face and a non-human face, infants no longer looked significantly longer toward two side-by-side faces. Additionally, infants’ looking time for one face increased from baseline to test. These findings provide converging evidence that humanness is a concept that infants possess and use to represent individuals. The present study extended past research findings in two meaningful ways. First, methodologically the present study used realistic human faces that were more ecologically valid than doll faces. When studying the way infants process or represent people it is most appropriate to use as realistic face stimuli as possible. In the present study we also varied the number of examples and types of human faces tested against non-human faces. This allowed for greater generalization of our findings.

Second, we tested whether a human face would be represented as an ontological kind across different race groups. Previous perceptual research suggest that within the
first year of life infants narrow their processing expertise to faces that represent the race they have the most experience with (e.g., Kelly et al., 2007). Additionally, 9-month-old infants will form a specific own-race face category, but will create a general other-race face category that includes any face of a race that is unfamiliar to them (Quinn et al., 2015). This perceptual work does not clearly indicate whether or not infants still represent faces of different races as belonging to the same ‘human’ kind. Prior to the current study it was unclear if infants’ formation of a general other-race face category also meant that faces from an out-group were not conceptually represented as human faces. Experiment 2 began to answer this open question by testing two types of human versus non-human face comparisons, one with Caucasian faces and the other with African-American faces. We found that infants in each age group succeeded in individuating a human face from a non-human face for both Caucasian and African-American faces. However older infants demonstrated more robust behavioral differences for each face comparison condition. Our findings support the conclusion that infants use human faces as a salient marker for representing and tracking individuals within a scene and that these features connect faces in a meaningful way beyond observable surface features. Furthermore our findings imply that the kind ‘human’ is most likely not limited to a particular race group.

**Infants’ Individuation of Kinds ‘Gender’ and ‘Race’**

Another aim of the current dissertation was to assess infants’ individuation of human faces based on finer-grained features that reflect social group membership. Research from infant face processing as well as social cognitive development in children provided the current project with the grounds to assess individuation based on kind
concepts of gender and race. Infants’ perceptual and categorization of faces quickly
develops in the first year of life (for reviews see Lee et al., 2011; Pascalis et al., 2011;
Scherf & Scott, 2012; Scott & Fava, 2013). The development of perceptual biases such as
the own-race bias (e.g., Kelly et al., 2007) and the own-species bias (e.g., Pascalis et al.,
2002) are observed when infants are better at discriminating between two faces
representative of a group that they have more experience with. These perceptual biases
are examples of how infants’ early experiences shape their expertise in differentiating
faces that are highly familiar. However it was unclear whether these early perceptual
biases support the development of conceptual representations of gender and race that
could translate into later occurring social preferences. Findings from Experiment 2 begin
to address these open questions.

**Individuation of gender kinds.** Early in infancy there is a strong visual
preference for faces that reflect the gender of one’s primary caregiver (Quinn et al.,
2002). Infants raised by females are observed to prefer female faces across age groups
and begin to create a female-specific face category (Hillairet de Boisferon et al., 2015;
Quinn et al., 2010; Rennels et al., 2016; Righi et al., 2014). Gender is hypothesized to be
a more salient marker of group membership and is categorized by children differently
compared to race (Dunham, Baron, & Banaji, 2008; Kinzler, Shutts, & Correll, 2010;
Rhodes & Gelman, 2009; Shutts, 2015; Shutts et al., 2011; Waxman, 2010; Waxman &
Grace, 2012). Interestingly, toddlers between 19 and 26 months of age recognized the
category of gender, but only with the use of novel auditory labels (Diesendruck &
Deblinger-tangi, 2014). Authors proposed that the formation of categories without the use
of labels may be a more fragile capability for infants at this age. Authors also suggested
that for toddlers using explicit verbal and pointing responses to prompted questions may
not have been sensitive enough to find evidence of gender category recognition
(Diesendruck & Deblinger-tangi, 2014). Studies have shown that between 3 and 5 years
children develop differential processing and essentialist thinking for gender (Diesendruck
& Weiss, 2015; Weisman, Johnson, & Shutts, 2015). For example, 5-year-olds make
judgments indicating their beliefs that gender, but not race or ethnicity are biologically
inherited (Diesendruck, Goldfein-Elbaz, Rhodes, Gelman, & Neumark, 2013;
Diesendruck & Weiss, 2015). Additionally, 5- to 7-year-old children reason that gender,
but not race, is a ‘natural kind’ that is used to conceptually group individuals together and
use this kind category to predict behavior (Rhodes & Gelman, 2009; Taylor, Rhodes, &
Gelman, 2009). This may indicate that gender is a social category that is quickly encoded
and is connected to the early perceptual biases that develop during infancy.

Experiments 1 and 2 of the present study included tests for individuation of faces
based of gender facial features. However data only from the manual search task of
Experiment 2 provide clear evidence that infants do indeed individuate faces based on
gender. Older, but not younger aged infants demonstrated longer reaching when they
could only find 1 of 2 hidden faces after seeing a male and female face be placed inside
of a box. Thus once they found the first face they had some representation that another
face was remaining within the box. The critical difference between these two individuals
was the gendered facial features, with one face having stereotypical male appearance and
the other stereotypical female appearance. Experimenters did not provide any information
to the infants about specific features they should attend to or label each face differently
during the task. Thus this pattern of reaching suggests that older infants individuated
male faces from female faces. Furthermore, the perceptual or observable features that
distinguish male and female faces were not thought of as interchangeable during the
course of the task. Infants’ individuation of these faces suggests that gendered features
are not only perceptually salient, but have a deeper, more meaningful distinction that
separates one face from another. Evidence for kind-category of gender has not been
previously seen prior to early childhood and through the use of more complex decision
making tasks with preschoolers (Rhodes & Gelman, 2009; Taylor et al., 2009). To our
knowledge, this is the first evidence that indicates even 2-year-old infants have a kind-
category for gender.

Our current findings provide evidence that 24-month-old infants begin to
individuate faces based on gender. To some extent this finding seems surprising
compared to the conclusions drawn from the face perception literature. With such a
strong female face bias seen as early as 3 months of age, why might this not translate into
younger infants also using gender cues to individuate faces? One important consideration
is that perceptual studies typically present faces simultaneously and do not require infants
to hold one distinct individual in their working memory while also tracking a second
individual. Thus it is possible that although younger infants can separate a human from a
non-human, male and female facial are not yet salient enough for infants to separate into
distinct individuals.

**Language and individuation by gender.** Another possibility for why younger
infants were unsuccessful at individuating female and male faces has to do with language
development. Past research provides evidence that language development, specifically
word knowledge supports kind-based individuation (Rivera & Zawaydeh, 2007; Xu,
In the present study we found evidence that further confirms word knowledge influences infants’ individuation of some types of kind categories. In Experiment 1 we found a positive relationship between the number of gendered words an infant knew and their looking time toward the 1-face test trials. Such that for every additional gendered word an infant was reported to comprehend (and express) they increased their looking to the unexpected 1-face outcome. Our findings related to gendered word knowledge is not to argue that infants have the same understanding of what words such as ‘girl’, ‘boy’, ‘aunt’, or ‘uncle’ mean as an adult. Instead it suggests that having words to identify people of different groups or relationships that reflect some type of gendered identity seems to influence infants’ conceptual representation of individuals who reflect what adults would identify as male and female. Interestingly, the majority of the older infants in our sample comprehended at least 6 or more gendered words. This demographic difference may in part explain why the 24-month-olds, but not the 12-month-old infants individuated male versus female faces.

**Individuation of race kinds.** The present investigation included race as the third ‘kind’ category to test for through the use of an individuation task. Infants develop perceptual biases based on race, that are reflected in better differentiation of individuals from familiar versus unfamiliar race groups (for reviews see Pascalis et al., 2011, Scherf & Scott, 2012). Children vary in using race as a category for making social decisions (Kinzler & Dautel, 2012; Kinzler et al., 2009; Kinzler & Spelke, 2011). For example, when 5- and 6-year-old Caucasian children were asked to match a photo of a child with a photo of an adult who represented the grown-up version of that child they found that children used language as a cue to match individuals even when this resulted in pairing a
child and adult who were of different races (Kinzler & Dautel, 2012). Interestingly, they found that 5- and 6-year-old African-American children living in an urban environment displayed accurate race-based matches between images of a child and the adult the child would become. This finding is important because it suggests that experience has a significant impact on children’s beliefs and the saliency of race group membership. Race group membership is used by children to make social decisions starting between 3 and 5 years of age (Kinzler & Spelke, 2011; Qian, Heyman, Quinn, Messi, & Lee, 2016). Recent cross-cultural studies provide evidence that children as young as 3 years of age begin to display implicit and explicit racial biases against other-race groups (Qian et al., 2016). For example, Chinese and Cameroonian preschoolers were tested on an implicit racial bias test as well as an explicit preference task. Children from both countries displayed more negative attitudes towards other-race groups and more often chose an own-race individual to be socially associated with. These previous findings provide ample justification for examining developmental origins of social biases that appear during early childhood.

In Experiment 2, Condition 2 we examined whether 12- and 24-month-old infants individuated faces based on race-group membership. We did not find statistically significant evidence that either age group individuated Caucasian from African-American faces. However, older infants did show a trend for longer reaching when they only succeeded in finding 1 of 2 hidden faces relative to their reaching on expected-empty trials. The older infants tested on individuation of different race faces showed a similar reaching pattern as the older infants tested on gender. Therefore it seems that some of the infants in our sample were individuating faces based on race.
Experience and individuation by race. The present study did not ask parents to report on race-specific language that their child may understand. This is a recognized limitation to the study, as it may have provided a richer picture of how language relates to kind-based individuation. We did include questions about infants’ time spent with individuals of same and different races as their primary caregivers. However, we did not find any significant relationships between infants’ time spent with individuals based on race and their performance on the manual search individuation task. This leaves several open questions including whether experience has any impact on the development of kind-based representations for people?

Connecting Perception to Conceptual Representations

By investigating conceptual representations of face gender and race, the present study tries to take initial steps in bridging an information gap between infants’ perceptual processes of faces and later occurring socio-cognitive understanding of social groups. The present data offers evidence that gender is a kind-based marker of distinct groups and that this occurs prior to race. From an evolutionary and socio-cognitive standpoint, researchers hypothesize that gender is a critical marker for one’s in-group and out-group (Kinzler et al., 2010). In review of the face perception literature, infants’ earliest face bias is gender-related (e.g., Pascalis et al., 1995). Thus, the present work further strengthens a gender-first hypothesis, such that distinctions of face gender are highly salient to infants. It is plausible that infants’ acquisition of the concept for gender groups is a continuous process that first starts to transition from perception to conceptual representation around infants’ second birthday. This transition to a kind concept of gender may be further supported with increased knowledge of words that distinguish people based on gender...
categories (e.g., girl, boy). By 5 to 7 years of age children have a more language and social experiences to have a much stronger concept that gender is a natural kind (Diesendruck & Weiss, 2015; Rhodes & Gelman, 2009).

The present work may also contribute to our understanding of developmental origins for social group biases. Social judgments for gender and race are present in early childhood, these biases may in part develop from infants’ early perceptual biases for different types of faces during infancy. However there is limited research that provides data to fully describe the development of social group biases. One hypothesis is that biases, in particular implicit biases, begin at the onset of having the concept of group membership (Dunham, 2017; Dunham et al., 2008). A second, recent hypothesis proposes a perceptual-social linkage between early perceptual experiences with particular face groups during infancy and social biases in childhood (Lee, Quinn, & Pascalis, 2017; Qian et al., 2016; Qian, Quinn, Heyman, Pascalis, & Lee, 2017; W. S. Xiao et al., 2015). Lee and colleagues (2017) propose that implicit biases start to develop from the extreme amount of time and positive experiences infants have with the race of their primary caregiver. This positive association develops into an unconscious bias for one’s own race. Data offered in the present study may further add to these recent hypotheses with evidence that infants between 1 and 2 years of age start to conceptually represent people’s faces as belonging to a distinct gender kind. Although we cannot offer evidence that infants in our sample have awareness of their own membership of a gender group, it seems that by about 2 years of age infants use representations of maleness and femaleness to individuate faces. This in turn could be the start of infants’ concept of group membership and the onset of implicit group biases (Dunham, 2017; Dunham et al., 2008).
The present data indicate that a socio-cognitive process of individuating people along different categories is occurring even before the experience of formal schooling and may mark an important period when infants’ are sensitive to information that denotes membership along different social categories.

**Future Directions**

This dissertation was the first to examine infants’ kind-based individuation for faces based on both gender and race. There are several opportunities to expand on the present findings. For gender kind representations it is unclear which feature or multiple features of the faces were used to conceptually distinguish between male and female faces. Although word knowledge is found to be relevant to gender individuation, it may not be the only underlying mechanism. From face perception literature there is evidence that hairline is a critical feature for young infants to perceptually detect differences between male and female faces (Hillairet de Boisferon et al., 2014). In the present study all of the female faces used in the gender individuation condition had longer hair than the male faces, thus this could be a critical cue for infants to individuate males from female faces and be part of their understand of ‘boy’ and ‘girl.’ Future research is needed to further examine what element(s) of ‘maleness’ and ‘femaleness’ are critical to infants’ individuation of gendered faces. This will further support our understanding of how infants are thinking about and may treat people of different genders.

The present study only tested individuation of male and female faces using Caucasian faces. Thus another open question is whether infants equally represent or individuate male and female faces broadly regardless of race, age, or other types of socially relevant features. Based on the fundamental definition of kind-based
individuation, that the conceptual representation of a particular item surpasses grave perceptual or feature differences (Sarnecki, 2008; Xu, 2010, 2013), then it would be expected that infants should individuate male and female faces regardless of race (or other social group feature). Research on category formation also suggests that by 7 months infants have a female face category that includes faces from different race groups (Waxman & Grace, 2012). Combing these findings (Waxman & Grace, 2012) with evidence from the current work that infants’ kind category for human includes multiple race groups could further suggest that gender-based individuation would be robust to feature differences such as race. In contrast, evidence from developmental perceptual biases indicate that infants’ preferred attention to female faces is modulated with whether or not the face is of the same race as an infants’ primary caregiver (e.g., Quinn et al., 2008). Therefore a critical follow-up study would be to test infants’ individuation of male and female faces who varied by race (or another salient feature such as age).

There are at least two important future directions needed to continue the work on kind-based individuation of race face groups. First, despite explicit efforts by experimenters in the present study, a more racially diverse sample is needed. Having cross-cultural data will of course provide a richer and more generalizable understanding of the development of infants’ representation of people based on race. As noted in social-cognitive development, children in minority status groups tend to recognize the saliency of the particular feature that they are marginalized for (e.g., Kinzler & Spelke, 2011). Thus an open question is even for a 2-year-old of a marginalized group (e.g., African-American in the U.S.) would markers of race be conceptualized enough to use as a factor to track distinct individuals over time and space? The second future direction is to further
unpack what factors are leading some infants to have a kind-based representation for individuals of different race groups. Is it word knowledge, as found for gender? Or is it experience driven? With a participant pool that includes a larger sample of infants who spend a greater portion of their time with individuals of different race groups it could be possible to better answer these open questions.

Conclusion

The present dissertation took initial steps in further investigating infants’ individuation of faces based on different socially salient groups. Present data provides evidence that by 12 months of age infants displayed the capability to individuate faces based upon the kind ‘human.’ This was supported by data from two individuation paradigms, a passive viewing (Experiment 1) and an interactive manual search (Experiment 2) task. Infants displayed greater looking time and reaching duration when presented with face outcomes that did not match what they had previously observed. By 2 years of age, infants also demonstrated the capability to use gender to track the number of distinct individuals involved in a presented scene. Interestingly, the present study did not find evidence of infants at either age tracking individuals based on race group membership. This suggests that distinctions of humanness and gender are more salient categories for infants’ representation of the different faces they experience in their environment. By investigating whether infants have kind concepts for gender and race, we aimed to bridge the gap in our understanding of when concepts of in-group and out-group membership begins to develop. Our goal is this type of work will only be the beginning of a line of research that will better understand the connection between perceptual biases and later occurring social prejudices.
APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE

What is your infant’s biological sex? Male       Female

What is your infant’s race (More than one box may be selected)?

- American Indian or Alaskan Native
- Native Hawaiian or Pacific Islander
- Black or African American
- Middle Eastern
- Does not wish to disclose

What is your infant’s ethnicity?

- Hispanic or Latino
- Not Hispanic or Latino
- Does not wish to disclose

If the primary caregiver is someone other than parent/guardian 1 or 2 please list their race and gender

Parent/Guardian 1

Relationship to your infant ________________ (i.e., Mother, Father)

- What is parent/guardian 1’s biological sex? Male Female Does not wish to disclose

Please consider each question independently. Your responses to the following questions do not need to add up to 100% of your infant’s time.

- Thinking of an average week, what percentage of your infant’s time is spent with parent/guardian 1? _____________ (out of 100%)

- Thinking of an average week, what percentage of time does your infant spend with other adults of the same biological sex as parent/guardian 1? _________ (out of 100%)
• Thinking of an average week, what percentage of time does your infant spend with other adults of a different biological sex as parent/guardian 1? _________ (out of 100%)

• Thinking of an average week, what percentage of time does your infant spend with other adults of the same race as parent/guardian 1? _________ (out of 100%)

• Thinking of an average week, what percentage of time does your infant spend with other adults of a different race than parent/guardian 1? _________ (out of 100%)
  ○ Please specify the race(s) of this person(s) - __________________________________

What language(s) does parent/guardian 1 speak?
  Primary___________ Secondary__________
  Tertiary___________

What percentage of time does parent/guardian 1 speak their Primary language to your infant? ______ (out of 100%)

What percentage of time does parent/guardian 1 speak their Secondary language to your infant? ______ (out of 100%)

What is parent/guardian 1’s race (More than one box may be selected)?

☐ American Indian or Alaskan Native ☐ Asian

☐ Native Hawaiian or Pacific Islander ☐ White or Caucasian

☐ Black or African American ☐ Does not wish to disclose

☐ Middle Eastern

What is parent/guardian 1’s ethnicity?

☐ Hispanic or Latino

☐ Not Hispanic or Latino

☐ Does not wish to disclose
Parent/Guardian 2

Relationship to your infant _______________ (i.e., Mother, Father)

- What is parent/guardian 2’s biological sex?  Female  Male  Does not wish to disclose

Please consider each question independently. Your responses to the following questions do not need to add up to 100% of your infant’s time.

- Thinking of an average week, what percentage of time does your infant spend with parent/guardian 2? _____________ (out of 100%)

- Thinking of an average week, what percentage of time does your infant spend with other adults of the same biological sex as parent/guardian 2? _________ (out of 100%)

- Thinking of an average week, what percentage of time does your infant spend with other adults of a different biological sex as parent/guardian 2? _________ (out of 100%)

- Thinking of an average week, what percentage of time does your infant spend with other adults of the same race as parent/guardian 2? _________ (out of 100%)

- Thinking of an average week, what percentage of time does your infant spend with other adults of a different race than parent/guardian 2? _________ (out of 100%)
  - Please specify the race of this person(s) -

What language(s) does parent/guardian 2 speak?

Primary__________  Secondary__________
Tertiary__________

What percentage of time does parent/guardian 2 speak their Primary language to your infant? _______ (out of 100%)

What percentage of time does parent/guardian 2 speak their Secondary language to your infant? _______ (out of 100%)
What is parent/guardian 2’s race (More than one box may be selected)?

- American Indian or Alaskan Native
- Asian
- Native Hawaiian or Pacific Islander
- White or Caucasian
- Black or African American
- Does not wish to disclose
- Middle Eastern

What is parent/guardian 2’s ethnicity?

- Hispanic or Latino
- Not Hispanic or Latino
- Does not wish to disclose

Please indicate the five individuals with whom your infant has the most contact with on a weekly basis (list by relationship to infant, (e.g., mother, father, siblings, aunt, daycare provider, babysitter, etc.), their gender, race, and an estimate of the relative percentage of time spent with that individual (for each person out of 100%):

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Gender</th>
<th>Race</th>
<th>Percentage of Time</th>
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<tr>
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<td>______</td>
</tr>
<tr>
<td>5.</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

Has your infant ever lived with people from other racial groups?  Y \ N

If so, please list:

<table>
<thead>
<tr>
<th>Their Race or Ethnicity</th>
<th>Length of cohabitation</th>
<th>Infant’s age during cohabitation (approximately)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Word Comprehension and Expression

Please indicate if your infant comprehends the following words or equivalent words used in your family:

- [ ] Happy
- [ ] Sad
- [ ] Angry
- [ ] Nice
- [ ] Mean
- [ ] Woman
- [ ] Man
- [ ] Lady
- [ ] Aunt
- [ ] Uncle
- [ ] Mommy
- [ ] Daddy
- [ ] Sister
- [ ] Brother
- [ ] Boy
- [ ] Girl
- [ ] Grandma (or equivalent term)
- [ ] Grandpa (Or equivalent term)

Please indicate if your infant expresses the following words or equivalent words used in your family:

- [ ] Happy
- [ ] Sad
- [ ] Angry
- [ ] Nice
- [ ] Mean
- [ ] Woman
- [ ] Man
- [ ] Lady
- [ ] Aunt
- [ ] Uncle
- [ ] Mommy
- [ ] Daddy
- [ ] Sister
- [ ] Brother
- [ ] Boy
- [ ] Girl
- [ ] Grandma (or equivalent term)
- [ ] Grandpa (Or equivalent term)

Please list any words used in your family that are alternatives to the above words:

_________________________________________________________________
_________________________________________________________________

Education & Income

Is Parent/Guardian 1 currently employed and earning a wage?

[ ] YES   [ ] NO   [ ] Does not wish to disclose

If yes, which of the following best describes Parent/Guardian 1’s employer (Check one)?

- [ ] Private company
- [ ] Business
Which of the following best describes the highest level of education that Parent/Guardian 1 has completed (check one)?

- Some high school
- High school graduate
- Some college
- Community college/Two-year degree
- Four-year college degree
- Some graduate school
- Master’s degree
- Doctoral degree
- Professional degree
- Does not wish to disclose

Is Parent/Guardian 2 currently employed and earning a wage?

- YES
- NO
- Does not wish to disclose

If yes, which of the following best describes Parent/Guardian 2’s employer (Check one)?

- Private company
- Business
- Individual
- Family
- Federal office
- State office
- Self-employed
- Farm operated
- Does not wish to disclose

Which of the following best describes the highest level of education that Parent/Guardian 2 has completed (check one)?

- Some high school
- High school graduate
- Some college
- Community college/Two-year degree
- Four-year college degree
- Some graduate school
- Master’s degree
- Doctoral degree
- Professional degree
- Does not wish to disclose
How many people contribute to your household income?

How many people under the age of 18 reside in your household?

How many people over the age of 18 reside in your household?

How would you categorize your household income before taxes (check one)?

- Less than $15,000 per year
- $15,000 - $25,000 per year
- $25,000 – $35,000 per year
- $35,000 – 45,000 per year
- $45,000 - $55,000 per year
- $55,000 - $65,000 per year
- $65,000 - $75,000 per year
- More than $75,000 per year
- Does not wish to disclose
REFERENCES


Casstevens, R. M. (2007). jHab: Java habituation software (version 1.0. 2) [computer software]. Chevy Chase, MD.


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