THE UNIVERSITY OF CHICAGO

# THE ORIGINS OF SOCIAL CATEGORIZATION: INFANTS' INFERENCES ABOUT SOCIAL RELATIONSHIPS AND SHARED SOCIAL ATTRIBUTES

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## ABSTRACT

Social categorization has vast implications for myriad aspects of human social life, and studying its origins and development can inform our understanding of its pervasive influences across the lifespan. While a growing body of research has found early-emerging social preferences for in-group members, first person social preferences may arise due to familiarity and therefore do not necessarily indicate abstract conceptual reasoning about social categories. In this dissertation, I use third-party violation of expectation looking time studies to investigate infants' inferences about social groups in the first two years of life. In Part I, I demonstrate that infants expect people who speak the same language to be more likely to affiliate than people who speak different languages, suggesting they may see language as a fundamental marker of social group. In Part II, I ask whether infants use other socially relevant behaviors, such as imitation of actions that may be seen as rituals, to make inferences about third-party social relationships. Here, I find that infants expect people who engage in the same causally-irrelevant actions to be more likely to affiliate than people who engage in different causally-irrelevant actions, and that these effects are not merely due to perceptual similarity. In Part III, I ask whether infants are selective in how they generalize socially relevant attributes across people. Results suggest that although infants' baseline expectation is that food preferences are generalizable, they withhold generalizing food preferences across people who seem to belong to different social groups. In the general discussion I integrate this work with other broader research from developmental psychology to advocate for a new definition of social categorization that does not rely on first person social preferences and instead makes central inferences about social structure

and inductive generalization. Taken together, this work indicates that infants demonstrate early emerging abilities to think about people as members of social groups, and provides novel insights into the origins of social categorization.

## Introduction

Social categorization has vast implications for myriad aspects of human social life, including how people learn from others (e.g., Howard, Henderson, Carrazza, & Woodward, 2015), how much empathic concern people show for others (e.g., Xu, Zuo, Wang, & Han, 2009), and even how people make decisions about allocating third-party punishments (e.g., Jordan, McAuliffe, & Warneken, 2014). In fact, the tendency to categorize people based on membership in certain social groups may be automatic (e.g., Brewer, 1988; Devine, 1989; Fiske, 2000; Fiske & Neuberg, 1990; Weisman, Johnson, & Shutts, 2015), and classification into these social groups can cause negative consequences. As example, people are prejudiced against those outside their own group (e.g., Aboud, 1988; Allport, 1954; Baron & Banaji, 2006; Bigler & Liben, 2006; Jacoby-Senghor, Sinclair, & Smith, 2015), which can lead to dehumanization of extreme outgroups (e.g, Harris & Fiske, 2006), and even to a greater proportion of guilty verdicts in cases with death sentences for vilified outgroups (e.g., Glaser, Martin, & Kahn, 2015). Classification into social groups can also have negative consequences for the self, for example when stereotype threat undermines task performance of a member of stigmatized group (see Spencer, Logel, & Davies, 2015 for review). Studying the developmental trajectory of social categorization can inform our understanding of its emergence, its underlying mechanisms, and the resulting pervasive influence that such categorization has over people's thoughts and behaviors across the lifespan.

Throughout this dissertation I argue that there are two particularly critical aspects of social categories. First, membership in a social category influences social behavior, meaning a person's group membership can be predictive of her likely social relationships or position in a social network. Second, social categories serve as organizers of socially relevant information,

such that people in a social group are likely to share important similarities in their personal attributes, and group membership can serve as an indicator that a group member is likely to possess those particular attributes. Here, I ask about the origins of social categorization by investigating infants' inferences about these two key features of social categories: shared social relationships and shared personal attributes.

Sensitivity to the connection between social relationships and social categorization begins early in ontogeny. In general, belonging to a social group influences the types of relationships that a person likely has with people both inside and outside her social group, and there may be specific cognitive adaptations that support within group cooperation and between group conflict (e.g., Kurzban & Neuberg, 2005). Indeed, children expect social group membership to guide interpersonal behavior: when introduced to novel social groups in the laboratory, children infer that members of the same group will not harm one another, even when there are no rules in place against such harm (e.g., Rhodes & Chalik, 2013). Because these expectations about social interactions based on group membership arise quickly, even in the presence of arbitrary groups, it is possible that understanding a link between group membership and social obligation is a fundamental piece of social cognition that emerges earlier, in infancy. To ask whether information about social group membership guides infants' expectations about patterns of third-party social relationships, I investigate infants' inferences about whether people from the same social group are more likely to affiliate with one another than people from different social groups (Parts I and II).

Seeing social categories as natural kinds that support rich inductive inferences, also begins early in life. Indeed, children may reason about membership in certain social categories, such as gender and race, as fixed at birth (e.g., Hirschfeld, 1996), and see these categories as

having an underlying essence that allows for generalization of learned information about one category member to other members of the same social category (e.g., Gelman & Hirschfeld, 1999; Gelman & Taylor, 2000; Haslam, Rothchild & Ernst, 2000; Prentice & Miller 2006). Here, I ask whether infants also demonstrate selective inductive generalization based on social group membership (Part III). Specifically, I investigate whether infants expect deeply social attributes of people, such as their food preferences (described further below), to be shared by people who seem to be part of the same social category, but not to be shared by all people.

In addition to concentrating on social relationships and inductive generalization, throughout this dissertation I suggest that there may be priorities in infants' early social categorization. Specifically, I hypothesize that rather than being agnostic as to what dimensions are socially important, infants may be predisposed to expect some dimensions of variation, particularly those that have fundamentally marked social identity across evolutionary time, to be especially informative for signaling social group membership. That is, infants may be inclined to pay attention to dimensions that provide social information that is inherently difficult to falsify because these dimensions can serve as honest and reliable signals of a person's social group. Most of the research presented here focuses on two such dimensions: the languages that people speak, and the foods people prefer to eat. For instance, native accents are notoriously hard to fake, making speaking a language with a native accent a robust and honest signal of a person's social group membership (e.g., Baker, 2001; Cohen, 2012; Heinrich & Heinrich, 2007). Similarly, rather than selecting foods exclusively based on availability, edibility, and taste, people also choose what to eat based on norms and prohibitions of their social group (e.g. Millstone & Lang, 2002; Rozin & Rozin, 1981), and it can be difficult to acquire a taste for foods that were not eaten early in life (e.g., Peryam, 1963; Rozin & Siegal, 2003), indicating that

a person's food choices can serve as a reliable marker of social group. In addition to language and food, this account would imply that infants may use other cues that fundamentally mark social identity when making inferences about social categorization, such as shared engagement in ritualistic behaviors, and kinship. On the other hand, I suggest that infants may not make these same types of social inferences based on arbitrary grouping or on trivial similarities between people.

Throughout this dissertation I ask about these questions of early social categorization by focusing on infants' third-party reasoning about the social world. Although much of the adult literature on social categorization focuses on first person social preferences and favoritism toward ingroup members (e.g., Tajfel, Billig, Bundy, & Flament, 1971), and a growing body of work suggests these social preferences emerge early in infancy (e.g., Kinzler, Dupoux, & Spelke, 2007; Mahajan & Wynn, 2012), first person social preferences do not necessarily indicate conceptual reasoning about social groups. Particularly in the infant work, social preferences for "ingroup" members may not be based on abstract reasoning about people as members of social groups. For example, an infant could prefer to look at, take toys from, and eat foods associated with native language speakers (e.g., Kinzler et al., 2007; Shutts, Kinzler, McKee, & Spelke, 2009) because of a simple preference for familiarity, which would not require an abstract understanding of social structure or of what features signal social categories. On the other hand, studies of third-party inferences can indicate whether infants have conceptual knowledge about people of members of abstract social categories.

Indeed, researchers have used violation of expectation looking time methods to investigate early-emerging abilities to form expectations about third-party patterns of behavior. In these types of studies, researchers first introduce infants' to a set of agents, and then show

infants test events where the agents engage in different behaviors or interactions. Because infants tend to look longer at events they find relatively unexpected (e.g., Hespos & Baillargeon, 2008), infants' natural attention to these test events can serve as an indication of infants' expectations about the agents' social behaviors. Studies using this methodology have revealed that infants' make nuanced inferences about social interactions: they form expectations about agents based on their position in dominance hierarchies (e.g., Mascaro & Csibra, 2012; Pun, Birch, & Baron, 2016; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011) and are able to make inferences about which people are likely to engage in dyadic affiliation (e.g., Kuhlemier, Wynn, & Bloom, 2003; Liberman, Kinzler, & Woodward, 2014; Powell & Spelke, 2013). Therefore, throughout the dissertation I use violation of expectation looking time studies to investigate infants' third-party expectations about social categorization by asking about how introducing infants to two agents who belong to the same social group or to different social groups influences infants' subsequent expectations about those agents' likely social relationships and infants' generalization of social attributes across those agents.

**Overview of Dissertation**

The following chapters describe several empirical studies of infants' early reasoning about social relationships and social groups. Part I, in two studies, explores infants' inferences about the role of language as a marker of social relationships. Although past research indicates that infants prefer to interact with native language speakers (e.g., Kinzler, Dupoux, & Spelke, 2007), prefer to eat foods associated with native language speakers (Shutts, Kinzler, McKee, & Spelke, 2009) and preferentially imitate native language speakers (e.g., Buttelmann Zmyj, Daum, & Carpenter, 2013; Howard, Henderson, Carazza, & Woodward, 2015), these social behaviors could be based on infants preferring to associate with familiar others, and would not require

reasoning abstractly about language as a cue to social group membership. To address this issue, the studies Part I ask whether infants expect people who speak the same language to be more likely to affiliate than people who speak different languages, and whether infants' inferences linking affiliative relationships to shared language depend on whether the language presented is familiar. If infants understand that language can serve as an abstract and reliable marker of social group, then they may make inferences about social relationships and social structure based on spoken language.

Part II continues to explore whether infants make inferences about how social categorization informs likely patterns of social relationships by investigating infants' expectations about third-party affiliation based on imitation. Infants show a robust propensity to imitate other people (e.g., Meltzoff, 1988), and though some researchers suggest imitation does not require social reasoning (e.g., Paulus, Hunnius, Vissers, & Bekkering, 2011), others argue that imitation can increase social bonding (e.g., Over & Carpenter, 2012) and is necessary for cultural learning (e.g., Kenward, 2012). For example, causally irrelevant actions, such as turning a light on using one's head, are not required to reach a desired outcome, but imitating these irrelevant features of actions may be relevant for learning cultural rituals (e.g., Legare & Neilsen, 2016). Therefore, in Part II, I ask whether infants' expect people who imitate one another's causally irrelevant actions to be more likely to affiliate than people who do not imitate one another, and whether infants' expectations about patterns of affiliation are based on perceptual similarity of actions or based on understanding deeper underlying goals. If infants expect causally-irrelevant actions to potentially mark cultural groups, then they may make inferences about likely social relationships based on patterns of imitation.

Part III shifts from asking about infants' inferences about social relationship to instead

ask about the other important piece of social categorization, infants' inductive inferences about when to generalize socially relevant attributes across agents. In particular, eating is an inherently social activity, and the foods that people choose to eat can serve as a social shibboleth whereby information about what a person eats affords insight into her likely cultural background and social relationships (e.g., Cashdan, 1994; Liberman, Kinzler, & Woodward, 2014; Miller, Rozin, & Fiske, 1998; Rozin & Siegal, 2003). Therefore, across 5 studies, Part III investigates infants' inferences about when to generalize versus withhold generalization of food preferences. In particular, Study 1 asks whether, due to the social nature of food preferences, infants differ in their propensity to generalize food preferences, as compared to non-food object preferences, across people. Studies 2 through 4 ask about how information about social group membership, such as the language a person speaks, influences infants' expectations about whether to generalize a food preference across agents. If infants understand the link between food preferences and social or cultural groups, then they may selectively generalize food preferences across members of the same group, but not across members of different social groups. On the other hand, if infants learn veridical information about edibility by watching other people eat, they might generalize food preferences regardless of information about social group membership. Study 5 investigates important limits to infants' system for reasoning about the link between food preferences and social group membership by asking whether infants' patterns of generalization for food preferences are different than their patterns of generalization for disgust towards food.

Finally, in the General Discussion I integrate the findings from Parts I, II and III with broader literature both from developmental psychology and from cognitive science research on categorization more generally to put forth a novel theory about the origins of social

categorization. In this section I suggest that developmental psychology can inform scientists' understanding of the mechanisms that underlie social categorization, and the resulting pervasive influence that such categorization has over adults' thoughts and behaviors. Specifically, I advocate for abandoning first person social preferences as evidence of reasoning about social categorization and instead suggest a definition of social categorization that makes central both patterns of social relationship (as demonstrated in studies from Parts I and II) and inductive inferences about shared social attributes (as demonstrated in studies in Part III). After discussing the contributions and implications of the empirical findings of this dissertation, I conclude with some suggestions for how this body of work opens questions for novel areas of future research.

# Part I: Preverbal infants infer third-party social relationships based on language [1]

[1] Paper in press in *Cognitive Science* (Liberman, Woodward, & Kinzler, in press)

Language is social. In addition to transmitting literal communication, a person's speech conveys nuanced information about her social identity, including evidence about her geographic origin, likely social relationships, and position in a broader social network (e.g., Labov, 2006). Because native accents are notoriously difficult to fake, language can serve as a particularly reliable signal of social group membership (e.g., Baker, 2001; Cohen, 2012; Henrich & Henrich, 2007). Here, we investigate the nature of humans' thinking about language as a signal of social affiliation by studying its developmental origins beginning in infancy.

For adults, language use marks social and cultural group (e.g., Babel & Munson, 2014; Casasanto, 2010; Giles & Billings, 2004; Glusek & Dovidio, 2010; Porter, Rhineschmidt-Same, & Richeson, in press). Children, too, make sophisticated inferences about others' identities based on their language and accent (e.g., Day, 1980; Hirschfield & Gelman, 1997; Kinzler & Dautel, 2012; Kinzler & DeJesus, 2013a; 2013b). These social inferences made by children and adults must, at least in part, reflect cultural learning, including experiences hearing diverse languages and exposure to other people's beliefs about foreign-language or accented speakers. Indeed, many reported language-based social attitudes reflect knowledge of linguistic stereotypes (e.g., Day, 1980, Giles & Billings, 2004; Kinzler & DeJesus, 2013a). Stereotypes that link specific accents, dialects, or languages to features of individuals' personalities must be culturally transmitted, and are presumably unavailable to preverbal infants.

Nonetheless, certain types of inferences about the social significance of language could exist independently of knowledge of cultural stereotypes about groups of speakers. For example, upon meeting a speaker of a completely unfamiliar language, you might not be able to draw any specific inferences about that speaker. But, you might infer that she would continue to speak that language at a different time point, and if you then met a second speaker of that language, you

might infer that the two individuals could be friends, or might share other common social attributes. Indeed, both adults and children utilize language and accent as robust indicators of an individual's social identity, and reliance on these cues can even surpass attention to visual cues such as ethnicity (Kinzler, Shutts, DeJesus, & Spelke, 2009; Kinzler & Spelke, 2011; Pietraszewski & Schwartz, 2014; Rakic, Steffens, & Mummendey, 2011). The propensity to infer that a person's language marks her social identity and potential social relationships could emerge early in human development, and set the stage for later reasoning.

Infants are sensitive to differences between languages (e.g., Hohle, Bijelijac-Babic, Herold, Weissenborn, & Nazzi, 2009), and they view language usage as a social behavior (e.g., Beier & Spelke, 2012; Martin, Onishi & Vouloumanos, 2012). Infants' own interactions with other individuals also depend on those individuals' language. Infants preferentially interact with and imitate native-language speakers (Buttelmann, Zmyj, Daum, & Carpenter, 2013; Kinzler, Dupoux & Spelke, 2007, 2012; Shutts et al., 2009). However, it is unknown whether infants' first-person interaction preferences simply reflect a preference for familiar speakers, or whether infants are likewise able to view language as a marker of an individuals' social identity. It thus remains an open question whether infants use language to make inferences about other people's patterns of affiliation, outside infants' own interactions with those individuals.

Here we investigate whether reasoning about affiliation intuitively recruits information about language. We test whether infants infer that people who speak the same language are more likely to affiliate than people who speak different languages. A growing body of evidence suggests that infants can reason about others' social relationships (e.g. Johnson et al., 2010; Kuhlmeir, Wynn, & Bloom, 2003; Liberman, Kinzler & Woodward, 2014; Mascaro & Csibra, 2012; 2014; Powell & Spelke, 2013). If spoken language serves as a reliable marker of social

identity, then reasoning about language as marking social relationships may emerge prior to being exposed to extensive social experiences and language-based stereotypes. On the other hand, if linking language and affiliation depends on culturally transmitted experiences and beliefs, then infants should not infer that same language speakers are more likely to affiliate. Understanding infants' inferences about language has implications for a theoretical understanding of the relationship between language and social categorization, and the developmental trajectory by which language signals social identification.

To test these ideas, we presented infants from monolingual English homes with videos featuring actors speaking English or Spanish. All conditions featured the same two bilingual individuals so that all infants saw the same two people varying only in terms of what languages they spoke. In Study 1, the actors were presented as two English speakers, or one English speaker and one Spanish speaker. Next infants saw videos where the speakers either affiliated with each other or socially disengaged. Because infants attend more to events that are inconsistent with their expectations, we used looking time to evaluate whether infants inferred information about the speakers' affiliation based on their languages. We predicted that infants would be more likely to expect the two English speakers to affiliate, and would be less likely to expect the English speaker and Spanish speaker to affiliate. In Study 2 we asked about infants' responses to two Spanish speakers to further understand their inferences about the link between language and affiliative behavior.

## Study 1

## Materials and Methods

### Participants

Thirty-two 9-month-old infants (18 female; $M_{age}$= 9 months, 3 days; range= 8;15– 9;17) participated. All infants were from monolingual English-speaking homes according to parental report, and had no regular exposure to non-English languages. This sample size included the number of infants needed to fully counterbalance the design with 16 infants in each of two conditions. Two additional infants were tested but excluded due to distress ($n$=1) and having total looking times more than 2 standard deviations above the mean of their condition ($n$=1). Participants were randomly assigned to the English-English or the English-Spanish condition.

### Procedure

During familiarization, infants watched a video repeat four times. Videos featured two actors seated together at a table. The actors faced forward and did not interact with each other: because the actors looked directly at the camera and spoke one at a time, they did not appear to be actively communicating. They instead each told a short vignette (approximately 12 seconds per actor) in either English or Spanish: one talked about the weather, and the other spoke about grocery shopping. All vignettes were spoken in infant directed speech and positive tones, meaning any differences between the conditions are likely not due to general positivity of the familiarization videos. The first speaker, her side of the table, and the language she spoke were counterbalanced across infants.

Infants were randomly assigned to one of two conditions (Fig. 1). Infants in the *English-Spanish* condition watched videos where one actor spoke English and the other actor spoke Spanish. Infants in the *English-English* condition watched videos where both actors spoke

English. The actors were both bilingual speakers of Spanish and English, so infants in each condition viewed the same two actors.

*Fig. 1. Familiarization conditions. This figure displays still images from videos of the conditions from both studies. The speech bubbles depict the beginning of each actor's vignette. In all familiarization movies the two actors sat together, but never directly interacted, they instead speak one at time while facing forward. The English-English and English-Spanish conditions were presented in Study 1, and the Spanish-Spanish condition was presented in Study 2.*

Following familiarization, all infants viewed six alternating test trials in which the actors interacted positively by affiliating or interacted negatively by socially disengaging. Because we wanted to show identical test trials across conditions, we ensured that featured vocalizations were expressive, but were not specific to English or Spanish. In affiliation trials, the actors started out facing the infant and then turned toward each other, paused briefly, and smiled and waved at one another while saying, "ā" (a long "a" sound) in a positive, high-pitched voice. In disengagement trials, the actors also started facing the infant and then turned toward each other, paused briefly, and finally turned away from each other, crossing their arms while saying

"hmph" in a negative, low-pitched voice (Fig. 2). The test trials each had the same overall length of the interaction, and in both types of test trials the actors maintained the same distance from each other throughout such that they started the same distance apart and their bodies were as close together after interacting negatively as they were after interacting positively. Infants' looking times were recorded to the still images at the end of each trial. Timing for test trials started when the motion on the screen stopped and ended when the infant looked away for 2 consecutive seconds or when 30 seconds had elapsed, whichever happened first. Test trial order (whether infants saw affiliation or disengagement interactions first) was counterbalanced across infants in each condition.

*Fig. 2. Test trials. This figure displays still images from the end of the videos of each type of test trial. Looking times were recorded to these still images*

Trained observers coded infants' attention online using jHab (Casstevens, 2007). Observers were unaware of participants' condition. For reliability, a second observer coded each infant from video. A correlation between the looking times measured by online observer and the video observer revealed high reliability (r>0.94). As a more conservative measure of agreement, we also measured whether the observers judged the same look away from the stimulus as ending the trial; observers agreed on the endpoint of 93% of test trials.

## Results

We first evaluated attention during familiarization. To ask whether gender or speaker order influenced attention, we conducted preliminary analyses looking at each of these factors separately. A repeated measures analysis of variance (ANOVA) on attention (in seconds) to familiarization trials with gender as a between-subjects factor and trial number (first, second, third, and fourth) as a within-subjects factor revealed no significant main effect of gender or significant interaction between gender and trial number ($p$s>0.80). A similar analysis revealed no significant effects of speaker order or interaction between speaker order and trial numbers ($p$s>0.19). So, further analyses collapsed across these factors. To ask whether attention differed based on the languages the actors were speaking, a repeated measures ANOVA on attention (in seconds) to familiarization trials was conducted with condition (English-English, and English-Spanish) as a between subjects factor and trial number (first, second, third, and fourth) as a within subjects factor. There was a significant effect of trial number ($F_{3,90}=4.09$, $p=.009$, $\eta_p^2=.120$) reflecting decreasing attention across trials, but no significant effect of condition ($F_{1,30}=0.671$, $p=.534$, $\eta_p^2=.017$). Thus, infants were equally attentive during regardless of the languages the actors spoke, suggesting any differences between the two conditions were not based merely on differences in attention or interest to speakers of different languages.

Next, we evaluated infants' looking patterns during test trials. For test trials, we used repeated-measures ANOVAs with attention to the screen (in seconds) after the test movies had ended as the dependent variable. Preliminary repeated-measures ANOVAs asking about potential effects of participant sex, speaker order, and test trial order found no significant main effects or interactions on attention to test trials based on gender ($p$s>.37), speaker order ($p$s>.16), or test-trial order ($p$s>.38), so subsequent analyses collapsed across these factors. A repeated

measures ANOVA evaluating infants' looking times to the test trials with condition (English-English and English-Spanish) as a between-subjects factor and test pair (first, second, or third) and test type (affiliation vs. disengagement) as within-subjects factors, revealed a significant effect of test trial type ($F_{1,30}$=9.00, $p$=.005, $\eta_p^2$=.231) with infants looking longer at engagement events ($M$=12.6 seconds, $SD$=7.7 seconds) than disengagement events ($M$=10.2 seconds, $SD$=3.7 seconds), a significant effect of pair ($F_{2,60}$=7.58, $p$=.001, $\eta_p^2$=.202), revealing decreasing attention across test trials. Critically, as predicted, this analysis also revealed a significant condition by test trial type interaction ($F_{1,30}$=27.51, $p$<.001, $\eta_p^2$=.478). In order to understand this interaction, each condition was analyzed separately by performing the same repeated-measures ANOVA on test-trial looking times for each condition with pair and test trial type as within-subjects factors.

**English-English Condition**

Infants in the English-English condition exhibited reduced attention across test trials ($F_{2,30}$=5.30, $p$=.011, $\eta_p^2$=.261), and looked significantly longer at disengagement events ($M$=10.4 seconds , $SD$=3.2 seconds) than affiliation events ($M$=8.5 seconds, $SD$=3.8 seconds; $F_{1,15}$=4.65, $p$=.048, $\eta_p^2$=.236; Fig. 3). This pattern of results held across the sample: majority of infants in the English-English condition looked longer at disengagement events than affiliation events ($n$=14 of 16, binomial $p$<.001, two-tailed; Table 1).

**English-Spanish Condition**

Infants in the English-Spanish condition looked significantly longer at affiliation events ($M$=17.0 seconds, $SD$=8.2 seconds) than disengagement events ($M$=10.0 seconds, $SD$=4.2 seconds; $F_{1,15=}$ 23.32, $p$<.001, $\eta_p^2$=.609; Fig. 3). This pattern of results held across the sample: the majority of infants in the English-Spanish condition looked longer at affiliation events than disengagement events ($n$=15 of 16, binomial $p$<.001, two-tailed; Table 1).

| | Positive Engagement | Disengagement | Binomial probability |
|---|---|---|---|
| English-English | 2 | 14 | p<.001 |
| English-Spanish | 15 | 1 | p<.001 |
| Spanish-Spanish | 6 | 10 | n.s. |

*Table 1. Number of infants looking longer to each type of test trial by condition.*

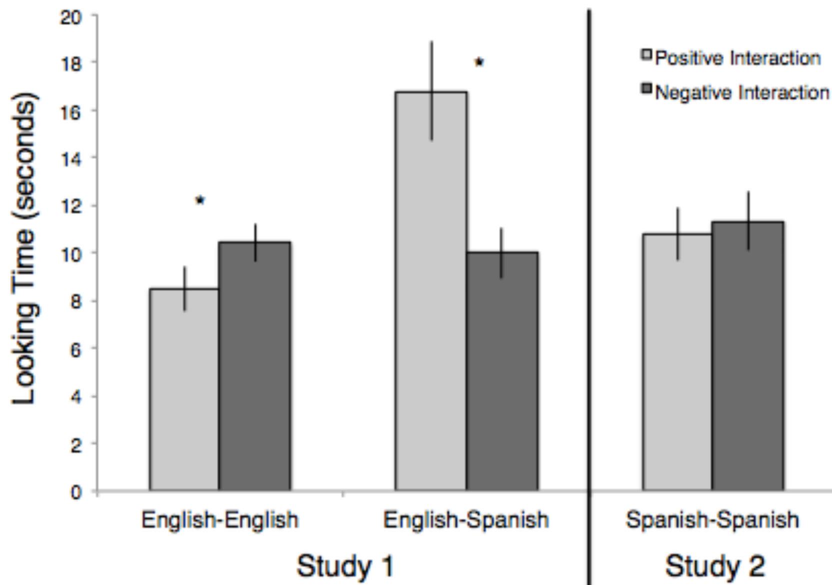


*Fig. 3. Looking times to test trials. This graph depicts the average looking time to positive and negative interaction trials for infants in each condition. Error bars represent the standard error of the mean looking time. Asterisks indicate a significant difference in the individual ANOVAs for each condition.*

## Discussion

Overall, infants' responses to the affiliation and disengagement events varied systematically based on the languages that the adults spoke. When the adults spoke two distinct languages, infants looked longer at subsequent affiliation, suggesting this was unexpected. However, the same pattern was not seen when the two adults spoke the same language. When infants heard both adults speak English they looked longer at the disengagement events. These results suggest that infants were more likely to expect affiliation between two people who spoke

the same language, English, than two people who spoke different languages, English and Spanish.

In study 2 we evaluated a potential alternative explanation for these findings. Whereas we argue that infants' responses in study 1 are due to expectations based on the actors speaking the same versus different languages, it is possible that infants' differential patterns of looking were due to the fact that one set of displays involved only familiar-language speakers (English), and one set of displays included an unfamiliar-language speaker (Spanish in addition to English). Perhaps infants found the presence of Spanish surprising or distracting, and thus any expectation they may have had of the two individuals' affiliation was disrupted. If this is the case, infants might find affiliation unexpected in any situation involving an unfamiliar language, regardless of whether or not the two individuals spoke the same or different languages. To ask whether infants found affiliation in the English-Spanish unexpected because the actors spoke different languages, or merely because of the presence of an unfamiliar language (Spanish), we ran another condition where infants were presented with the same two actors both speaking Spanish. If the mere presence of Spanish disrupts infants' expectations about affiliation, then infants should find affiliation unexpected, and the results of the Spanish-Spanish condition should mirror those in the English-Spanish condition. Alternatively, if infants found affiliation unexpected in the English-Spanish condition due their attention to the fact that the two people were speaking two different languages, then infants' pattern of looking in the Spanish-Spanish condition should more closely resemble infants' pattern of looking in the English-English condition.

## Study 2

## Materials and Methods

### Participants

Sixteen 9-month-old infants (9 female; $M_{age}$= 9 months, 0 days; range= 8;9– 9;16) participated. All infants were from monolingual English-speaking homes according to parental report, and had no regular exposure to non-English languages. No additional infants were tested.

### Procedure

The procedure was identical to Study 1, except the two actors both spoke Spanish. During familiarization, infants watched a video repeat four times. The video featured the same two actors from the first study seated together at a table, facing forward and telling short vignettes. As in Study 1, the actors spoke in positive tones using infant directed speech, and one talked about the weather while the other spoke about grocery shopping. Infants in this *Spanish-Spanish* condition watched videos where both actors spoke Spanish.

Following familiarization, all infants viewed identical test trials to first study. Trained observers coded infants' attention online using jHab. Observers were unaware of participants' condition. For reliability, a second observer coded each infant from video. A correlation between the looking times measured by online observer and the video observer revealed high reliability ($r>0.94$) between the observers. As a more conservative measure of agreement, we also measured whether the observers judged the same look away from the stimulus as ending the trial; observers agreed on the endpoint of 95% of test trials.

### Results

We first evaluated attention during familiarization using the same repeated-measures ANOVA method as in Study 1. Preliminary analyses revealed no effects of participant sex

(*p*s>.30) or speaker order (*p*s>.15) during familiarization, so analyses collapsed across these factors. As in Study 1, a repeated measures ANOVA on attention (in seconds) to familiarization trials with trial number (first, second, third, and fourth) as a within subjects factor revealed significant effect of trial number ($F_{3,45}$=11.76, $p$<.001, $\eta_p^2$=.439), reflecting decreased attention across familiarization trials. Importantly, an ANOVA comparing attention to this study to attention in both conditions of Study 1 (English-English, and English-Spanish) revealed no significant effect of condition ($F_{2,45}$=0.35, $p$=.677, $\eta_p^2$=.017), suggesting infants were equally attentive during familiarization regardless of the languages the actors spoke.

For test trials, a repeated measures ANOVA on the looking times (in seconds) to each test trial with test pair (1$^{st}$, 2$^{nd}$, or 3$^{rd}$) and type (affiliation, disengagement) as within subjects factors did not reveal any significant main effects or interactions. That is, infants in the Spanish-Spanish condition did not look significantly longer at either disengagement events (*M*=11.3 seconds, *SD*=5.0 seconds) or engagement events (*M*=10.8 seconds, *SD*=4.6 seconds; $F_{1,15}$=0.30, $p$=.86, $\eta_p^2$=.002; Fig. 3). Indeed, there was no significant difference in the number of infants who looked longer at either test movie (*n*=10 of 16 looked longer at disengagement, binomial *p*>.4; Table 1).

Although infants in the Spanish-Spanish condition did not show a statistically reliable pattern in their looking times, the pattern of responses in this condition more closely mirrored the English-English condition of Study 1 than the English-Spanish condition of Study 1. In particular, the number of infants in the Spanish-Spanish condition who looked longer at disengagement trials (*N*=10 of 16) differed significantly from the number of infants in the English-Spanish who looked longer at disengagement trials (*N*=1 of 16; Fisher's exact test, *p*<.001, two-tailed), but did not differ significantly from the number of infants in the English-

English condition who looked longer at disengagement trials (*N*=14 of 16; Fisher's exact test, *p*=.22, two-tailed).

## Discussion

Although infants from monolingual English-speaking houses did not display clear expectations about whether two Spanish-speakers would affiliate or disengage, comparing the Sp*anish-Spanish* condition to the *English-English* and *English-Spanish* conditions of Study 1 allows us to draw some conclusions about infants' inferences relating language to social relationships. First, infants expectations that a English speaker will not affiliate with a Spanish speaker are not likely due to infants' finding any type of affiliation involving an unfamiliar speaker unexpected: infants do not look significantly longer at affiliation events between two Spanish speakers. Second, the fact that infants' general pattern of responses, as seen in the non-parametric data, to viewing two Spanish speakers are significantly different from their responses to viewing an English and a Spanish speaker, but not significantly different from their pattern of responses to viewing two English speakers, suggests that infants expect same language speakers to be more likely to affiliate than different language speakers. That is, even though infants did not evidence clear expectations about the relationship between two Spanish speakers, in relative terms they expected two Spanish speakers to be more likely to affiliate than an English speaker and a Spanish speaker.

## General Discussion

Before infants speak themselves, they expect spoken language to be an important marker of social relationships. In addition to understanding perceptual differences between languages (e.g., Hohle et al., 2009), the social nature of language (e.g., Beier & Spelke, 2012), and preferring native language speakers (e.g., Kinzler et al., 2007), our study suggests infants use

language to make inferences about which people are likely to affiliate with each other. Our findings indicate that a conceptual link between spoken language and social relationships emerges before children have access to explicit cultural beliefs and stereotypes about the social significance of language.

Although our findings suggest that languages people speak influence infants' inferences about whether those people will affiliate, the specific nature of these inferences is still an open question. One possibility is that infants' inferences are related to their understanding of communication. Infants understand that speech communicates information (e.g. Martin, Onishi & Vouloumanos, 2012; Vouloumanos, Marin, & Onishi, 2014), and monolingual infants may expect people to only understand one language (Pitts, Onishi, & Vouloumanos, 2015), suggesting infants in our study may infer relationships between speakers of the same language because they expect those people to be able to communicate. Alternatively, infants might appreciate that languages mark individuals as members of larger social groups (e.g. Labov, 2006). Infants expect members of the same group to share common behaviors or preferences (e.g. Powell & Spelke, 2013; Liberman, Woodward, Sullivan, & Kinzler, submitted). So, if infants' inferences about social relationships are tied to their thinking about social groups more broadly, they might make inferences that people who speak the same language will share common behaviors and preferences, or expect speakers of the same language to participate in a range of social interactions that favor linguistic ingroup members. Further research is needed to investigate these possibilities.

The infants in our sample were from monolingual homes, suggesting direct experience with diverse languages is not required for infants to be able to make inferences about affiliation as related to linguistic diversity. That is, monolingual exposed infants expected familiar language

speakers to affiliate, but found it unexpected for speakers of different languages to affiliate. Importantly, these results were not due to mere unfamiliarity of Spanish: infants did not find it unexpected for two Spanish speakers to affiliate. This suggests that infants expect same-language speakers to be more likely to affiliate than different language speakers, even when the same language speakers are using an unfamiliar language (i.e., Spanish). However, experience likely plays a role in shaping language-based social inferences. Infants' inferences about speakers of familiar languages were more robust than their inferences about speakers of unfamiliar languages, suggesting infants may need some exposure to a particular language to form specific expectations about people speaking that language. In this case, we might expect that infants from monolingual Spanish-speaking communities would make stronger inferences about two Spanish speakers than about two English speakers. More generally, our results suggest that infants have the ability to use language to make inferences about social relationships, but that experience with their native language may help them form more robust expectations about familiar-language speakers.

Multilingual language experience may also play an important role in shaping infants' inferences about language. For instance, multilingual exposure influences social cognitive skills such as imitation and perspective taking, even for infants and children who are in predominantly English-speaking homes (e.g. Fan, Liberman, Keysar & Kinzler, 2015; Howard, Carrazza & Woodward, 2014). It is possible that exposure to a multilingual environment would also influence infants' expectations about how language relates to social identity and social relationships. Infants raised in multilingual homes may be less likely to use language as a marker of affiliation since they have experience seeing positive social interactions among people who speak multiple languages. On the other hand, it is possible that even infants from multilingual

backgrounds may base their inferences about others' social relationships on those peoples' languages. Future research looking at infants from monolingual non-English speaking homes and from multilingual homes will help elucidate the role of experience on inferences linking spoken language to social relationships.

Our findings also raise interesting questions about which types of similarity guide infants' reasoning about third-party affiliation. When forming expectations about affiliation infants may be particularly sensitive to similarities that likely mark social group. Language and food preferences are socially relevant cues that fundamentally mark cultural group membership and social relationships (e.g. Cohen, 2012; Germov & Williams, 2008). Past research suggests that infants expect people with shared food preferences to be more likely to affiliate than people with opposing food preferences (Liberman, Kinzler, & Woodward, 2014). Taken together with this study, these results suggest that infants are able to use fundamental social markers to make inferences about third party affiliation. It is possible that infants would not use similarities on more arbitrary or socially irrelevant dimensions to reason about affiliation.

These questions aside, the current findings provide the first evidence that infants use a person's spoken language to make third-party social inferences. Infants expect people who speak the same language to be more likely to affiliate than people who speak different languages, providing evidence that they use language to reason about social relationships. Thus, infants appear to be ready to detect linguistic diversity and use this information to form inferences about people and their likely social interactions. Even before infants speak their native language, they see language as a robust cue that can help them understand the social world.

# Part II: Infants expect imitation of causally-irrelevant actions to carry social meaning

Imitation is a pervasive and important aspect of human behavior throughout development. Starting in the first year of life, infants understand and selectively reproduce other people's goals (e.g., Hamlin, Hallinan, & Woodward, 2008; Meltzoff, 1995; Meltzoff, 1988; Woodward, 1998). Indeed, a seminal finding in developmental psychology suggests that infants' imitation is not a simple low-level reenactment of what they see a model do, but is instead guided by interpreting the model's underlying intentions (Gergely, Bekkering, & Kiraly, 2002). Gergely and colleagues (2002) showed 14-month-olds an event in which a model activated a light by pressing it with her head, and then gave infants the chance to imitate the action. Importantly, some infants saw events where the model's choice to use her head was an intentional and important feature of the event: the model's hands were free, but she placed them on the table and used her head to activate the light. Other infants saw the same head touch event, but the set up suggested that the model used her head based on situational constraints: the model's hands were occupied holding a blanket around herself, so she used her head to turn on the light. Infants imitated differentially in these cases: they used their heads to active the light more often when the model intentionally chose to do so, and were more likely to use their hands when the model used her head based on situational constraints (Gergely et al., 2002). The authors deemed this phenomenon *rational imitation* because infants seemed to selectively encode and imitate the model's underlying goal.

It is possible that this type of rational imitation is a precursor to cultural learning. In particular, like turning on a light using one's head, many cultural conventions and rituals are causally opaque but socially stipulated (e.g., Humphrey, & Laidlaw, 1994; Legare & Souza, 2012). Because these cultural behaviors are not necessary for achieving instrumental goals, and only have meaning as conventions, they must be learned through high fidelity imitation of

members of one’s social group. Indeed, although imitation almost certainly has multiple functions, one important function of imitation is that it enables transmission of cultural norms and conventions (e.g., Legare, & Neilsen, 2015; Neilsen, 2012; Whiten, Hinde, Laland, & Stringer, 2011). Children show a robust propensity to imitate other people’s actions, even when it is clear that those actions are not causally necessary for reaching a particular outcome (e.g., Lyons, Young & Keil, 2007; Lyons, Damrosch, Lin, Macris, & Keil, 2011), and a growing body of recent research provides compelling evidence that this type of imitation of causally-irrelevant features of actions is based on cultural learning. As example, children are more likely to imitate irrelevant actions that are presented as conventional rather than instrumental (Clegg & Legare, 2016; Herrmann, Legare, Harris, & Whitehouse, 2013; Legare, Wen, Herrmann, & Whitehouse, 2015), are more likely to imitate causally-irrelevant actions done by cultural ingroup members than those done by outgroup members (e.g., van Schaik & Hunnius, 2016), and imitating conventional goals increases children affiliation with ingroup members (Wen, Herrmann & Legare, 2016). The tendency to constrain imitation of causally-irrelevant actions (including turning on a light with one’s head) to cultural ingroup members emerges in infancy (e.g., Buttelmann, Zmyj, Daum, & Carpenter, 2013; Howard, Henderson, Carazza, & Woodward, 2015), suggesting that rational imitation may indeed be linked to learning cultural group norms and rituals.

However, the idea that the original head-touch findings (e.g., Gergely et al., 2002) demonstrate rational imitation at all has recently come under scrutiny. For instance, Paulus and colleagues (Paulus, Hunnius, Vissers, & Bekkering, 2011; Paulus, Hunnis, & Bekkering, 2013) suggest that rather than being relevant to social learning, infants’ differential imitation in the head-touch paradigm could be instead be due to physical constraints and infants’ own motor

abilities. By designing further conditions, they found that infants imitate head touches when the required motor behavior is in their motor repertoire, but not in highly similar cases where a motor behavior is not in their motor repertoire (Paulus et al., 2011; Paulus et al., 2013).

Other researchers suggest that infants' imitation of causally-irrelevant actions is social but not that it is necessarily relevant to cultural learning. For instance, affiliative accounts argue that infants imitate to bond with the model. Indeed, imitation more generally can lead to increased interpersonal closeness for adults and children (e.g., Chartrand & Bargh, 1999; Lakin & Chartrand, 2003; Lakin, Chartrand, & Arkin, 2008; Over & Carpenter, 2012; 2013; Over, Carpenter, Spears, & Gattis, 2013; Uzgiris 1981), and even infants show social preferences for people who have imitated them (Metlzoff, 1990). Thus, infants may imitate a model's goal to initiate positive social relationships without evidencing any abstract understanding of the role of imitation in learning of cultural norms and conventions. Indeed, although infants whose actions and expressions are imitated by an adult subsequently engage in more prosocial behavior, their prosociality is not restricted towards the person who previously imitated them (Carpenter, Uebel, & Tomasello, 2013), suggesting imitation may support general positivity and social bonding rather than carrying specific social and culturally relevant information.

Studies involving infants' own imitation cannot successfully differentiate between non-social, affiliative, and cultural normative accounts because all of these accounts would expect infants to demonstrate imitation (at least in some cases). Therefore, in order to ask whether infants make inferences that engaging in the same causally irrelevant actions can potentially be a signal of social structure and cultural norms, it is necessary to use alternative methods. Specifically, studies of expectations about third-party imitation are particularly informative because non-cultural normative accounts (such as non-social explanations or accounts based on a

desire to bond with the model) would not predict third-party judgments or expectations based on patterns imitation. Indeed, studies about third-party judgments and expectations have provided some of the clearest evidence that children reason about imitation as socially meaningful and culturally normative: children use patterns of imitation to make inferences about friendship (Over & Carpenter, 2015), enforce imitation of non-causally relevant actions on third-parties (e.g., Kenward, 2012; Kenward, Karlsson, & Persson, 2011), and protest when third-parties refrain from imitating (e.g., Keupp, Behne, & Rakoczy, 2013).

Although spontaneous protest and explicit judgments methods cannot be used with infants, there are other methods available that allow researchers to investigate third-party reasoning. Specifically, violation of expectation looking time studies use infants' natural attention to examine third-party expectations non-verbally, and find that in general infants look longer at events that are inconsistent with their expectations (e.g., Hespos & Baillargeon, 2008). Therefore, we employed a violation of expectation looking time methodology to ask whether infants form third-party expectations about relationship between social structure and shared engagement in causally-irrelevant actions. In particular, we created events based on the original head touch procedure (e.g., Gergely et al., 2002; Meltzoff, 1988) in order to ask whether infants expect people who imitate one another by performing the same causally irrelevant action to be more likely to affiliate with each other than people who instead perform different actions.

## Study 1

For the first study, infants saw two actors use causally irrelevant means to achieve the same goal of turning on a light. Infants were randomly assigned to see one of two conditions: half of the infants were assigned to the Same Actions condition and therefore saw videos where the actors used the same irrelevant action to achieve the same outcome (e.g. turning on the light

using their forehead), while the other half were assigned to the Different Actions condition and saw videos where the actors used different irrelevant actions to achieve the same outcome (e.g. one turned on the light using her forehead, and the other turned on the light using her elbow). Subsequently, we used infants' natural attention to ask whether they expected the two actors to affiliate with one another or socially disengage. If infants expect imitation to carry social or conventional meaning, then they might infer that people who choose to imitate each another by performing the same action are more likely to affiliate than people who actively choose not to imitate each other. As a secondary question, we were also interested in infants' own actions and whether their patterns of imitation of the causally-irrelevant features of actions varied based on whether they were assigned to the Same Action or Different Actions conditions, so infants were also given a period of time both before and after watching the videos in which they could explore the light that the actors used in the videos.

## Method

### Participants

32 sixteen-month-olds (16 female; $M_{age}$ = 16;15, range = 15;19 to 17;19) participated. No additional infants were tested but excluded. Half of the infants were randomly assigned to the Same Action condition, and half were randomly assigned to the Different Actions condition.

### Procedure

The procedure consisted of three phases. In the first phase of the study each infant was seated on a parent's lap at a small table. An experimenter brought out a push-light toy for the infant to explore. The toy consisted of a light that was mounted on a transparent green box covered in star stickers, and inside the box there were bells that made noise if the toy was moved or shaken. The experimenter placed the toy in front of the infant on the table and said, "Look!

Here is a new toy! You can play with it however you like." After the instruction, the experimenter allowed the infant to play with the toy for 30 seconds (Figure 4). Parents were told not to interfere and not to instruct their children on how to play with the toy. Thus, children explored the toy on their own, unless they dropped the toy, in which case the experimenter picked it up and placed it back on the table. After 30 seconds, the experimenter removed the toy from the table, and took it behind a large screen to start the next phase of the study.

*Fig. 4. Infant exploring the push-light toy. Before and after watching videos of the actors demonstrating how to use the toy, infants were given 30 seconds to explore the toy in any way they liked.*

In the second part of the study, infants watched videos projected onto the large screen. These videos featured life-sized actors interacting with the push-light and with each other. The videos differed based on whether the infant had been randomly assigned to the Same Action condition ($N$=16) or the Different Actions condition ($N$=16). The familiarization section of this phase of the experiment consisted of videos of the two actors sitting at a table with the push-light between them. On each trial, the actors took turns activating the light. In the Same Action

condition infants saw each actor use the same novel action to turn on the light: either both actors turned on the light by pressing it down with their heads, or both actors turned on the light by pressing it down with their elbows. In the Different Action condition infants saw the two actors turn on the light using different novel actions: one actor turned on the light by pressing it down using her head, and the other turned on the light by pressing it down using her elbow (Figure 5). Which actor acted first, and the type of action she performed (using her head vs. her elbow) were counterbalanced across subjects. The familiarization movie repeated four times.

*Fig. 5. Study 1 Design. Infants were randomly assigned to the Same Action condition (left) or the Different Actions condition (right). In both conditions infants first saw familiarization trials where actors turned on the light using novel actions (4 trials), and then saw alternating test trials where the actors interacted by affiliating and socially disengaging (6 trials).*

The second phase continued by having infants view videos of six alternating test trials where the actors interacted with each other by either affiliating, or socially disengaging. Affiliation test trials started with the actors standing next to one another on the screen. They then turned toward each other, smiled and waved, while saying “Hi!” in high-pitched voices. Disengagement test trials also started with the actors standing next to one another on the screen.

They then turned away from each other, frowned and crossed their arms, while saying "Hmp!" in low-pitched voices (Figure 5). Looking time was coded by trained observers using jHab (Casstevens, 2007). Each test trial was coded starting when the movement on the screen ended (with the actors facing each other with their arms extended for affiliation trials, or with the actors facing away from each other with their arms crossed for disengagement trials) and ending when the infant looked away for two consecutive seconds or when 30 seconds had elapsed. One observer coded online during the study, and a second observer coded each infant from video. Observers were unaware of the participant's assigned condition. For reliability we measured whether the observers agreed about the endpoint of the trial; coders agreed on 92% of test trials. Because infants look longer at events that are inconsistent with their expectations (e.g., Hespos & Baillargeon, 2008), attention during the test trials served as evidence concerning infants' inferences about which type of relationship the actors were likely to have.

The third phase of the experiment was nearly identical to the first phase. After watching the movies, the experimenter reemerged from behind the screen with the push-light toy and said to infants, "Look! Remember this toy? You can play with it however you want." She then placed the toy on the table in front of the infant and allowed the infant to engage with the toy for 30 seconds. Both phases where infants were allowed to play freely with the push-light were later coded from video. In this coding, the coder measured the amount of time infants spent playing with the light portion of the toy (as opposed to other parts of the box), whether the infant turned the light on (or clearly attempted to turn the light on), and the methods that each infant used to turn on (or attempt to turn on) the light.

## Results

### Infants' initial exploration of the push-light

Approximately one third of the infants turned on the light during their initial exploration (*N*=11 of 32). The number of infants who turned on the light did not differ between the Same Action condition (*N*=6 of 16) and the Different Action condition (*N*=5 of 16; Fisher's exact test *p*=1.00). Infants also spent similar amounts of time interacting with the light in each condition (Same Action: *M*=11.7 seconds; Different Actions: *M*=11.1 seconds). No infants turned on (or attempted to turn on) the light using a body part other than their hand. Thus, at baseline, infants' initial exploration of the light was the same regardless of which condition of the experiment they had been randomly assigned to.

### Looking time measures

Preliminary analyses revealed no effects of sex or test trial order, so analyses collapsed across these factors. A repeated measures ANOVA evaluating infants' looking times to test trials with condition (Same Action vs. Different Actions) as a between subjects factor and pair ($1^{st}$, $2^{nd}$, or $3^{rd}$) and test trial type (Affiliation vs. Disengagement) as within subjects factors revealed a main effect of pair ($F_{2,29}=10.80$, $p=.003$), reflecting decreasing attention, a significant type by pair interaction ($F_{2,29}=12.29$, $p<.001$), and a significant test trial type by condition interaction ($F_{1,30}=13.32$, $p<.001$), suggesting the effect of test trial type was different based on whether the actors had used the same action or used different actions to turn on the light. No other main effects or interactions reached significance (*p*s>.20). To investigate the interaction between condition and test trial type, the conditions were analyzed separately.

### Different Actions Condition

Each condition was analyzed using two types of analysis: parametric and non-parametric.

The parametric analysis allowed us to ask about whether there are overall differences in the amount of time infants spent attending to each type of test trial, while the non-parametric analysis allowed us to ask whether the majority of the infants in a particular condition show a consistent pattern of responses. For the parametric analysis, we ran a repeated measures ANOVA evaluated infants' looking times with pair ($1^{st}$, $2^{nd}$, or $3^{rd}$) and type (Affiliation vs. Disengagement) as within subjects factors. This analysis revealed a significant main effect of test trial type ($F_{1,15}$=22.25, $p$<.001), and no other significant main effects or interactions ($p$s>.22). The significant effect of type was due to infants looking longer at Affiliation trials ($M$=9.4 seconds) than Disengagement trials ($M$=7.0 seconds; Figure 6), suggesting infants found it unexpected for the actors to affiliate.

The non-parametric analysis categorized each infants based on whether she looked longer at affiliation events or disengagements events, and asked whether more infants demonstrated one of these patterns of responses. In fact, the majority of infants in the Different Actions condition looked longer at Affiliation trials than at Disengagement trials ($N$=15 of 16, binomial $p$<.001, two-tailed). Thus, the non-parametric analyses conceptually replicated the parametric analyses and suggest that infants who saw the actors use different causally irrelevant actions found it unexpected for those actors to subsequently affiliate.

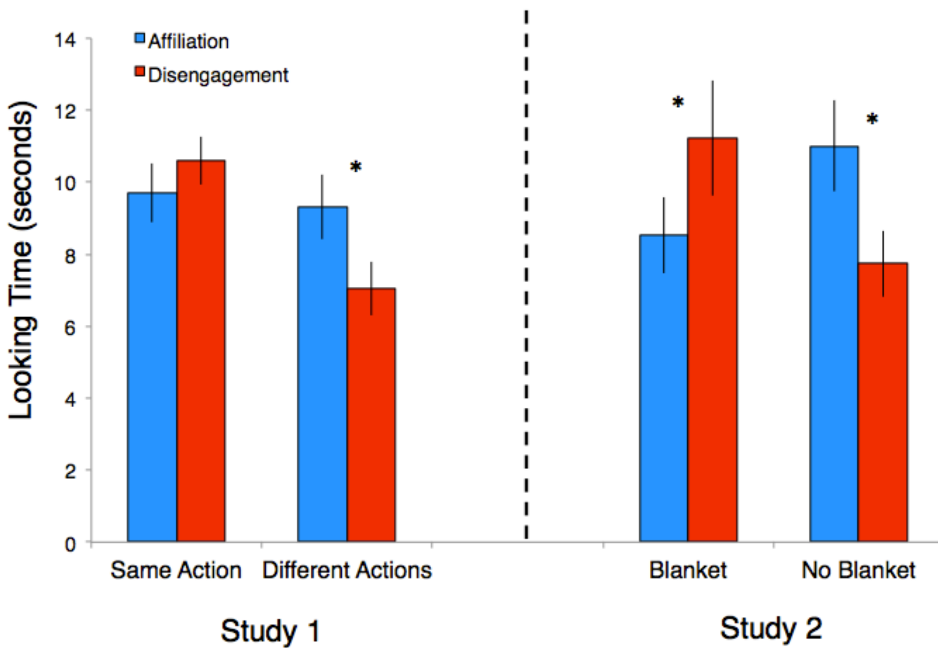


*Fig. 6. Looking times to test trials. This figure illustrates the average looking times to both types of test trials for infants in each study with error bars indicating the standard error of the average looking time. Asterisks indicate a significant difference in looking to the different trial types as indicated by the ANOVAs.*

**Same Action Condition**

The Same Action condition was analyzed with the same parametric and non-parametric analyses. For the parametric analyses, a repeated measures ANOVA evaluated infants' looking times with pair (1$^{st}$, 2$^{nd}$, or 3$^{rd}$) and type (Affiliation vs. Disengagement) as within subjects factors. The analysis revealed a significant main effect of pair ($F_{2,14}$=8.92, $p$=.001), reflecting decreasing attention across trials, and a marginally significant trial type by pair interaction ($F_{2,14}$=2.67, $p$=.085), because the looking to Affiliation trials decreased faster than looking to Disengagement trials (see Figure 7 for details). The main effect of trial type was not significant ($F_{1,15}$=1.83, $p$=.196); infants looked for similar amounts of time on average at Disengagement trials ($M$=10.6 seconds) and Affiliation trials ($M$=9.7 seconds; Figure 6). Thus, the parametric data do not reveal clear expectations about the actors' likely social relationship.

However, the non-parametric analyses suggested a clearer pattern. Although there were no significant difference in the average amount of time infants spent looking at each type of test movie, the majority of infants in the Same Action condition looked longer at Disengagement trials than at Affiliation trials ($N$=13 of 16, binomial $p$=.021, two-tailed). Thus, the non-parametric results suggest infants may find it unexpected for actors who imitate one another and engage in the same causally irrelevant novel action to socially disengage. Additionally, this pattern of results was significantly different from the non-parametric results seen in the Different Actions condition (Fisher's exact test $p$<.001).

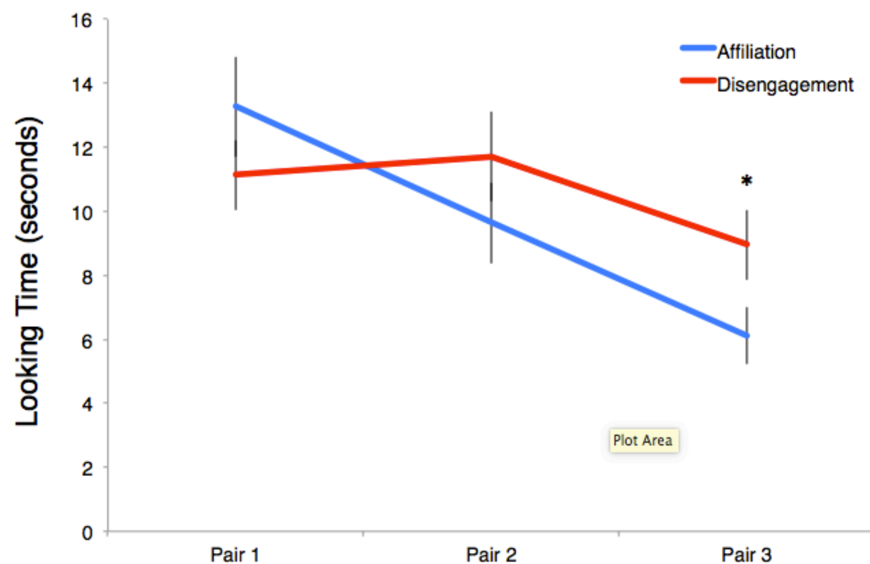


*Fig. 7. Looking times to Same Action condition of Study 1 by Pair. This figure illustrates the average looking times to all test trials for infants the Same Action condition of Study 1 with error bars indicating the standard error of the average looking time. Looking time to the affiliation trials decreases more quickly than looking time to the disengagement trials, and whereas there are no significant differences in looking time based on trial type in the first two pairs, posthoc analyses reveal that on the third test pair infants looked significantly longer at the Disengagement event than at the Affiliation event.*

**Infants' exploration of the push-light at the end of the study**

Infants' exploration of the light following the looking time measures was the same regardless of which condition of the experiment they had been assigned to. More specifically. half of the infants turned on the light during the final phase (*N*=16 of 32), but the number of infants who turned on the light did not differ between the Same Action condition (*N*=10 of 16) and the Different Action condition (*N*=6 of 16; Fisher's exact test *p*=.289). Infants also spent similar amounts of time interacting with the light in each condition (Same Action: *M*=14.1 seconds; Different Actions: *M*=12.6 seconds). Turning on the light using a method other than a hand touch was rare: 3 infants in the Same Action condition and one infant in the Different action condition turned on the light using their head, which was not significantly different across conditions (Fisher's exact test *p*=.600). There are a few possible reasons why infants' imitation was so low: the models were presented on video, which may have lead to a video deficit effect (e.g., Anderson & Pempek, 2005; Barr & Hayne, 1999), the toy used in this study was more exciting than toys in past studies as it had multiple affordances, meaning there were many ways to interact with the toy without imitating the models' action, and studies with baseline periods where infants are able to figure out that they can use their hand to activate the toy generally have lower levels of imitation of causally irrelevant actions (e.g., Pinkham & Jaswal, 2011).

## Discussion

Infants made different inferences about the actors' likely relationship based on how the actor's had previously interacted with the push light. When the actors intentionally turned on the light using different novel actions, infants looked significantly longer at subsequent affiliation, suggesting they found affiliation unexpected. However, the same pattern was not seen for infants who saw the two adults use the same novel action to turn on the light. More infants who saw the

actors use the same novel action looked longer at disengagement events. Thus, infants may be more likely to expect affiliation between people who imitated each other by using the same novel action to act on the light than between people who used different novel actions. These results suggest that infants expect it to be socially meaningful for two people to choose to engage in the same versus different causally-irrelevant actions, and provide potential evidence for an early-developing understanding of the link between imitation and social or cultural norms. In addition to past work suggesting that social factors influence infants' own imitation, our research indicates that infants form abstract expectations about third-party social relationships based on whether people imitate each other by using the same actions to reach their goal.

In study 2 we extended our findings by running a conceptual replication that allowed us to rule out a lower-level explanation. Specifically, because the actors in the Same Action condition did the exact same action, while actors in the Different Action condition did perceptually distinct actions, it is possible that the results were not due to a deep understanding of the role of shared engagement in causally irrelevant actions, but rather that infants find affiliation unexpected between actors who do perceptually dissimilar actions. Thus, in order to ask whether infants' expectations were based on the similarity of the actions performed by the actors, or were based on whether the actors engaged in the same underlying goal, we created stimuli where the actions in both conditions did perceptually distinct actions, but in one case the actors seemed to have the same goal, and in other, their goals differed.

In particular, infants in both conditions saw two actors use different means to turn on the push light: one actor turned on the light using her head, and the other turned on the light using her hand. The conditions differed only in terms of whether the actor using her head could have easily also chosen to use her hand (No Blanket condition) or whether the actor using her head

was unable to accomplish the outcome of turning on the light by using her hand (Blanket condition). Past studies suggest infants are sensitive to this manipulation in their own imitation and are more likely to imitate the head-touch action in cases where the model could have easily chosen to use her hands (e.g., Gergely et al., 2002), suggesting that in cases where it seems like the model intentionally used her head when she did not need to, infants see using their head as a relevant part of the overall goal. So, even though actors in both conditions are engaging in perceptually dissimilar actions, in the Blanket condition, both actors seem to have the same underlying goal of turning on the light using whatever means they have available, while in the No Blanket condition, infants may see the means of turning on the light as an integral part of goal, since either actor could have chosen to conform to the other. Therefore, if the results of the first study were due to the actors performing perceptually similar versus perceptually dissimilar actions, then infants might not expect affiliation between actors who engage in perceptually dissimilar actions, even in cases where the dissimilarity is due to situational constraints. Alternatively, if infants' responses in the first study were due to seeing the actors' intentional but non-causally relevant actions as socially relevant, then infants might expect affiliation between actors who engage in the same goal, even if the actors need to perform perceptually different actions to reach that goal.

## Study 2

## Method

### Participants

32 sixteen-month-olds (17 female; $M_{age}$ = 16;16, range = 15;18 to 17;19) participated. Two additional infants were excluded due to inattention (*N*=1) and experimenter error (*N*=1). Infants were randomly assigned to the Blanket condition (*N*=16) or the No Blanket condition (*N*=16).

**Procedure**

The procedure was identical to Study 1, except for the second phase of the study. Specifically, in the looking time portion of the study infants were randomly assigned to one of two conditions, the Blanket Condition, or the No Blanket Condition. The familiarization section of this phase consisted of videos of two actors sitting at a table with the push-light between them. On each trial, the actors took turns activating the light: one turned it on by pressing it down using her hand, and the other turned it on by pressing it down using her head. The only difference between conditions was that in the Blanket Condition the actor using her head to activate the light was wrapped in a blanket, meaning her hands were inaccessible so it was not possible for her to use them to turn on the light. However, in the No Blanket Condition, the actor who used her head to turn on the light was not wearing a blanket, meaning she could have used her hands to turn on the light, but instead placed her hands on the sides of the box and intentionally chose to use her head (Figure 8). The order of the actions (hand first vs. head first) as well as which actor used her head to turn on the light was counterbalanced across subjects. The familiarization movie repeated four times. Infants then viewed the same test trials used in Study 1, where they saw the actors alternate between affiliating with one another and socially disengaging. Live looking time coding and reliability coding were also measured in the same way as Study 1, with coders agreeing on 93% of test trials.

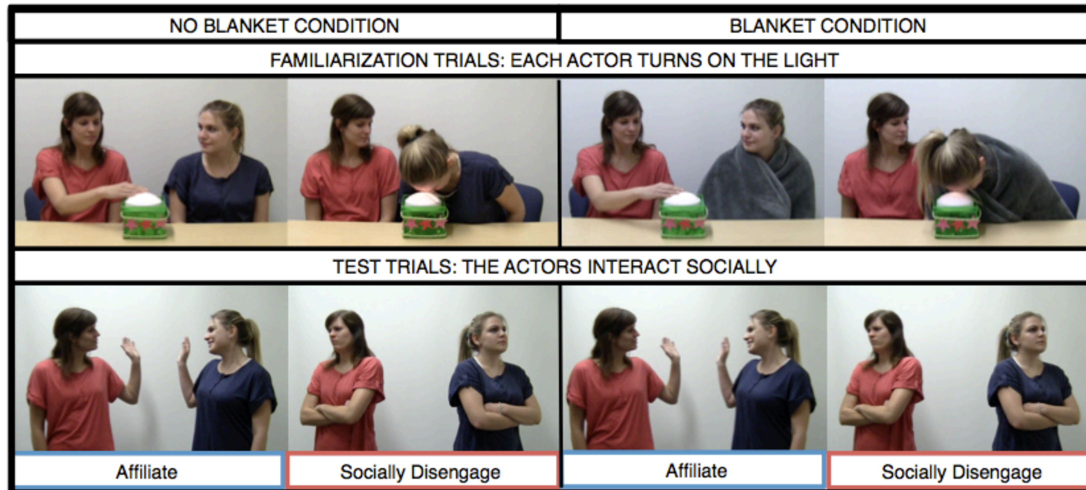


*Fig. 8. Study 2 Design. Infants were randomly assigned to either the Blanket condition (left) or the No Blanket condition (right). In both conditions infants first saw familiarization trials where one actor turned on the light using her hand, while the other actor turned on the light using her head (4 trials), and then saw alternating test trials where the actors interacted with one another by affiliating and socially disengaging (6 trials).*

## Results

### Infants' initial exploration of the push-light

Approximately one third of the infants turned on the light during their initial exploration ($N$=11 of 32). The number of infants who turned on the light did not differ between the Blanket condition ($N$=5 of 16) and the No Blanket condition ($N$=6 of 16; Fisher's exact test $p$=1.00). Infants also spent similar amounts of time interacting with the light in each condition (Blanket: $M$=15.1 seconds; No Blanket: $M$=15.6 seconds). No infants turned on (or attempted to turn on) the light using a body part other than their hand. Thus, at baseline, infants initial exploration of the light was the same regardless of which condition of the experiment they were randomly assigned to.

### Looking time measures

Preliminary analyses revealed no effects of sex or test trial order, so analyses collapsed across these factors. A repeated measures ANOVA evaluating infants' looking times to test trials

with condition (Blanket vs. No Blanket) as a between subjects factor and pair ($1^{st}$, $2^{nd}$, or $3^{rd}$) and test trial type (Affiliation vs. Disengagement) as within subjects factors revealed a marginal main effect of pair ($F_{2,29}$=3.06, $p$=.062), reflecting decreasing attention, and a significant test trial type by condition interaction ($F_{1,30}$=29.54, $p$<.001). No other main effects or interactions reached significance ($p$s>.20). To investigate the interaction between condition and test trial type, the conditions were analyzed separately.

**Blanket Condition**

A repeated measures ANOVA evaluating infants' looking times with pair ($1^{st}$, $2^{nd}$, or $3^{rd}$) and type (Affiliation vs. Disengagement) as within subjects factors revealed a significant main effect of type ($F_{1,15}$=10.73, $p$=.005). Infants looked significantly longer at Disengagement trials (*M*=11.2 seconds) than Affiliation trials (*M*=8.5 seconds; Figure 6). This pattern held across the sample in non-parametric analyses: the majority of infants looked longer at Disengagement trials than at Affiliation trials (*N*=13 of 16, binomial $p$=.021, two-tailed). No other effects or interactions reached significance ($p$s>.40). Thus, infants found it unexpected for the actors who had the same underlying goal to disengage, even though they used perceptually different means to achieve their goal.

**No Blanket Condition**

A repeated measures ANOVA evaluating infants' looking times with pair ($1^{st}$, $2^{nd}$, or $3^{rd}$) and type (Affiliation vs. Disengagement) as within subjects factors revealed a significant main effect of pair ($F_{2,14}$=3.84, $p$=.047), reflecting decreasing attention, and a significant effect of type ($F_{1,15}$=20.30, $p$<.001). The interaction between pair and type was not significant ($F_{2,14}$=1.13, $p$=.35). The effect of type was due to infants looking significantly longer at Affiliation trials (*M*=11.0 seconds) than Disengagement trials (*M*=7.7 seconds; Figure 6). This pattern held across

the sample in non-parametric analyses: the majority of infants looked longer at Affiliation trials than at Disengagement trials ($N$=15 of 16, binomial $p$<.001, two-tailed). Thus, infants found it unexpected for the actors who intentionally used different means to achieve their goal to affiliate.

**Infants' exploration of the push-light at the end of the study**

Infants' exploration of the light following the looking time measures was the same regardless of which condition of the experiment they had been assigned to. Approximately half of the infants turned on the light during the test phase ($N$=14 of 32). The number of infants who turned on the light did not differ between the Blanket condition ($N$=8 of 16) and the No Blanket condition ($N$=6 of 16). Infants in the Blanket condition spent more time interacting with the light ($M$=12.0 seconds) than infants in the No Blanket condition ($M$=9.0 seconds), but this difference was not significant ($t(30)$=0.94, $p$=.36). Only one infant, who was in the Blanket condition, turned on the light using a head-touch action.

## Discussion

Overall, infants' responses to the affiliation and disengagement events varied systematically based on whether the actors appeared to have the same underlying goal. When the actors intentionally used different means to reach the same outcome, as in the No Blanket condition, infants looked significantly longer at subsequent affiliation, suggesting this was unexpected. However, the same pattern was not seen when the actors appeared to have the same goal, of turning on the light, but accomplished their goal using whatever means they had available, such as in the Blanket condition. In fact, when infants saw the actors as having the same underlying goal, they instead looked significantly longer at the disengagement events, suggesting they found disengagement unexpected. Importantly, in this case the actors who shared an underlying goal engaged in perceptually dissimilar actions (by using different body parts to

turn on the light), suggesting the pattern of results here, and likely in Study 1, are not merely based on perceptual similarity of actions. These results indicate that infants were more likely to expect affiliation between two people who engage in the same underlying goal, than between two people who intentionally use different actions. Thus, this study replicated the general pattern of results seen in the first study, and further suggests that infants' expectations are not driven by low-level perceptual similarity in the actor's actions, but instead may be based on understanding shared goals and expecting people who engage in shared goals to also be more likely to engage in shared positive social relationships.

## General Discussion

Taken together, this work indicates that infants expect imitation of causally-irrelevant actions to carry social meaning. Specifically, infants expected actors who engaged in shared actions to be more likely to affiliate than actors who intentionally engaged in different actions. This finding held regardless of whether the actors were imitating each other's perceptually identical actions (Study 1) or imitating each other's underlying goals using perceptually dissimilar means (Study 2), suggesting perceptual similarity in actions is not necessary for infants' to make inferences about patterns of likely social relationships. Overall, infants evidence an early developing understanding that imitation is relevant for inferring third-party social relationships, which suggests they expect imitation to carry social meaning, potentially supporting accounts that relate imitation to learning of cultural group norms.

In fact, we focused on causally irrelevant actions, such as the head touch to turn on a light, because they may have an especially important social and cultural status. In particular, these causally irrelevant actions can serve as reliable signals to social group membership: they are not instrumentally required for reaching the desired outcome, so two people who chose to perform

the same irrelevant action may be demonstrating shared cultural knowledge of a group norm (e.g., Legare & Neilsen, 2015). More generally, understanding whether performing a particular action can be used as marker or social group requires an ability to infer whether the action is causally necessary or irrelevant. If the action is causally necessary, then it is likely being done to research the desired outcome, therefore the action is not necessarily serving as a cultural marker. On the other hand, actions that are causally irrelevant are not done in order to reach an instrumental goal, and therefore may be done in order to signal group membership.

Infants seem to be able to make this distinction: they make different inferences about the same novel action based on whether the action is causally necessary in order to achieve the desired outcome. Specifically, infants expectations about third-party social relationships varied based on whether the novel action appeared necessary: when an actor used a head touch action because she had no other way to complete her goal, infants did not see her as doing something meaningfully different than the actor who used a perceptually different hand touch action. However, if the actor who used her head did so purposefully, when she could have used her hands, then infants saw it as a meaningfully different action than the actor who used a hand touch, and did not expect the two actors to affiliate. Thus, infants are sensitive not only to the mechanics of actions, but also to the underlying intentions behind those mechanics. And, when infants see people intentionally engaging in different causally irrelevant actions, they find it unexpected for those actors to subsequently affiliate, suggesting they may see imitation of causally irrelevant but intentional actions as carrying relevant information about social relationships, and potentially about cultural groups.

An open question concerns infants' inferences linking shared causally-irrelevant actions to social interactions and groups norms is whether imitation is actually necessary. Specifically, the

actors in this study completed causally-irrelevant actions while sitting at the same table and while watching each other act, giving it the appearance that the second actor chose whether or not to imitate the first actor. Is imitation is critical for infants to form expectations about social relationships based on causally-irrelevant actions? Although imitation may be necessary, it is also possible that infants' inferences are instead based on whether people share knowledge of the casually-irrelevant action. If these actions potentially serve as markers of cultural group membership (e.g., Legare & Neilsen, 2015), then infants may expect people who use the same casually irrelevant actions in general to be more likely to affiliate that people who use different actions, even if the people are not engaging in active imitation. Future work can ask about the role of imitation by presenting infants with people who engage in the same versus different causally-irrelevant action separately and investigating whether infants' infer that people who engage in the same action will affiliate, and whether infants selectively generalize information people who use the same causally-irrelevant means to reach their goals.

Interestingly, factors that drive infants' own imitation of causally irrelevant actions do not appear to be the same as the factors that drive how they interpret third party imitation of the same kind. For example, even though infants displayed very low levels of imitation of irrelevant actions across both of our studies, they were able to form expectations that third-party imitation was socially meaningful. On the other hand, while motor skills likely influence infants' own ability to imitate different types of actions (e.g., Paulus et al., 2011), infants in our studies formed expectations about patterns of social relationships after seeing adults engage both in behaviors that were inside their own motor repertoires (e.g. an actor turning on a light using her hand) and behaviors that were outside their motor repertoires (e.g. an actor using her head to turn on the light without supporting herself with her hand, such as in the Blanket condition).

Therefore, future studies investigating whether different factors influence infants' own imitation, their expectations about third-party imitation, or both, can shed light on the mechanisms behind the role of imitation in social learning, and the role of imitation in understanding social structure.

To conclude, this work opens novel questions about the kinds of features that infants expect to mark social relationships and cultural groups. Recent evidence suggests infants can reason in sophisticated ways about the social world, for example by forming expectations about patterns of affiliation (e.g., Kuhlmeier, Wynn, & Bloom; Powell & Spelke, 2013; Rhodes, Heatherington, Brink, & Wellman, 2015). Interestingly, inferences about affiliation are influenced by similarities that are particularly social: infants expect people who share food preferences or speak the same language to be more likely to affiliate than people who disagree in their food preferences or speak different languages (Liberman, Kinzler, & Woodward, 2015; Liberman, Woodward, & Kinzler, in press). Given the current findings, it is possible that imitation, and perhaps specifically imitation of causally irrelevant actions, is another cue that infants expect to fundamentally mark social relationships and social group membership. Future research can investigate the extent to which infants link cultural group membership and imitation, for instance by asking whether infants expect people from the same cultural group to know and use the same causally irrelevant actions. Overall, the current findings provide evidence that a connection between imitation of causally irrelevant actions and social structure can be traced to infancy. In addition to choose to imitate specific features of actions that seem goal relevant (e.g., Gergely et al., 2002; Meltzoff, 1995) and demonstrating selectivity which people they decide to imitate (e.g., Buttelmann et al., 2015; Howard et al., 2015), infants expect patterns of third-party imitation to carry social meaning and to indicate likely patterns of social relationships.

# Part III: An early emerging system for reasoning about the social nature of food

Although eating is a basic drive, humans' food selection is incredibly complex (Rozin, 1976). Being a competent eater requires considerations of safety, nutritional diversity, caloric intake, and, at least in modern times, health (Gripsover & Markman, 2013; Hill & Peters, 1998). Discovering the developmental trajectory and mechanisms involved in food choice can help us understand how people solve the critical problem of selecting appropriate foods. Given its ecological importance, there may be early-emerging adaptations that support complex reasoning in the food domain. Yet, past research has revealed that human infants are surprisingly inept at categorizing and selecting appropriate foods (Rozin Hammer, Oster, Horowitz, & Marmora, 1986; Shutts, Condry, Santos, & Spelke, 2009). However, these studies did not consider the importance of social aspects of food choice. Eating is inherently social, and the foods that people eat are embedded in cultural systems (Fischler,1988; Fox, 1994; Frazier, Gelman, Kaciroti, Russell, & Lumeng, 2012; Germov & Williams, 2008; Grunfeld, 1975; Harris, 1966; Kass, 1994; Korsmeyer, 2005; Lewin, 1943; Millstone & Lang, 2002; Nemeroff & Rozin, 1989; Rozin & Rozin, 1981; Shutts, Kinzler, & DeJesus, 2013). Thus, although infants may not be skilled at reasoning about perceptual or nutritional properties of foods, they may instead be skilled at thinking about the relationship between food choice and social identity. Here, we explore a new idea: that a specialized system for reasoning about food choice is present early in life, and depends on *social* input about people and their relationships.

On first blush, infants' reasoning about food seems surprisingly limited. Although infants and young children have basic taste preferences (Aldridge, Dovey, & Halford, 2009; Birch, 1999; Hausner, Nicklaus, Issanchou, Molgaard, & Moller, 2010; Lumeng, Patil, & Blass, 2007; Mennella, Jagnow, & Beauchamp, 2001), they make maladaptive food choices, including ingesting inedible and dangerous substances (e.g. Cashdan, 1994; Fallon, Rozin, & Pliner, 1984;

Rozin, Fallon, & Augustoni-Ziskind 1985; Rozin et al., 1986). Indeed, children under 2 years of age are the most likely age group to accidentally poison themselves (Cashdan, 1994). Additionally, though adults, older children, and even adult monkeys rely on different perceptual properties to make inferences about foods and about artifacts (e.g., using color when reasoning about foods, shape when reasoning about artifacts), human infants do not (Graham, Kilbreath, & Welder, 2004; Lavin & Hall, 2002; Macario, 1991; Santos, Huaser, & Spelke, 2001; 2002; Santos, Miller, & Hauser, 2003; Shutts, Condry, Santos, & Spelke, 2009; Shutts, Markson, & Spelke, 2009; Spelke, Breinlinger, Jacobson, & Phillips, 1993; Welder, & Graham, 2001). Because human infants have historically relied on caregivers to provide safe and nutritious diets, they may not need to have mechanisms in place for reasoning about food. In this case, cognitive mechanisms that support careful food choice may only emerge once children are actively selecting foods themselves. Indeed, young children begin to display neophobia and picky eating (Addessi, Galloway, Visalberghi, & Birch, 2005; Carruth, Ziegler, Gordon, & Barr, 2004; Cashdan, 1994), which could protect them from selecting potentially dangerous novel foods.

Critically, though, humans do not choose their foods in isolation. Reframing food selection as a social rather than nutritional problem may shed light on the relevant mechanisms that could support early reasoning about food (Wertz & Wynn, 2013). Social learning about food selection and food avoidance has been observed in a diverse range of animal species (Buttelmann, Call, & Tomasello, 2007; Galef, 1993; Galef & Whiskin, 1995; Jaeggi, van Noordwijk, Burkhart, & van Schaik, 2009; Schiel, & Huber, 2006; Ueno & Matsuzawa, 2005). For humans, in addition to social learning about edibility, food choice has broad social and cultural significance (Fischler, 1988;  Fox, 1994; Frazier et al., 2012; Germov & Williams, 2008; Kass, 1994; Shutts et al., 2013). People decide not only *what* they should eat, but also *how*, *when*

and *with whom* to eat, and human cultures converge on radically different food choices and eating practices (Grunfeld, 1975; Harris, 1966; Korsmeyer, 2005; Lewin, 1943; Millstone & Lang, 2002; Nemeroff & Rozin, 1989; Rozin & Rozin, 1981). Food choice can even serve as a social shibboleth, whereby information about what an individual eats affords insight into her cultural background and social relationships (Appadurai, 1981; Barker, Tandy, & Stookey, 1999; Cashdan, 1994; Cashdan, 1998; Counihan, 1992; Johnson, White, Boyd, & Cohen, 2011; Liberman, Kinzler, & Woodward, 2014; Miller, Rozin, & Fiske, 1998; Peryam, 1963; Rozin & Siegal, 2003; Vartanian, Herman, & Polivy, 2007). Due to the inherent social and cultural nature of eating, even human infants may interpret eating behaviors as communal across agents who share a common social identity.

Consistent with the possibility that early reasoning about food may be fundamentally social, the cases where infants appear to make savvy decisions about food occur in situations that provide social context. Infants eat more when other people are eating with them (Lumeng et al., 2007), they learn about edibility by watching other people eat (Wertz & Wynn, 2013), and they preferentially eat foods associated with native speakers and prosocial actors (Hamlin & Wynn, 2012; Shutts, Kinzler, McKee, & Spelke, 2009). However, existing data do not provide evidence for a system of reasoning that specifically targets the food domain and allows infants to make socially-relevant inferences about food choices. Critically, first person social preferences offer little insight on infants' conceptual representations because these behavioral responses may arise based on infants' domain-general preferences for familiarity, rather than as a result of abstract inferences about familiar people's identities or social relationships. In fact, infants rely on the same cues (e.g. prosociality and native language) to inform their choices for foods and for non-food objects (Shutts et al., 2009; Fawcett & Markson, 2010; Kinzler, Dupoux, & Spelke, 2007;

Mahajan, & Wynn, 2012; Sloane, Baillargeon, & Premack, 2012), suggesting these social preferences cannot tell us whether infants form a specific link between social identity and food choice. Therefore, we investigate infants' third-party expectations about what other people will eat to gain traction on infants' conceptual system for reasoning about food choice. We asked whether there is an early-emerging, domain specific, system for reasoning about food that relies on input about agents' identities and social relationships.

We first asked whether infants' inferences about food choice are qualitatively different from their inferences about non-food objects. After learning that a person prefers a particular object, infants typically do not generalize that person's preference to a new person (Buresh & Woodward, 2007; Henderson & Woodward, 2012; Novack, Henderson, & Woodward, 2014). However, given the ecological and social significance of food, infants may expect people to eat the same foods, and therefore they might generalize one person's food preference to a new person. We tested infants around one year of age because this age is typically studied in research on inductive inferences in infancy (Buresh & Woodward, 2007; Henderson & Woodward, 2012; Novack et al., 2014), and because infants this age are gaining more agency in their food choices (Birch, 2002).

An initial study compared 14-month old infants' expectations about food versus object preferences by creating perceptually similar movies in which actors interacted with two items (bowl A and bowl B), and expressed their preferences. During familiarization, one actor interacted with one item. In the food condition, she ate a bite from bowl A, liked the food, smiled, and said, "Ooh. I like that!" in a positive tone. In test trials, a second actor alternated between eating a bite from each bowl, disliking it, frowning, and saying, "Ew. I don't like that" in a negative tone. The object condition was identical except that rather than eating from each

bowl, the actors lifted and examined each empty bowl before providing evaluations (Figure 9). When the second actor disliked food A or bowl A, she was actively disagreeing with the first actor. However, when the second actor disliked food B or bowl B, she provided no information because the first actor had not interacted with that item. Familiarization and test trials were infant controlled: after the actor expressed her opinion, movement on the screen paused and the infant's cumulative looking time to the display was measured until the infant looked away for 2 consecutive seconds. If infants only attended to perceptual properties of the events, we would expect them to look longer when the second actor disliked food or bowl B, since this event was the most perceptually novel event, given that it was the first time anyone interacted with that item. However, if infants generalized preferences across actors, then we would expect them to find disagreement unexpected and to look longer when the second actor disagreed with the first actor by disliking food or bowl A.

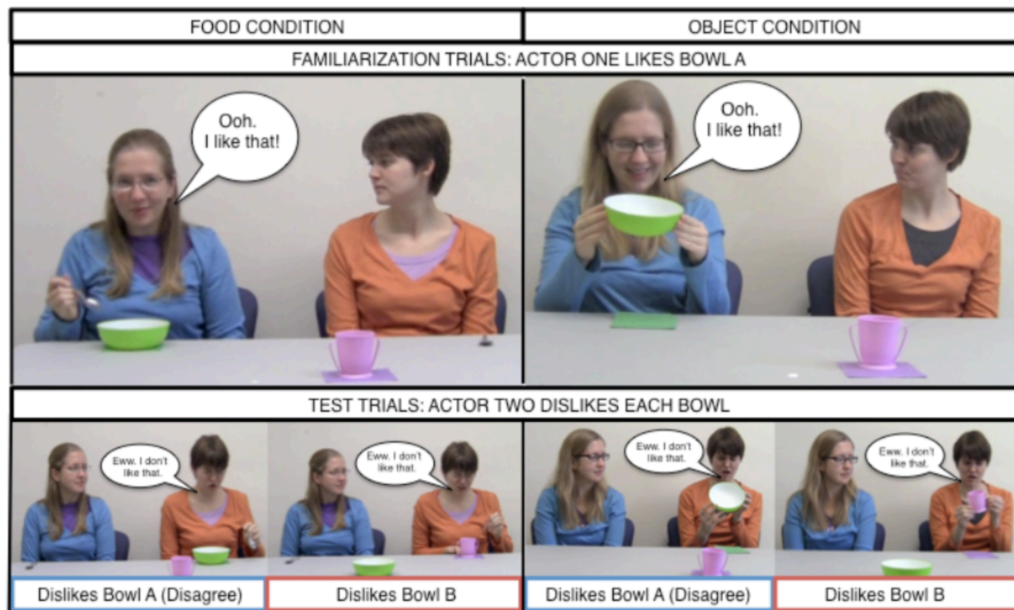


*Fig. 9. Study 1 Stimuli. During familiarization the first actor liked either food A or bowl A. During test, the second actor actively disagreed by disliking food A or bowl A, or disliked the previously untouched item, food B or bowl B.*

A repeated measures ANOVA revealed a significant interaction showing that infants' patterns of looking to the two types of test trials (A vs. B) differed across condition (foods vs. objects; $F_{1,30}$=18.565; $p$<.001). Replicating past work, infants in the object condition did not generalize object preferences across actors: infants looked significantly longer at the perceptually novel event ($M_B$=9.6s) than at the disagreement ($M_A$=7.9s; $F_{1,15}$=6.919, $p$=.019; Figure 11, left). However, infants in the food condition successfully generalized food preferences: infants looked significantly longer when the second actor actively disagreed with the first actor ($M_A$=8.3s) than when she disliked the perceptually novel food ($M_B$=5.7s; $F_{1,15}$=11.781, $p$=.004; Figure 10, left).

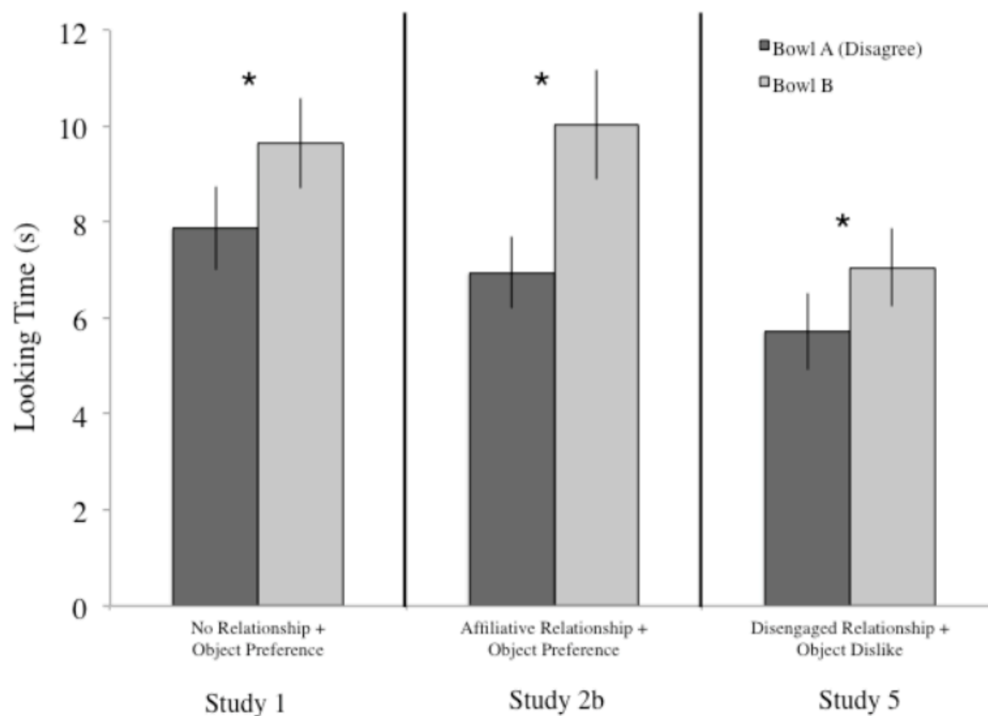


*Fig. 10. Looking times for Studies 1, 2a, and 5. This graph depicts the average looking time to bowl A and bowl B trials for infants in the food conditions of studies 1, 2a and 5. Error bars represent the standard error of the mean looking time. Asterisks indicate a significant difference in the individual ANOVAs for each condition.*

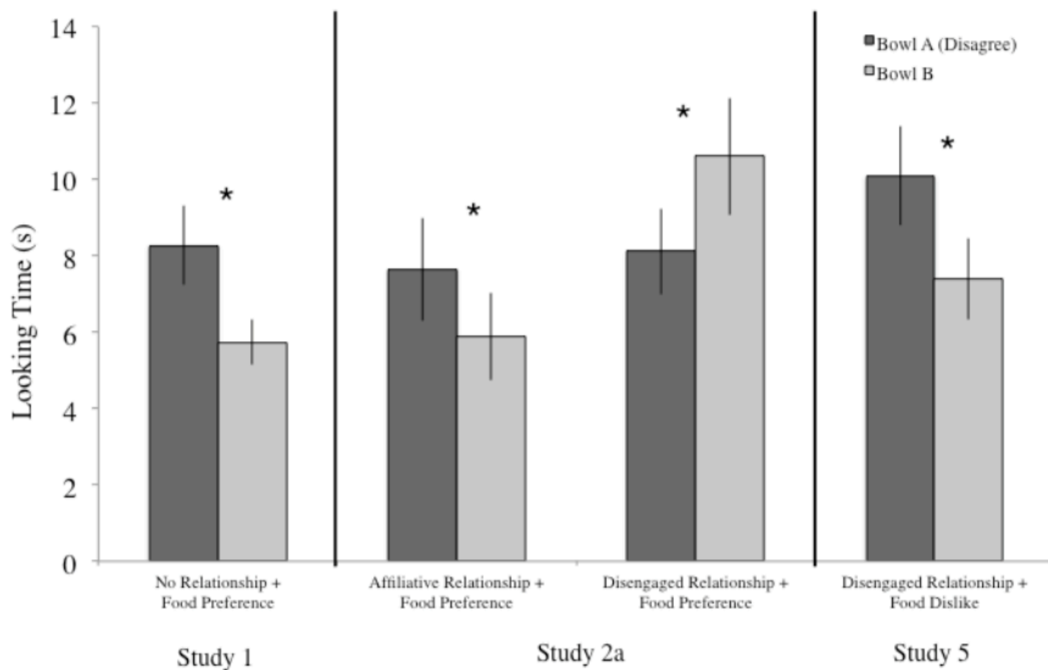


*Fig. 11. Looking times for Studies 1, 2b, and 5. This graph depicts the average looking time to bowl A and bowl B trials for infants in the object conditions of studies 1, 2b and 5. Error bars represent the standard error of the mean looking time. Asterisks indicate a significant difference in the individual ANOVAs for each condition.*

Infants generalized food preferences but not object preferences across individuals. One explanation for these results could be that infants learn that food A is edible from watching the first person eat, and therefore expect the second person to also like food A. In fact, young children learn about which foods are safe and palatable by observing other people eat (e.g., Harper & Sanders, 1975). As illustration, when an infant sees someone eat from a plant, she learns that the substance is likely edible, and later generalizes her expectation of edibility to a new person (e.g., Wertz & Wynn, 2013). Yet, important open questions remain about the nature of infants' representation of others' food choices. If seeing someone like a food exclusively provides infants with veridical information about edibility, then infants should expect all people to share food preferences. Alternatively, if infants' reasoning about food relies on information

about agents and their social relationships, then infants may constrain their generalization of food preferences to people who share a common social identity.

Capitalizing on infants' ability to track social relationships and make inferences about when individuals will affiliate (Kuhlmeier, Wynn, & Bloom, 2003; Liberman et al., 2014), in study 2a, we asked whether infants use social relationships to inform their inferences about who will share food preferences. In an introduction phase, a new group of 14-month-old infants were randomly assigned to see the two actors affiliate with each other or disengage from one another. In the affiliation condition, the actors turned toward each other, smiled, waved, and said, "Hi" in a positive tone. In the disengagement condition, the actors turned away from each other, crossed their arms, and said, "Hmph" in a negative tone. Next, infants watched the familiarization and test trials from the food condition of study 1. A repeated measures ANOVA revealed that infants' patterns of looking to the test trials (A vs. B) differed across the conditions (affiliation vs. disengagement; $F_{1,30}$=15.527; $p$<.001; Figure 10, middle). Infants who saw the actors affiliate generalized the food preference: they looked significantly longer when the second actor disagreed with the first ($M_A$=7.6s) than at the perceptually novel event ($M_B$=5.9s; $F_{1,15}$=13.443, $p$=.002). However, infants did not generalize food preferences across actors who disengaged; they instead looked significantly longer at the perceptually novel event ($M_B$=10.6s), than when the second actor disagreed with the first actor ($M_A$=8.1s; $F_{1,15}$=6.609, $p$=.021). Thus, infants' inferences about food preferences depended on the social relationships at play. Rather than expecting food preferences to be indiscriminately shared across people, infants generalized food preferences across affiliative partners but not across people who disengaged.

Study 2b investigated whether social information uniquely constrains infants' generalization of food choices, or whether social information is equally impactful for infants'

inferences about objects. Because at baseline infants do not generalize object preferences, we asked whether giving additional information that the actors affiliated would lead infants to generalize an object preference across individuals. Study 2b was therefore identical to the affiliation condition of study 2a, except that the actors expressed their opinions about the bowls, rather than about foods. Even when given information that the actors affiliated, infants did not generalize object preferences across individuals: they looked significantly longer at the perceptually novel event ($M_B$=10.0s), than when the second actor disagreed ($M_A$=7.0s; $F_{1,15}$=14.329; $p$=.002; Figure 11, middle). These results further indicate that infants' reasoning about food is distinct from their reasoning about objects – infants' inferences about agents' food preferences, but not about agents' object preferences, were guided by information about the agents' social relationships.

In study 3 we conceptually replicated the influence of social relationships on infants' generalization of food preferences with a slightly different method. After seeing two actors affiliate or disengage, infants viewed familiarization events in which the first actor expressed a preference for a food, and test events in which the second actor either liked the same food (agreement), or liked the previously uneaten food (perceptually novel event). Infants expected affiliative partners to agree, but found agreement unexpected if people had disengaged (see methods section for detailed procedures and results). Taken together, studies 2a and 3 indicate that although infants may learn about edibility by watching people eat, knowing that a food is edible does not lead them to expect all people to like it. Rather, infants generalize food preferences across some people (those who have affiliated) but not across others (those who have disengaged).

A further question is whether infants use more abstract aspects of social structure to reason about which people share food preferences. Language and accent are robust indicators of social and cultural groups (e.g., Cohen, 2012; Labov, 2006), and infants are sensitive to the social significance of language (Kinzler et al., 2007; Liberman, Woodward, & Kinzler, in press). Therefore, we asked whether infants selectively generalize food preferences across people who speak the same language. In study 4a, 11-month-old infants from monolingual English-speaking backgrounds were randomly assigned to one of three introductions: native bilingual actors were presented as two English speakers (English-English), two Spanish speakers (Spanish-Spanish), or as one English speaker and one Spanish speaker (English-Spanish). Then, infants watched familiarization and test trials like the food condition of study. Infants' patterns of looking to the test trials (A vs. B) differed across the conditions ($F_{2,45}$=12.378; $p$<.001; Figure 12, left). Infants who saw the actors speak the same language generalized the food preference. In both same-language conditions (English-English and Spanish-Spanish) infants looked significantly longer when the second actor disagreed with the first actor than when she disliked the perceptually novel food (English-English: $M_{\mathrm{A}}$=6.2s, $M_{\mathrm{B}}$=4.5s, $F_{1,15}$=5.695, $p$=.031; Spanish-Spanish: $M_{\mathrm{A}}$=6.3s, $M_{\mathrm{B}}$=4.0s, $F_{1,15}$=14.148, $p$=.002). Infants therefore found disagreement about food preferences unexpected among same language speakers. However, infants did not generalize food preferences across speakers of different languages: infants in the English-Spanish condition looked significantly longer at the perceptually novel event ($M_B$=6.2s), than at disagreement ($M_A$=4.2s; $F_{1,15}$=9.957, $p$=.007). These results indicate that the language that people speak, which serves as an informative indicator of social group, influences infants' inferences about shared food preferences. Infants constrain their generalization of food preferences to people who speak the same language.

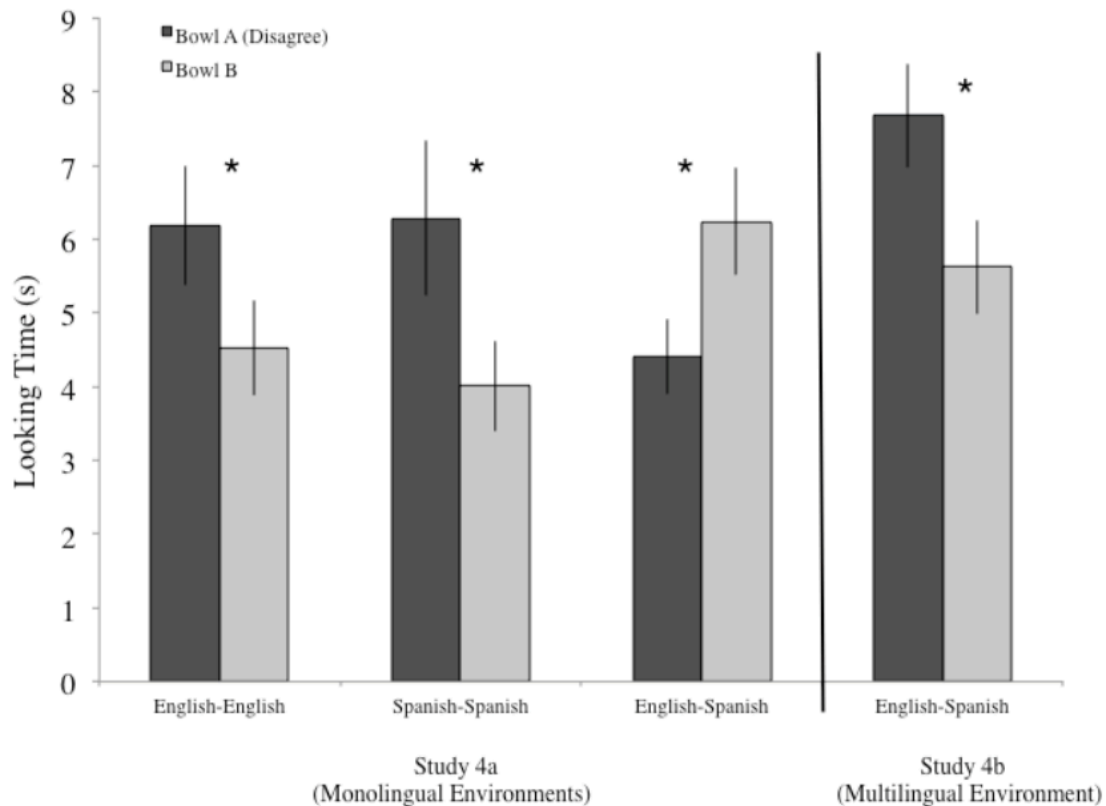


*Fig. 12. Looking times for Studies 4a & 4b. This graph depicts the average looking time to bowl A and bowl B for infants in each condition. Error bars represent the standard error of the mean looking time. Asterisks indicate a significant difference in the individual ANOVAs for each condition.*

An adaptive social learning system would likely be influenced by variation in infants' social experiences, which could modulate the types of information deemed meaningful for making social inferences. One important dimension in which infants' environments vary is the diversity in their sociolinguistic backgrounds. Experiencing a monolingual vs. multilingual environment might lead infants to make different inferences about the degree to which a common language marks a common social group, which, in turn, could influence infants' generalization of food preferences. We hypothesized that infants raised in multilingual environments might expect food preferences to be shared even across different-language speakers. In study 4b we replicated the English-Spanish condition of study 4a with infants who

were raised in bilingual environments. Unlike monolingual infants, infants who were raised in bilingual environments generalized the food preference across individuals who spoke in different languages: they looked significantly longer when the second actor disagreed ($M_A$=7.4s) than at the perceptually novel event ($M_B$=5.4s; $F_{1,15}$=20.267, $p$<.001; Figure 12, right). Interestingly, infants' generalization across speakers of English and Spanish did not appear to depend on exposure to Spanish per se (see methods section for more details). Taken together, studies 4a and 4b indicate that infants' inferences about food preferences are adaptively responsive to variation in their social environments.

The findings from the first four studies indicate that infants' reasoning about food choice is tightly linked to their reasoning about social behaviors and social identity. Nevertheless, an adaptive system for reasoning about food choice as social might have important limits. In particular, choosing appropriate foods requires avoiding ingesting dangerous substances, so a competent social learning system should show special responses to foods that may be harmful. Given the potential value of being able to use one person's disgust response to learn veridical information about potential danger, infants may generalize disgust even across people who do not share a common social identity. That is, there might be critical asymmetries in infants' thinking about the generalizability of someone liking versus disliking a food.

Study 5 asked this question by investigating whether infants generalize food dislike even across people who have socially disengaged. In study 5, after seeing the actors disengage in the introduction phase, infants saw a familiarization phase where the first actor expressed dislike toward food A. Then, in alternating test trials (A versus B) the second actor liked each food. Thus, during bowl A test trials the second actor actively disagreed with the first actor by liking the previously disliked food, whereas during bowl B test trials she liked the previously uneaten

food, which was perceptually novel, but which did not provide information about disagreement. Infants generalized food disgust: they looked significantly longer when the second actor actively disagreed ($M_A$=10.1s) than at the perceptually novel event ($M_B$=7.4s; $F_{1,15}$=19.636, $p$<.001; Figure 10, right). To ask whether these results were specific to reasoning about disliked foods, a second group of infants saw identical events except that the actors expressed their opinions about the bowls themselves rather than about foods. Infants did not generalize object disgust across actors: they looked significantly longer at perceptually novel event ($M_B$=7.0s) than at the disagreement ($M_A$=5.7s; $F_{1,15}$=5.749, $p$=.030; Figure 11, right). Infants' patterns of looking to the two types of test trials (A vs. B) differed across the conditions (foods vs. objects; $F_{1,30}$=23.953; $p$<.001), suggesting infants' generalization of food dislike was not due to a general negativity bias (e.g., Hamlin, Wynn, & Bloom, 2010; Vaish, Grossman, & Woodward, 2015). Critically, these results provide further evidence that infants' inferences about others' food choices are again specific to reasoning about foods: infants generalized information about disliked foods across all people (even those who disengaged), but they did not generalize perceptually similar information about disliked objects. Seeing opinions about disgust towards foods as universally shared could be a helpful strategy that allows infants to eventually make their own safe choices.

Taken together, the current findings reveal early-emerging, domain-specific adaptations for reasoning about food selection that are distinct from reasoning about non-food objects. Although infants seem to lack expectations about which physical properties are relevant for reasoning about foods (Shutts et al., 2009), and they can make maladaptive food choices themselves (e.g., Cashdan, 1994), they nonetheless reason adaptively about other people's food preferences and dislikes. Infants readily recruit social information about agents and their social relationships to make inferences about food choice, adapt these expectations based on their own

sociocultural experience, and show critical asymmetries in their generalization of people's liking versus disliking of foods. These responses suggest a strong conceptual foundation for solving the complex learning problems that human infants and children need to become competent in the food domain.

Our findings raise new questions about the origins and species-specificity of these adaptive responses. It is possible that parts of infants' system for reasoning about food are evolutionarily ancient and seen across a variety of species. As example, infants may learn about which foods to approach or avoid by watching other people eat, and seeing someone dislike a food may teach infants objective information that the food is bad and should be avoided. This ability to determine whether a substance is edible or inedible by watching someone else eat has immense adaptive value in that it might help infants avoid dangerous foods without having to try those foods themselves. This aspect of social learning in the food domain is not specific to humans: non-human primates and rats also use socially provided information from conspecifics to make inferences about edibility (Buttelmann et al., 2007; Galef, 1993; Galef & Whiskin, 1995; Jaeggi, et al., 2009; Schiel, & Huber, 2006; Ueno & Matsuzawa, 2005).

On the other hand, other aspects of infants' social system for reasoning about food may be unique to humans. Specifically, in addition to being able to reason about edibility, infants form a rich conceptual link between food preferences and social identity: human infants reason about who is likely to eat which foods, and expect people with a shared social identity to be more likely to share food preferences than people from dissimilar backgrounds. Additionally, this social-cognitive system is importantly flexible such that infants can use their own social experiences, such as their sociolinguistic background, to determine what social input is relevant to constraining their generalization of food preferences. Constraining generalization of food

preferences to people who belong to the same social group may be specific to humans and could arise because, for humans, food choice and eating behaviors are fundamentally social experiences (Fischler,1988;  Fox, 1994; Frazier et al., 2012; Germov & Williams, 2008; Grunfeld, 1975; Harris, 1966; Kass, 1994; Korsmeyer, 2005; Lewin, 1943; Millstone & Lang, 2002; Nemeroff & Rozin, 1989; Rozin & Rozin, 1981; Shutts et al., 2013).

The fact that infants have specialized, socially-laden mechanisms for reasoning about foods revolutionizes how we can think about infant social cognition by opening entirely novel questions. As an example, rather than being agnostic as to what dimensions are socially important, infants may be predisposed to expect some dimensions of variation to be informative for signaling social relations. We provide evidence that infants are sensitive to at least two of these dimensions: the languages people speak and the foods people eat. Although there has been growing interest in infants' reasoning about intrapersonal social structure (e.g., Baillergeon, Setoh, Sloane, Jin, & Bian, 2014; Johnson, Dweck, & Chen, 2007; Powell & Spelke, 2013), little is known about which factors infants use to decide whether two individuals likely belong to the same group. We propose that infants may begin with a circumscribed set of sensitivities (which can be adapted based on experience) that allow them to focus on, and learn about, aspects of human behavior that signal intrapersonal structure. In addition to language and food, this account would imply that infants may use other cues that fundamentally mark social identity when making social inferences, such as dominance, ritual behaviors, and kinship (Howard, Carazza, & Woodward, 2014; Legare & Nielsen, 2015; Mascaro, & Csibra, 2012; Medin & Ortony, 1989; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011). On the other hand, we would not expect infants to make inferences about social structure based on arbitrary or trivial similarities. Further studies can probe the boundaries of features that infants view as socially or culturally relevant.

Our findings reveal the deeply social nature of human thinking about food, which could have real-world implications. Many researchers have focused on nutritional properties in explaining food choice (Hill & Peters, 1988), but our results indicate that early reasoning about food is strongly related to social factors (e.g., Shutts et al., 2013). Indeed, obesity spreads through social networks (Christakis & Fowler, 2007), further suggesting that reframing food selection as a social problem could be useful in encouraging healthy eating practices. Thus, we suggest that health-based interventions focusing on the social aspects of eating may be a more profitable approach than interventions focusing solely on nutrition (Blom-Hoffman, Kelleher, Power, & Leff, 2004; Greenhalgh  Dowey, Horne, Lowe, Griffiths, & Whitaker, 2009; Hendy, & Raudenbush, 2000; Murphy, Youatt, Hoerr, Sawyer, & Andrews, 1995; Wardle & Huon, 2000). More generally, the current findings reveal a tight connection between food and social cognition early in ontogeny which can shed light on the mechanisms that drive food-related behaviors in social and cultural groups, and can contribute to an understanding of the origins of the relationship between food choice and social cognition across the lifespan

## Materials and Methods

### General Methods

All study procedures were approved by the Institutional Review Board of the University of Chicago. Across studies infants were from diverse racial and ethnic backgrounds, representative of the Chicago area: 43.2% White, 25.6% Black, 4.5% Asian, 17.1% Hispanic, and 9.5% Multiracial. Parents gave informed consent for their infants to participate and were compensated with either a travel reimbursement or a gift for their child.

**Study 1**

Participants were 32 full-term infants (18 females, *M*=14;12, range, 13;19-15;15). Infants were randomly assigned to the food or object condition. Stimuli consisted of two actors sitting at a table with two bowls (A and B). The study featured familiarization (3 trials) and test phases (6 trials). All movies were approximately 10 seconds long. During familiarization one actor liked one of the bowls (A) by saying, "Ooh! I like that!" in a high pitched voice. During test the second actor disliked each bowl on alternating trials by saying, "Ew. I don't like that" in a low pitched voice. In the food condition, the actors each ate the food before expressing their opinion; in the object condition, the actors each lifted and examined the bowl itself before expressing their opinion. We counterbalanced the following: which actor was first, which bowl she talked about, and which bowl was referred to first in the test phase.

Familiarization and test trials were infant controlled, meaning trials advanced when an infant met the looking criteria. Trials started when motion on the screen ended, and ended when the infant looked away for 2 consecutive seconds. Infants' looking was coded by two coders who were unaware of condition. The first coder recorded infants looking live, during the study, and the second coder coded independently from video. We measured reliability by looking at whether the two coders agreed on the endpoint of each trial. Coders agreed about the look-away that ended the trial on 94% of trials. We also looked at non-parametric statistics to determine whether the patterns of results held across the majority of individuals in the sample. The majority of infants in the object condition looked longer when the second actor disliked bowl B (*N*=13 of 16, binomial *p*=0.021, two-tailed). In contrast, the majority of infants in the food condition looked longer when the second actor disagreed with the first by disliking the food in bowl A (*N*=13 of 16, binomial *p*=0.021, two-tailed).

**Study 2a**

Participants were 32 full term infants (16 females, *M*=14;7, range, 13:12-15:4). Three additional infants were excluded due to fussiness (*N*=2), and experimenter error (*N*=1). The study was identical to the food condition of study 1 with the addition of an introduction phase (3 trials). Infants were randomly assigned to see the actors either affiliate or disengage before eating. The coders agreed about the look-away that ended the trial on 91% of trials. The repeated measures ANOVA on test trial looking times also revealed a main effect of pair ($F_{2,29}$=3.57, *p*=.041), indicating decreased looking across the session. The majority of infants who saw the actors affiliate looked longer when the second actor disagreed by disliking bowl A (N=13 of 16, binomial *p*=0.021, two-tailed). In contrast, the majority of infants who saw the actors disengage looked longer when the second actor disliked bowl B (N=13 of 16, binomial *p*=0.021, two-tailed).

**Study 2b**

Participants were 16 full term infants (7 females, *M*=14;9, range, 13:9-15:14). The study design was identical to the affiliation condition of study 2a, except the actors expressed their opinions about the bowls themselves. The coders agreed about the look-away that ended the trial on 93% of trials. The majority of infants looked longer when the second actor disliked bowl B (N=14 of 16, binomial *p*=0.004, two-tailed).

**Study 3**

Participants in study 3 were 32 full term 14-month-old infants recruited from the greater Chicago area (18 females, mean age, 14 months, 10 days, range, 13:12-15:9). Studies 1 & 2 suggest that early thinking about food preferences may be tied to reasoning about social relationships and social groups. Specifically, infants found disagreement about food preferences

unexpected for some people (i.e., those who have affiliated) but not for others (i.e., those who have disengaged). If these results are due to infants linking social group membership to shared food preferences, then infants should also make the related inference that people in the same group should agree. Study 3 replicated study 2a, except that test trials asked about agreement rather than disagreement. Specifically, in test trials the second actor liked each food. When she liked food A, she actively agreed with the first actor. However, when she liked food B, she provided no information because the first actor had not interacted with that food. Thus, we asked whether there were cases where infants found it unexpected, and therefore looked longer, for the second actor to agree with the first actor by liking the food in bowl A. A repeated measures ANOVA revealed a main effect of pair ($F_{2,60}$=3.30, $p$=.049), indicating a decrease in looking across the test session, and a significant interaction showing that infants' patterns of looking to the two types of test trials (A vs. B) differed across the conditions (affiliation vs. disengagement; $F_{1,30}$=17.70; $p$<.001).

In order to understand the interaction, we analyzed the conditions separately. Infants who saw the actors affiliate looked significantly longer when the second actor liked the food in bowl B (*M*=9.5s), the perceptually novel event, than when she actively agreed with the first actor by liking the food in bowl A (*M*=6.8s; $F_{1,15}$=21.42, $p$=.002; Figure 13). However, when the actors socially disengaged infants looked significantly longer when the second actor actively agreed by liking the food in bowl A (*M*=9.1s), than when the second actor liked the food in bowl B (*M*=6.3s; $F_{1,15}$=6.60, $p$=.021; Figure 13). To determine whether the patterns of looking held across the majority of infants, we also looked at non-parametric statistics. The majority of infants who saw the actors affiliate looked longer when the second actor liked bowl B (N=14 of 16, binomial $p$=0.004, two-tailed). In contrast, the majority of infants who saw the actors disengage

looked longer when the second actor agreed by liking bowl A (N=15 of 16, binomial $p<0.001$, two-tailed). Thus, infants found it unexpected for people who socially disengaged to converge in their food preferences. The live coder and the reliability coder agreed about the look-away that ended the trial on 92% of trials. Taken together, studies 2 and 3 suggest that infants use social information to make inferences about whether people will agree and disagree in their food preferences: they expect people who affiliate to agree, and people who disengage to disagree.

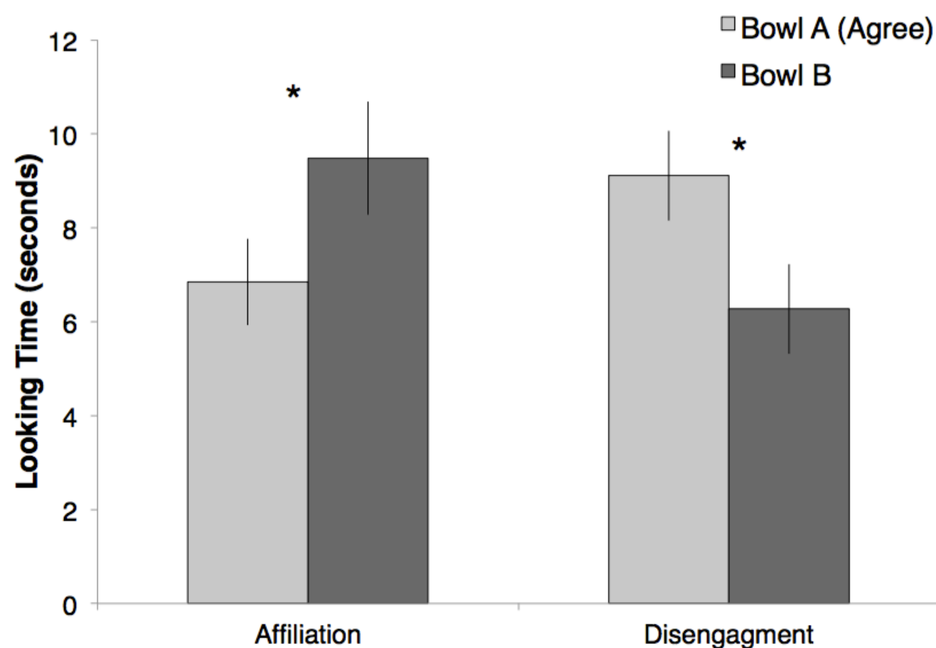


*Fig. 13. Looking times for Study 3. This graph depicts the average looking time to bowl A and bowl B trials for infants in study 3. Error bars represent the standard error of the mean looking time. Asterisks indicate a significant difference in the individual ANOVAs for each condition.*

**Study 4a**

Participants were 48 full term monolingual infants (21 females, *M*=10;26, range 10;5=11;28). One additional infant was tested but excluded due to fussiness. The design was like the food condition of study 1 with a few changes. First, infants saw an introduction phase (3 trials, 30 seconds each) before familiarization where the actors introduced themselves by speaking either English or Spanish. The actors were bilinguals, which allowed us to randomly

assign infants to see the actors either speak the same language (English-English; Spanish-Spanish), or speak different languages (English-Spanish). Then, infants saw familiarization (3 trials) and test phases (6 trials). To show all infants the same videos, actors expressed liking by saying, "Ooh! Ooh!" in high pitched voices, and expressed disliking by saying, "Ugh. Ugh." in low pitched voices after eating.

The repeated measures ANOVA on test trial looking times revealed a marginal main effect of trial type ($F_{1,45}$=3.75, $p$=.059), and a significant effect of pair ($F_{2,44}$=5.86, $p$=.006), indicating decreasing looking across the test session. The coders agreed about the look-away that ended the trial on 95% of trials. The majority of infants who saw the actors speak the same language looked longer when the second actor disagreed by disliking bowl A (N=25 of 32 combining across same-language conditions, binomial $p$=.002, two tailed). In contrast, the majority of infants who saw the actors speak different languages looked longer when the second actor disliked bowl B (N=14 of 16 from English-Spanish, binomial $p$=0.004, two-tailed).

**Study 4b**

Participants were 16 multilingual infants (8 female, *M*=11;2, range 10;15-11;22). In addition to English, infants were exposed to their non-English language between 10% and 70% of the time according to parental report. The languages they heard were: Spanish (N=8), French (N=3), Cantonese (N=1), Gujarati (N=1), Mandarin (N=1), Swahili (N=1), and Tagalog (N=1). The coders agreed about the look-away that ended the trial on 93% of trials. The majority of infants looked longer when the second actor disagreed by disliking bowl A (N=15 of 16, binomial $p$<0.001, two-tailed).

Although we did not plan to investigate differences based on the particular languages to which the multilingual infants were exposed, and we did not have an a priori prediction about the

results, half of our sample were infants who were exposed to English and Spanish (*n*=8), and half were infants who were exposed to English and another non-Spanish language (*n*=8). Post-hoc analyses revealed that both groups of infants, those who were exposed to English and Spanish ($F_{1,7}$=13.555, *p*=.008), and those who were exposed to English and a non-Spanish language ($F_{1,7}$=19.243, *p*=.003), generalized the food preference across two individuals, one who spoke English and the other Spanish. Thus, infants did not need to be specifically familiar with both presented languages (in this case, English and Spanish) to expect generalization. Instead, regular experience hearing multiple languages, regardless of which specific languages, may influence infants' expectations about the link between spoken language and food preferences. These data suggest that infants' inferences about who will share food preferences are adaptively responsive to variation in their social environments.

**Study 5**

Participants were 32 full-term infants (18 females, *M*=14;21, range, 13;19-15;23). One additional infant was tested but excluded due to experimenter error. Infants saw an introduction phase where the two actors socially disengaged. Familiarization and test events were like study 1, but the pattern of emotions switched. The coders agreed about the look-away that ended the trial on 94% of trials. The repeated measures ANOVA on test trial looking times also revealed a main effect of pair ($F_{2,29}$=11.663, *p*<.001), indicating a decrease in looking across the test session. The majority of infants in the food condition looked longer when the second actor actively disagreed by liking bowl A (N=15 of 16, binomial *p*<0.001, two-tailed). In contrast, the majority of infants in the object condition looked longer when the second liked bowl B (N=12 of 16, binomial *p*<0.076, two-tailed).

# General Discussion

**Summary of findings**

In three parts, this dissertation has demonstrated that infants exhibit an early emerging ability to think of people as members of social groups. In Part I, infants used language as a marker of social group membership: they expected people who spoke the same language to be more likely to affiliate than people who spoke different languages. Although infants' inferences may be more robust for speakers of familiar languages, their expectations about patterns of social relationships were driven more by similarity between the two speakers than by familiarity of the language. In Part II, infants expected imitation of causally-irrelevant actions to be another potential indicator of social group membership: infants inferred that people who imitated one another's novel actions and underlying goals would be more likely to affiliate than people who refrained from imitating one another. These findings suggest that infants' may see imitation, particularly imitation of causally-irrelevant actions, as carrying social information, which may be related to learning culturally relevant information and rituals. Together, Parts I and II suggest that infants are able to reason about patterns of social relationships and social structure, and that they make inferences that people who display a similarity that indicates that they may be members of the same social group are more likely to affiliate than people who seem to be members of different social groups.

In Part III, infants demonstrated a tendency to generalize food preferences, but not non-food object preferences across people. However, infants' generalization was importantly flexible, and therefore allows for multiple important inferences about the social nature of food choice. First, infants withhold generalizing food preferences across people who seem to belong to different social groups, suggesting that in addition to being able to learn about edibility, infants form a link between food preferences and likely social group membership. Second, infants'

inferences about this link are flexible and calibrated to their own social experiences: infants' sociolinguistic backgrounds influenced whether they expected food preferences to generalize across people who spoke different languages. Finally, infants' expectations varied for food preferences compared to disgust towards food, such that they were less likely to use information about social identity or social group membership when reasoning about disgust. Taken together, these results suggest that infants are able to make nuanced social inferences about the connection between food preferences and social structure, and that infants demonstrate an early-emerging tendency towards selectively generalizing social attributes, such as food preferences, across people who are in the same social group, but not across all people.

**Differentiating third-party reasoning about social categories from social preferences**

The experiments presented here suggest that infants are able to think about people as members of social categories. Although a large body of research from developmental psychology has demonstrated preferences for ingroup members during the first two years of life in terms of both infants' demonstrating higher visual attention to ingroup members (e.g., Anzures, Quinn, Pascalis, Slater, Tanaka, & Lee, 2013; Kelly, Quinn, Slater, Lee, Ge, & Pascalis, 2007; Kinzler, et al., 2007; Kinzler et al., 2012; Liu, Xiao, Xiao, Quinn, Zhang, Chen, Ge, Pascalis, & Lee, 2015; Quinn, Lee, Pascalis, & Tanaka, 2016; Xiao, Xiao, Quinn, Anzures, & Lee, 2013) and higher rates of social interactions with ingroup members (e.g., Fawcett & Markson, 2010; Gerson, Bekkering, & Hunnius, 2016; Kinzler et al., 2007; Mahajan & Wynn, 2012; Shutts, Kinzler, McKee, & Spelke, 2009), these first person preferences do not necessarily provide evidence for social *categorization*.

Instead, social preferences for "ingroup" members may primarily reflect domain-general familiarity preferences and therefore would not require abstract reasoning about people as

members of social groups. For example, an infant could prefer to look at, take toys from, and eat foods associated with people who speak their native language in a native accent (e.g., Kinzler et al., 2007; Shutts et al., 2009) because the native speaker is relatively more familiar and therefore feels safer than the foreign speaker, which would not require advanced social reasoning. Thus, while early emerging social preferences are interesting, and may help infants choose appropriate social partners (e.g., Cirelli, Wan, & Trainor, 2016), social preferences do not provide clear evidence that infants are able to reason categorically about people as members of distinct social groups.

Indeed, infants' social preferences are highly malleable based on experience, highlighting the role of familiarity in first person reasoning. As example, although infants typically prefer to look at female and feminine faces (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002, Rennels, Kayl, Langlois, Davis, & Orlewicz, 2016), infants whose primary caregiver is male actually show a reversal and prefer to look at male faces (e.g., Quinn et al., 2002). Additionally, although numerous studies suggest there is an "own-race bias" that develops as early as 6-months-of age (e.g., Kelly et al., 2007), this "bias" actually reflects experience viewing different types of faces. Specifically, infants who regularly encounter faces of diverse races do not show an "own-race" effect (e.g., Bar-Haim, Ziv, Lamy, & Hodes, 2006; Gaither, Pauker, & Johnson, 2012; Heron-Delaney, Anzures, Herbert, Quinn, Slater, Tanaka, Lee, & Pascalis, 2011). Interestingly, infants also tend to show the "own-race bias" earlier in development when viewing female faces compared to male faces (Kim et al., 2015; Liu, Xiao, Quinn, Zhu, Ge, Pascalis, & Lee, 2015; Tham, Bremner, & Hay, 2015), further suggesting these "biases" are likely a result of expertise gained for processing for the types of faces that are most common in each particular infant's social environment, such as faces that share the primary caregiver's gender and race.

More generally, being able to reason about people as members of social groups does not necessitate forming a preference for one group over the other. For instance, it is possible think about people from different national origins as members of different social groups without preferring people of one background. As example, independent of liking Germans, people would be able to use the social group identity of “German” to infer likely properties of a person who belongs to that social group, such as what language he might speak, what foods he might prefer to eat, what religion he might practice, and which other types of people he might choose to interact with. Therefore, social biases, such as preferring ingroup members (e.g., Tajfel et al., 1971) may be independent of our ability to think about people as members of abstract social categories: people can have social biases without forming an abstract category, and forming an abstract category does not necessitate having a social bias. Thus, studying social preferences may not elucidate the mechanisms underling social categorization.

Unlike studies that focus on first person social preferences, studies on third-party reasoning, as presented throughout this dissertation, can shed light on abstract conceptual reasoning about social groups. In particular, the research in this dissertation focused on third-party inferences about two key aspects of social categories: expectations about patterns of social interaction (Parts I and II) and inductive generalization (Part II). Below I describe why each of these aspects, (a) expectations about social interactions and (b) inductive generalization, are particularly relevant to thinking about social categorization, whether each aspect of social categorization seems present in infancy, and broader open questions regarding the emergence and development of each aspect.

**Inductive generalization**

First, inductive generalization, the process by which people apply information learned about one category member to countless other members of a social group, is a primary function of categorization (e.g., Carey, 2009; Gelman & Markman, 1986). As example, after learning that a particular apple grows on a tree, children infer that "growing on trees" is an important property that applies to all other members of the category "apple." In fact, this ability to generalize learned information selectively to members of a category begins in the first year of life (e.g., McDonough & Mandler, 1998; Vukatana, Graham, Curtin, & Zepeda, 2015). Indeed people may even be spontaneously predisposed to generalize information across category members (Sutherland, Cimpian, Leslie, & Gelman, 2015), and starting by middle childhood, generalization based on category membership can overcome generalization based on perceptual similarity (e.g., Badger & Shapiro, 2015; Gelman & Davidson, 2013; Walker, Lombrozo, Legare, & Gopnik, 2014). Because inductive generalization is a hallmark of categorization for artifact and natural kind categories, it should also be relevant for learning about similarities between people who are members of a *social* category. Therefore, selectively generalizing information across members of a social category, but not across all people, would be strong evidence of categorical reasoning about social groups.

In fact, children make inductive generalizations that suggest they expect members of social groups to share deep, essential properties with one another (e.g., Hirschfeld, 1996; Diesendruck & HaLevi, 2006). For instance, children judge the boundaries for membership of certain categories, such as gender, as strict and discrete (e.g., Rhodes, Gelman, Karuza, 2014) and expect members of a social categories to be fundamentally similar to one another, to share preferences, and to be beholden to the same group norms and personality traits (e.g., Birnbaum,

Deeb, Segall, Ben-Eliyahu, & Diesendruck, 2010; Brandone & Gelman, 2009; Gelman, Collman, & Maccoby, 1986; Kalish 2012; Kalish & Lawson, 2008; Schmidt, Rakoczy, & Tomasello, 2012; Taylor, Rhodes, & Gelman, 2009). Similarly, a newly emerging body of work suggests that infants are selective in their inductive generalization of social attributes such that they understand that some features should generalize only across members of a social group. Specifically, infants use social group markers, such as language, to constrain generalization: they expect food preferences to generalize across people, unless those people speak different languages (See Part III, Liberman, Woodward, Sullivan, & Kinzler, under review), and they generalize object labels across same-language speakers (e.g., Buresh & Woodward, 2007; Henderson & Woodward, 2012), but not across different-language speakers (Scott & Henderson, 2013). Taken together, this research suggests that inductive generalization can serve as an important feature of social categorization, and that the ability to selectively generalize information across members of a social group emerges in infancy.

Although infants' are able to make inductive generalizations, there are still many open questions about the link between these inductive inferences and social categorization. For instance, while the research presented here suggests that infants are able to think about some features of social identity (such as friendship and spoken language) as relevant for inductive inferences, future work is needed to determine whether infants reason in this conceptually rich way about all types of social categories. It is possible that, rather than being agnostic as to what dimensions are socially important, infants may begin with circumscribed expectations that certain features are fundamentally relevant for social categorization while others are not. In particular, infants might use dimensions that reliably serve as signals to social group and are difficult to fake as fundamental and early-emerging markers of social category.

Indeed, the dimensions focused on for the majority of this dissertation, spoken language and food preferences, are both examples of social attributes that reliably signal social group. Specfically, native accents are difficult to fake and therefore serve as an honest signal of social group (e.g., Baker, 2001; Cohen, 2012; Heinrich & Heinrich, 2007), and it can be difficult to acquire a taste for foods that were not eaten early in life (e.g., Peryam, 1963; Rozin & Siegal, 2003), and people decide what to eat based on norms and prohibitions of their culture (e.g. Millstone & Lang, 2002; Rozin & Rozin, 1981), suggesting that each of these dimensions may be honest signals of social group membership. This account would predict that infants may be sensitive to other features that reliably mark social group, such patterns of kinship relationships among group members or knowledge of group rituals.

On the other hand, there are many features that adults use for reasoning about people as members of social groups that are not necessarily honest markers of group membership, and therefore that infants might be less sensitive to. As example, adults quickly form minimal groups and discriminate against outgroup members even when the groups were arbitrary or formed by random assignment (e.g., Tajfel et al., 1971). Infants likely to do not form expectations about shared social behaviors or about social structure based on arbitrary groups. This may seem trivial, but the same argument also potentially applies to other group markers that are particularly meaningful in many adult contexts. For example, although race is a salient and highly studied marker of social group n (e.g., Simpson & Yinger, 2013), attention to race might be based on its relevance in our culture for determining alliances, rather than being an early-emerging and not universally important marker of social group.

In fact, in situations where race is not a predictive marker of coalitional structure, even adults are less likely to rely on race for categorizing (Kurzaban, Tooby, & Cosmides, 2001;

Pietraszewksi, Cosmides, & Tooby, 2014). However, using a similar paradigm, adults categorize strongly by native accent even when it is not predicative of alliances (Pietraszewski & Schwartz, 2014), suggesting it may be harder to overcome thinking about people based on their accent than it is to overcome thinking about people based on their race. In other words, language and accent may be fundamental markers of social categories in a way that race is not. Additionally, infants do not show social preferences for own-race individuals (Kinzler & Spelke, 2011), and children do not selectively generalize properties across same race individuals (Rhodes & Gelman, 2009; Shutts, Roben, & Spelke, 2013), or even necessarily expect race to be stable over time (Kinzler & Dautel, 2011), further suggesting that infants might inductive inferences based on race.

In addition to potential differences in terms of which categories are relevant for making inductive generalizations, there are open questions about what types of information should be generalized across which types of people. For example, whereas infants use information about social identity to inform their expectations about when to generalize food preferences, this same information about social identity does not influence their expectations about when to generalize object preferences (Liberman et al., under review). That is, social group membership may be relevant for generalizing some types of information more than other types. One possibility is that, in infancy, the same information that inherent signals social identity is the type of information that should be selectively generalized based on group membership. For example, because both language (e.g., Cohen, 2012) and food preferences (e.g., Rozin & Siegal, 2003) can serve as honest social group markers, whether people either speak the same language or prefer the same foods may provide relevant information about whether they are similar in terms of the other feature. On the other hand, the same information (e.g., that people speak the same language or prefer the same foods) may not provide relevant information about whether they will likely

share less social properties, such as object preferences or trivial similarities. More generally, future research is needed to investigate whether there are priorities in infants' social categories, and whether these potential priorities influence patterns of inductive generalization. I hypothesize that there are specific boundary conditions of infants' expectations about which dimensions are used to classify people as members of social groups, and that these boundaries are based on whether the dimension could have served as an honest signal of social group membership throughout humans' evolutionary history.

**Expectations about social relationships**

Another primary function of social categories is that knowing what social groups a person is a member of can provide insight into that person's likely patterns of social relationships and position in the broader social structure. In fact, one important feature that makes social categories distinct from other kinds of categories (e.g. artifact categories or animal categories), is their social nature: social categories can be used to predict patterns of interactions both within a social group and across social groups. In addition to being more likely to engage in cooperative relationships with people in their own social group (e.g., Balliet, Wu, & De Dreu, 2014), adults quickly track patterns of cooperation and competition and band people into social groups based on perceived alliance structure (e.g., Kurzban, Tooby, & Cosmides, 2001; Pietraszewski, Cosmides, & Tooby, 2014). Therefore, information about how people engage in social relationships may indicate whether people are likely in the same versus different social groups.

Indeed, people may hold intuitive expectations that people in a social group are socially obligated to one another (e.g., Rhodes, 2012). The expectation that social groups define appropriate patterns of social relationships emerges by childhood. For example, children think that people in a social group should refrain from harming each other, even if there are no explicit

rules in place, but this expectation of avoiding harm does not hold for members of different groups (e.g., Chalik & Rhodes 2014; Chalik, Rivera, & Rhodes, 2014; Rhodes, 2013; Rhodes & Brickman, 2011; Rhodes & Chalik, 2013). Additionally, children predict patterns of third-party friendship based on information about social group membership (Shutts, Roben, & Spelke, 2013), and expect members of social groups to be loyal to one another, engage in prosocial relationships, and share with each other (e.g., Misch, Over, & Carpenter, 2014; Plotner, Over, Carpenter, & Tomasello, 2016).

In fact, evidence from this dissertation, in conjunction with recent work from developmental psychology suggests that expectations linking patterns of social interactions to social group membership begins in infancy. For example, starting in the first year of life, infants expect people with shared attributes, including shared language and shared food preferences, to be more likely to affiliate with one another (Liberman et al., 2014; Liberman et al., in press), expect people's patterns of cooperation and competition to depend on their past social interactions (e.g., Choi, & Luo, 2015; Rhodes, Hetherington, Brink, & Wellman, 2015), and expect members of a social group to act alike (e.g., Powell & Spelke, 2013). Thus, an understanding that social group membership guides patterns of social interaction and social structure emerges in infancy.

However, there are many important open questions about the link between social group membership and social relationships. For example, infants are able think about numerous types of social relationships, including relationships involving dominance hierarchies (Mascaro & Csibra, 2012; 2014; Pun, Birch, & Baron, 2016; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011), and relationships based on resource distribution (Geraci & Surian, 2011; Sloane, Baillargeon, & Premack, 2012). However, there are other types of relationships that importantly

guide social structure for which there is substantially less research, including kinship relationships. Thus, future research could ask whether infants are able to track people as members of families and how this related to reasoning about broader social groups (e.g., Spokes & Spelke, 2016). Additionally, future research is needed to investigate whether infants' reasoning about these other types of relationships is guided by information based on social group membership. For example, are infants able to make inferences about which social groups are dominant to compared to other groups, as well as inference about which characters are dominant within a social group? Similarly, does information about social group membership influence infants' expectations about how resources will be distributed such that infants would expect people to show partiality towards others in their social group?

Additionally, while the work in this dissertation focuses on dyadic affiliation, social categories contain substantially larger numbers of people. In fact, people who belong to a social category (e.g. English speakers) may not know each other, or may even actively dislike each other. Therefore, it is important to ask whether infants are able to reason about larger groups of people, and how the types of inferences infants' make about people based on seeing them as affiliative partners versus as seeing them members of the same social group are both similar and different. For example, in cases where there is a social group norm, such as inferences about what foods are appropriate to eat, group membership may be a more important indicator than friendship of whether two people will be similar. In other cases, such as inferences about a favorite activity to engage in, friendship may be a more reliable indicator for generalization than social group.  More generally, future research should investigate infants' and children's expectations about how both friendship and social group membership influence other patterns of social relationships and influence inductive inferences about likely shared social attributes.

**Conclusions**

In sum, the experiments presented in this dissertation suggest an early-emerging ability to think about people as members of abstract social categories. Infants form third-party expectations that people who share socially relevant similarities are likely members of a social group: they expect people who share these similarities to be more likely to affiliate with each other than people who are dissimilar, and selectively generalize information across people who share these similarities but not across people who are dissimilar. These findings raise questions about the best way to define social categorization, whether there are priorities in infants' social categorization such that they are most sensitive to social groups based on particular types of similarities, and how infants' initial inferences about social categorization are shaped by experience into adult-like thinking about social groups. Future research is necessary to better understand the origins and developmental trajectory of how dividing people into social groups influences reasoning about the social world, and to address the negative downstream consequences of social categorization, including prejudice and discrimination.

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