Family Matters: Tracing the Social Cognitive Development of Kinship Understanding

The Harvard community has made this article openly available. Please share how this access benefits you. Your story matters

<table>
<thead>
<tr>
<th>Citable link</th>
<th><a href="http://nrs.harvard.edu/urn-3:HUL.InstRepos:40050041">http://nrs.harvard.edu/urn-3:HUL.InstRepos:40050041</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Terms of Use</td>
<td>This article was downloaded from Harvard University’s DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at <a href="http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA">http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA</a></td>
</tr>
</tbody>
</table>
Family Matters:

Tracing the Social Cognitive Development of Kinship Understanding

A dissertation presented

by

Ann Spokes Frost

to

The Department of Psychology

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Psychology

Harvard University

Cambridge, Massachusetts

April 2018
Family Matters:

Tracing the Social Cognitive Development of Kinship Understanding

Abstract

Kinship provides the major framework for social organization, but when do infants and children develop understanding of these social relationships and how they affect social behaviors? This dissertation proposes that caregiving relations are relevant from infancy in humans, as it is across many species in the animal kingdom, and may be a dimension that is factored into a candidate core knowledge domain for reasoning about social partners, along with additional relevant social information like dominance. Furthermore, I propose that kin relatedness is relevant to children’s social decision making when deciding with whom and when to help, share, or cooperate, consistent with evolutionary psychology’s proposal of a welfare tradeoff psychology and cognitive developmental psychology’s proposal of a naïve utility calculus, as a component of reward—where individuals closer in relatedness and higher in social value are more rewarding to help than those more distantly related. This dissertation explored these theories in three lines of research. First, in a series of six looking-time experiments using animated events, we found that 15- to 18-month-old infants tracked relationships in caregiving networks—but not a social context among peers—and expected babies soothed by the same adult or two adults who soothed the same baby to affiliate with one another more so than babies or adults who did not share a social connection (Paper I). This suggests that caregiving—which is
often but not exclusively, or specifically, kin—is incorporated into infants’ social inferences. Next, we tested through three looking-time experiments how five-month-old infants evaluate caregiving behaviors in animated events and found that infants showed a preference for an adult who responded rather than avoided a crying baby, providing evidence that young infants are sensitive to and evaluate an adult’s responsiveness as a caregiver, further supporting early integration of caregiving information into social evaluations (Paper 2). Finally, in three experiments, we investigated three- to five-year-old children’s explicit conceptual understanding of kin and non-kin relationships to test if children identify kinship as a relevant social dimension and if children’s expectations for social interactions change when kin relations are involved, potentially benefitting related over unrelated others (Paper 3). We found that children had clear distinctions between familiar and unfamiliar relations—sibling versus stranger and friend versus stranger—but did not have as clearly delineated understanding in answering conceptual questions about the relations, or expectations when asked about hypothetical sharing scenarios between siblings and friends. This pattern of results is consistent with kinship affecting social decisions in addition to other factors like the likelihood of an individual reciprocating—a quality friends may have more than siblings. Together, these three papers provide evidence that infants and children are incorporating caregiving (Papers 1-2) and kin relatedness (Paper 3) into their social inferences and decision making. A candidate core knowledge domain of social partners may include information about caregivers: their likely affiliative partners (Paper 1) and their responsiveness to a crying baby (Paper 2). In addition, children made different sharing decisions based on who was involved (Paper 3), suggesting that social value and kin relatedness weighs into a welfare tradeoff psychology and/or the reward of an action in a naïve utility calculus. Finally, I discuss ongoing research and remaining open questions that further these hypotheses.
# Table of Contents

Introduction.................................................................................................................................................1

Paper 1: The Cradle of Social Knowledge:
   Infants’ Reasoning about Caregiving and Affiliation.................................................................26

Paper 2: Five-month-old Infants Prefer Those who are Responsive to Baby Cries..................73

Paper 3: Children’s Expectations and Understanding of Kinship as a Social Category.........96

Conclusion and Future Directions........................................................................................................134

Appendix A..............................................................................................................................................153

Appendix B..............................................................................................................................................157

References...............................................................................................................................................164
Acknowledgements

I could write a whole dissertation on people I am thankful for and who have helped me progress this work and pursue my degree over the last six years. Here, I briefly mention some of the individuals and institutions to whom I am deeply grateful.

First, I want to thank my friends and colleagues in Leverett House, who welcomed me into their community and brought me a constant sense of belonging, love, and support through my most difficult years. In particular, thank you to the orchestrators of all things Leverett: Howard “Chief” and Ann “Coach” Georgi, Bilal Malik, Rabia Saifullah, JoAnn Haas, and Kim Gulko. I would like to thank my fellow tutors for their encouragement, camaraderie, and inspiration, especially Katie Derzon, Jess Tollette, Siri Uotila, Emily Harrison, and Chris Gilbert. I want to thank the many Bunnies who helped me live, laugh, and love Lev.

I also want to thank the members of the Spelke Lab (Harvard), the Lab for Developmental Studies (Harvard), and the Center for Brains, Minds, and Machines (MIT) for their thoughtful and critical feedback on my work throughout the years. An enormous thank you to lab managers/problem-solving gurus Natasha Kalra, Kerrie Pieloch, Rosa Guzman, Conisha Cooper, Heather Tarr, and Olivia Fiske, who devoted endless hours to this research in addition to keeping the lab running and smiling. I want to thank Lindsey Powell and Alia Martin for their mentorship and Shari Liu for collaboration, coding advice, and conference fun. I want to thank Ellyn Schmidt, my ginger twin, who started as my lab manager and became a close friend as we made our way through graduate school together. I also want to thank my friend, colleague, Zumba instructor, and role model in the Spelke Lab, Molly Dillon (w00t), whose brilliance, work ethic, and kind heart made me feel inspired and supported during my time at Harvard.
I want to thank faculty members and staff of the Department of Psychology at Harvard who have supported this work and my progress through the program. I want to thank Felix Warneken and Jesse Snedeker for their feedback and mentorship in LDS. I want to thank Josh Buckholtz, Steve Pinker, and Laura Chivers for their instruction and guidance in teaching and advising. I want to thank Celia Raia, the senior administrator, who has answered my many questions and genuinely cared for me and all graduate students. I also want to thank my community of mentors from Yale: Annie Wertz, Karen Wynn, Paul Bloom, and Kristina Olson.

For all of the joy, memories, activities, and adventures during our time together in Cambridge, I would like to thank my “gang” at Harvard: Ilya Feige, Lauren Forbes, Andrew Ong, Tessa Montague, Marc Warner, and Will Frost. I also want to thank my cohort in Psychology for their fellowship and friendship, especially Annemarie Kocab and Rachel Magid. For their love from far and wide, through the highs and lows, and for reunions and visits to Cambridge that reinvigorated my happiness, I want to thank all my friends from Boston, Kansas, and Yale.

I want to thank my collaborators and the research assistants who supported this work: Kristin Shutts, Tara Venkatesan, Stephanie Campbell, Emily Tan, Rhea Howard, and Sam Mehr. I want to thank the Faculty of Arts and Sciences at Harvard University, the National Science Foundation and the National Institutes of Health for funding this work and my graduate career.

I want to thank my committee members: Laurie Santos, Max Krasnow, and Susan Carey. I want to thank Laurie for being the spark that ignited my passion for science and research in the CapLab, serving as my guide and cheerleader in applications, and remaining a beacon of success toward which I have always aimed my work, career, and life. I want to thank Max for giving critical thought to my research and fostering a lab environment that made all, even outsiders like
me, feel welcome and encouraged to discuss and improve our work. I want to thank Susan for sharing her deep wisdom and knowledge of cognitive development and shaping my research program in many, meaningful iterations throughout the years. Finally, I want to thank my advisor, Elizabeth Spelke, whose brilliance in science is matched in greatness only by her enthusiasm for discovery and piecing together the core knowledge domains that shape human thought. Her openness, availability, and investment in me and my work has been tremendous. I also want to thank her for caring deeply not only for me as a researcher, but also as a person.

My studies of kinship are centrally inspired and sustained by my own kin, so I would like to thank my family for their inspiration, prayers, love, and support. I would like to thank my siblings, who I would almost definitely share with over my friends—Pete, Erin, Megan, Charlie, and Tim Spokes—and their amazing partners and children. I would like to thank my aunts, Kate Spokes and Anne Drolet, for being a strong family force for me in Boston. For boundless encouragement, getting me through all of the to-do lists (short- and long-term), making me lots of coffee, for embracing our Leverett family, and for his unwavering commitment to my health, happiness, and success, I want to thank my best friend and husband, Will Frost.

I would like to thank and dedicate this thesis to my parents, Barb and Peter Spokes, without whom I would not be here. I want to thank my mom for anchoring “Team Annie,” and for being my rock and frequent visitor through all phases of graduate school. Finally, this thesis is dedicated to my late father, a fellow Yalie, whose main critique would probably be, “Why Harvard?” I know you will be with us, even if reluctantly, for graduation in Cambridge on May 24th in 2018 as you were in New Haven in 2010.
**Introduction**

The human social world is complex, and some argue that humans have become more intelligent over evolutionary time due to the complexity of our social relationships and cultures (Herrmann, Call, Hernandez-Lloreda, Hare, & Tomasello, 2007; Chapais, 2008; Rodseth, Wrangham, Harrigan, & Smuts, 1991). How do humans navigate so many relationships and daily interactions with ease, processing social information at almost every moment? Furthermore, how do people make their own social decisions, and how do they predict how others will behave? One strategy employed by humans is to divide the world into social groups or categories (Brewer, 1979), and much research has focused on social categories of age, gender, race, and language or accent (e.g., Kinzler, Shutts, & Correll, 2010). However, another social dimension that has received less investigation in cognitive psychology despite its clear relevance to human psychology and relationships is kin (Lieberman, Oum, & Kurzban, 2008). Biologically, kin are a network of individuals that have different degrees of relatedness to an individual based on shared genes: for example, your sibling shares more genes with you than your cousin (Hamilton, 1964). Though adults may be able to identify individuals as kin or non-kin, this categorical distinction is not what is most relevant to social decision making, specifically, decisions about helping and cooperation; instead, degree of relatedness is important for kin. For non-kin, other factors such as the ability to reciprocate may be important and similarly weigh into decisions about helping and cooperation (Nowak, 2006). The precise way degree of kin relatedness affects social decisions is still an open question: how does being kin relations to varying degrees affect social decisions and behavior, and how do characteristics of kin relations and networks influence human psychology throughout development?
To explore these questions, this dissertation takes two approaches: (1) studying infants’ inferences about caregiving relationships and behaviors; and (2) studying children’s verbal reasoning about kin and non-kin relationships and how their social decisions like who to share with are influenced when kin or non-kin are involved. This research uses methods and frameworks from cognitive science and is also motivated by evolutionary theory and a focus on kin relations, which may function as a foundation or framework upon which human social relation psychology has developed. I predict that infants and children possess the ability to identify others by kinship degrees of relatedness and to integrate this information into their social decisions along with other relevant social information (e.g., likelihood of reciprocity, cost of actions, etc.). Though the most direct tests of this prediction would involve varying degrees of relatedness within kin, the present experiments begin by testing caregiving versus non-caregiving and kin versus non-kin comparisons.

First, I begin with a review of the social cognitive development literature on naïve sociology, or how infants and children reason about social categories and situations, then motivate the study of kinship with a review of interdisciplinary approaches to studying the development of kinship knowledge, including evolutionary psychology, anthropology, non-human animal studies, and language acquisition.

**Naïve sociology: State of the field**

*Social Categories*

Dividing the world into social groups and categories happens early and often: young children have explicit and implicit preferences for their own social group based on gender, race, and language (Brewer, 1979; Kurzban, Tooby, & Cosmides, 2001; Tajfel, Billing, Brundy, &
Flament, 1971; Dunham, Baron, & Banaji, 2008; Renno & Shutts, 2015; Kinzler, Depoux, & Spelke, 2007; Kinzler et al., 2010), and they encode some of these social categories automatically (Weisman, Johnson, & Shutts, 2015). Not only do children identify and distinguish between these social categories, but they also make inferences about members of them: expecting in-group members to receive help from other members of their group and members of different groups to be harmed by non-group members (Rhodes, 2012). Children themselves act according to social category lines: they favor their own in-group members and punish outgroup members (Rhodes, 2012; Jordan, McAuliffe, & Warneken, 2014). Children do so whether these categories are those we consider more trait-like and socially meaningful, such as gender or age (e.g., Dunham et al., 2008), and for temporary, assigned minimal groups like those with the same t-shirt color (e.g., Bigler, Jones, & Lobliner, 1997). Thus, social categories hold significant weight in expectations for behavior as well as children’s own behavior.

In their first two years, human infants understand a wealth of social information, including helping and fairness (Hamlin, Wynn, & Bloom, 2007; Sloane, Baillargeon, & Premack, 2012), dominance and hierarchy (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011; Mascaro & Csibra, 2012, 2014; Pun, Birch, & Baron, 2016), and imitation (Powell & Spelke, 2013, 2016). Infants demonstrate their own preferences for a helper (Hamlin et al., 2007), speaker of their native language (Kinzler et al., 2007), and singer of a familiar song (Mehr, Song, & Spelke, 2016). In third-party social interactions, they expect someone to prefer another who helped them (Kuhlmeier, Wynn, & Bloom, 2003), copied them (Powell & Spelke, 2018), spoke the same language (Liberman, Woodward, & Kinzler, 2017b), or shared their preference for the same food (Liberman, Kinzler, & Woodward, 2013). In their first two years,
infants demonstrate rich social preferences in addition to conceptually-rich social reasoning about social dimensions (Liberman, Woodward, & Kinzler, 2017a).

One open question is what social dimensions beyond age, race, gender, and language are infants and children sensitive to, if any. Liberman and colleagues (2017a) suggest that infants may first be sensitive to categories that were relevant during human evolutionary history, and by childhood, they start adopting other social categories learned through socialization by peers and adults. For example, race was not a relevant social group marker in early human history, and infants and children do not make the same inferences about social groups based on race as they do for language or gender (Weisman et al., 2015; Kinzler & Dautel, 2012; Shutts, Roben, & Spelke, 2013; Roberts & Gelman, 2016; Olson, Key, & Eaton, 2015; Kinzler et al., 2010; for review, Liberman et al., 2017a). One feature that was certainly relevant to humans, as it is to almost all species, is kinship (Hamilton, 1964), which has not received much study in social cognitive development but is the central focus of this dissertation. I propose that kinship is a social dimension that is relevant to human psychology and that degree of relatedness to someone should be information that infants and children will be sensitive to and will influence their social behaviors. I propose kinship as an important dimension, but instead of infants and children considering kinship to be categorical in nature, and thus similar to previously studied social categories that split into in-group and out-group, kinship is more continuous, with closer kin being more highly valued than distant kin and not all kin necessarily being valued over non-kin. 

*Paper 3* tested children’s social reasoning about kin versus non-kin using the comparison of sibling to friend and sibling to stranger.

*Naïve utility calculus framework*
To better understand children’s reasoning about a specific social dimension, it would be helpful to know more about the underlying representations and principles guiding infants’ and young children’s expectations in the social domain, more broadly. One theory proposes that infants and children use a naïve utility calculus that includes a social agent’s costs, behaviors, and desires, using these variables to predict and interpret the agent’s actions and mental states and to evaluate the agent’s prosocial actions (Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016). The theory involves an agent choosing the action that will maximize their utility, which is comprised of the reward of the action minus any costs of the action. Consistent with this theory, infants expect an individual to take the most direct path to their goal (Gergely & Csibra, 2003) and to prefer an individual they took a greater personal cost to reach (Liu, Ullman, Tenenbaum, & Spelke, 2017). Children also evaluate other people’s refusals to complete prosocial actions as nice or mean based on how difficult it was for the actor to complete the action (Jara-Ettinger, Tenenbaum, & Schulz, 2015b). For example, a tall person would be judged more harshly than a shorter person for refusing to get a book off a high bookshelf, because it is more difficult for the short person to retrieve the book. A naïve utility calculus accounts for an agent’s costs and the value the agent assigns to goals.

Nevertheless, all studies thus far have held constant or ignored any prior social relation between individuals engaging in the social transactions. This could be because much of the research exploring the naïve utility calculus has focused on the costs involved in the actions rather than the rewards (Jara-Ettinger, Gweon, Tenenbaum, & Schulz, 2015a; Jara-Ettinger, Tenenbaum, & Schulz, 2015b; Liu et al., 2017). Considering the rewards in a naïve utility calculus, one dimension that I propose to be relevant to a given reward when the action involves two individuals, is the relationship between the two individuals, or the social value of the
decision maker to the recipient. For example, imagine again that someone was asked to retrieve a book from a tall shelf, and the book was out of reach for that person. Whether they find a means to retrieve the book and how much effort they put into doing so would depend on who they are retrieving it for: is it a close friend, their child, or a complete stranger? In the context of different social relationships, the same action may result in different rewards depending on the value to the actor of the beneficiary, or recipient, of the action: a mother values her child more than strangers value one another, intuitively and evolutionarily (Hamilton, 1964). Therefore, I propose that social value could be integrated into a component of reward in a naïve utility calculus to account for the effect of prior social relations on actions of helping. Social value and relationships should be included in a mature naïve utility calculus, and this variable would capture kin relations in addition to other types of social relationships, such as a friendship characterized by reciprocity and social closeness.

Children from two- to five-years-old have demonstrated social reasoning consistent with naïve utility calculus (Jara-Ettinger et al., 2015a, 2015b, 2016), so I propose that evidence supporting the integration of social value—including kin relatedness—into rewards should be present in young children as well. To explore how social relationships might weigh into social decisions for young children, Paper 3 tested how three- to five-year-old children responded when a sibling, friend, or unfamiliar child was involved predictions or decisions about sharing with limited resources.

Infants show social reasoning consistent with precursors to the naïve utility calculus in experiments exploring goal-direction actions (Gergely, Nadasdy, Csibra, & Biro, 1995; Gergely & Csibra, 2003), sample and preferences (Xu & Garcia, 2008; Xu & Denison, 2009; Denison, Reed, & Xu, 2013), communication and pedagogy (e.g., Liszkowski, Carpenter, & Tomasello,
2008), and social and moral reasoning (Kuhlmeier et al., 2003; Hamlin et al., 2007; Hamlin, Wynn, & Bloom, 2011; for review, see Jara-Ettinger et al., 2016). Recent research has also provided evidence that 10-month-old infants infer the value of goals from the costs of individuals’ actions (Liu et al., 2017), suggesting that expectations consistent with a naïve utility calculus that maximizes utilities is operating even in the first year. Liu and colleagues (2017) manipulated the costs of actions, and infants made inferences about the rewards of achieving those goal states. Though currently untested, infants may also be able to reason about factors like social value that affect the rewards, and they may be able to make inferences about the costs an individual would take to achieve them. For example, if infants expected an adult to take a higher cost action to help their child than to help an unrelated individual, this would suggest that they infer a higher reward for helping a related (parent-child) rather than unrelated individual. To make that inference, infants would first need to be able to identify a parent-child relationship, so evidence that infants identify and make inferences about parent-child relationships is a necessary precursor. The present dissertation thus first explores infants’ inferences about parent-child caregiving relations—such as whether infants infer affiliation through a mutual social connection in a caregiving context versus non-caregiving context (Paper 1), and whether infants prefer an adult who responds to a crying baby over one who avoids it (Paper 2). These experiments are important to understanding how infants reason about parent-child caregiving relationships before testing for their ability to integrate this information into inferences about the rewards of actions. Overall, the integration of a social value into the reward function of the naïve utility calculus provides a means of including social relationships that were relevant in our evolutionary history into a mental calculus that operates across social situations.
A core knowledge domain for social partners

Accumulating evidence supports a theory of core knowledge domains in humans, which are present from birth and shared with non-human animals (Spelke & Kinzler, 2007). Evidence for core domains of objects, actions, numbers, places, and agents support shared cognitive mechanisms among humans and non-human animals—for example, signatures of agent representations were found in newly hatched chicks, rhesus macaques, and chimpanzees (Spelke & Kinzler, 2007; Salva, Regolin, & Vallortigara, 2007; Flombaum & Santos, 2005; Hare, Call, & Tomasello, 2001). A core domain of agents includes reasoning about individuals’ goal directed actions and achieving these actions efficiently (Spelke & Kinzler, 2007), which coheres with a naïve utility calculus reviewed earlier (Jara-Ettinger et al., 2016).

An additional candidate system has been proposed for identifying and making inferences social partners and social group members (Spelke & Kinzler, 2007). What dimensions might be relevant to a system that works to identify potential social partners and group members? Kinzler and Spelke (2007) propose that language may be a relevant group marker for humans, and infants’ ability to reason about dominance relations from a young age (Thomsen et al., 2011; Mascaro & Csibra, 2012, 2014; Pun et al., 2016), suggests that dominance may also contribute to evaluating social partners. An additional dimension that could be relevant to a social partner core knowledge system and that is prevalent across species (see ‘Why kinship? Motivation from anthropology and animal studies’) could be degree of relatedness, or kinship. The prevalence of tracking and benefiting kin across species supports this dimension as potentially relevant to human social partner psychology, though evidence that infants and children identify kin and related individuals and integrate this information into their decisions is still needed. The present
dissertation provides initial tests of whether infants track caregiving, which may serve as the foundation for what children and adults later identify as kin.

*Evolutionary psychology: A welfare tradeoff framework*

Evolutionary biologists and psychologists have applied theories of evolution to inform predictions about psychological mechanisms and behavior (Hamilton, 1964; Axelrod & Hamilton, 1981; Trivers, 1971; Nowak, 2006; Cosmides & Tooby, 2013). In the social domain, one such theory proposed that humans have ‘internal regulatory variables’ that incorporate information from the world into flexible but stable values that guide an individual’s behavior in any given scenario (Cosmides & Tooby, 2013; Delton & Robertson, 2016). Many variables contribute to one composite variable, a ‘welfare tradeoff ratio’, which signifies how someone values themselves relative to someone else (Delton & Robertson, 2016). This variable has been reliably measured with a task that involves repeated resource trade-off decisions where people choose between two reward options—typically, money; in one option, they keep the reward, and the other gets nothing, or in the other, someone else gets the reward, and they get nothing. People demonstrated relatively stable ‘switch points’ in these decisions where they changed from favoring themselves to favoring the other person (Kirkpatrick, Delton, Robertson, & de Wit, 2015; Delton & Robertson, 2016). People made these kinds of decisions consistently when rewards were either real or hypothetical (Locey, Jones, & Rachlin, 2011). Decision ‘switch points’ varied based on how costly it was to help, how valuable the reward was, and who the recipient of the reward was (Delton & Robertson, 2016; Stewart-Williams, 2007; Ostaszewski & Osinski, 2015). Ongoing research demonstrates that from the age of four years, children’s resource distribution choices also showed consistent welfare trade off ‘switch points,’ and
children calibrated their choices differently when the recipient was a friend, stranger, or enemy (Howard, Spokes, Mehr, Krasnow, in preparation). Children’s responses were consistent with adults’ responses in the same social transactions, suggesting that a welfare tradeoff calculation may guide behavior in children that are still learning to navigate new social circles outside the home.

The framework of an internal variable such as the welfare trade-off ratio is consistent with a naïve utility calculus that integrates additional information relevant to social decisions—specifically, social value—into the rewards. Proponents of welfare tradeoff ratios include social value through additional internal regulatory variables: for example, a kinship index variable (Lieberman, Tooby, & Cosmides, 2007). The kinship index feeds into a welfare tradeoff, so relatedness influences decisions in a social transaction. Cues that increase the likelihood of being siblings—co-residence and witnessing your mother care for a newborn—tracked with individual’s altruism and incest avoidance toward siblings (Lieberman et al., 2007). These patterns held true across a diversity of cultures and unique non-kin communal rearing contexts (Sznycer, De Smet, Billingsley, & Lieberman, 2016; Lieberman & Lobel, 2012). Relatedness affects altruism even when social closeness is held constant: people gave more to relatives than non-relatives (Rachlin & Jones, 2008). Thus, adults behave consistently with a kinship index variable that influences social decisions, but understanding the development of these behaviors could reveal more about whether the behaviors in adults are learned social constructs or earlier emerging, possibly innate, and potentially similar to or shared with kin-tracking mechanisms of other species. This dissertation explores whether and how caregiving, relatedness, and kinship might be relevant to a candidate core knowledge domain of social partners through three lines of research, detailed below.
Why kinship? Motivation from anthropology and animal studies

Even in disciplines that champion cultural distinction, researchers concede to a universal when it comes to the existence and importance of kinship in the human social world and the necessity to study kinship to better understand human nature (Parkin & Stone, 2004; Shenk & Mattison, 2011; cf. Schnieder, 1972, 1984). Kinship has been a foundational area to anthropological study since the earliest days of academic anthropological study in universities (Fox, 1967; Shenk & Mattison, 2011), but the importance of kin relations is not limited to humans.

Tracking and benefiting kin is pervasive across species small to mighty (Hamilton, 1964). Tiny social insects work together in colonies that exclude unrelated individuals (Crozier & Pamilo, 1996; Passera, Aron, Vargo, & Keller, 2001; Queller & Strassmann, 1998). Birds help raise the young of related birds (Emlen & Wrege, 1988; Baglione, Canestrari, Marcos, & Ekman, 2003). Belding’s ground squirrels (*Spermophilus beldingi*) announce a predator with an alarm call at higher rates to benefit their relatives (Sherman, 1977). Primates who have relatively recent shared ancestry with humans like baboons, macaques, vervets, and red howlers demonstrate preferential support of kin (Silk, 2002; Chapais & Berman, 2004). Thus, kinship and genetic relatedness dictate altruistic behaviors—helping, protecting, and sharing valued resources—toward kin in addition to violent behaviors toward non-kin (Emlen & Wrege, 1988; Daly & Wilson, 1988). Compared with our primate ancestors, human kinship systems are more complex and expansive—including larger social networks, numerous groups, and spanning further geographical distances (Chapais, 2008; Fox, 1975; Palmer, Steadman, & Coe, 2006; Rodseth & Wrangham, 2004; Rodseth et al., 1991). Despite the greater complexity of kinship systems, given
the shared ancestry and pervasiveness of kin-tracking and support, humans may show similar behaviors of tracking and benefiting kin. The present dissertation searches for signatures of this psychology in infancy and childhood, building upon a foundation of work studying human kinship psychology in evolutionary psychology. Papers 1 and 2 tested how infants might track caregiving relations, which are typically but not always comprised of kin. In Paper 1, we tested infants’ inferences about shared social connections in a caregiving context compared to a non-caregiving context, and Paper 2 tested whether infants might prefer caregivers who are responsive to a baby’s cry over ones who avoid it. Paper 3 explored the question of whether children benefit kin over non-kin testing their sharing behaviors among siblings, friends, and unfamiliar children.

The ontogeny of kinship understanding

In households across the globe, from the United States to Italy and China, the first words spoken by toddlers are consistently some form of “mommy” and “daddy” (Caselli et al., 1995; Tardif et al., 2008). Kin terms are learned early, but when do children understand the meaning of such words and relationships instead of simply using them as names for their loved ones? The study of kinship knowledge acquisition dates back to early studies of kinship terms by Piaget (1928), who documented stages of acquisition, delineated by the ability to separate an egocentric from objective perspective on kin relations. For example, young children did not see the contradiction between the existence of three sisters in one family (Erin, Megan, myself) and the statement, “I have three sisters” (Erin, Megan, myself), and it was not until age 9 or 10 that children started to demonstrate a reciprocal understanding of a relationship (Piaget, 1928). Explicit reasoning about kinship relations and networks thus may require both experience and
cognitive changes that occur throughout childhood before children can succeed on such
definition tasks (Piaget, 1928). Further language acquisition research across multiple cultural
groups replicated the stages of acquisition and documented differences in order and age of
acquisition by complexity of term (Danziger, 1957; LeVine & Douglass, 1974; Heider, 1976;
Danziger, 2000; Ellis, Green, & Kral, 2017). Haviland and Clark (1974) argue that development
hinges on semantic complexity, and others argue that experience with certain relations drives
performance (Benson & Anglin, 1987). Generally, early research on children’s acquisition of
kinship knowledge suggests that their explicit verbal reasoning through definition tasks emerges
relations instead of soliciting definitions has helped children to succeed at younger ages
(Chambers & Tavuchis, 1976). Young children also struggled with explicit understanding of kin,
selecting an elderly woman as grandmother over a more youthful woman who parented a parent
(Landau, 1982). This line of research charts acquisition of kinship terms but leaves open many
questions regarding the acquisition of kinship concepts and how kin relations might affect
children’s behavior and predictions about others’ behavior.

In developmental psychology research, children have failed to demonstrate clear patterns
of preferential altruism toward kin over non-kin (Olson & Spelke, 2008). Children did
demonstrate some sensitivity to the recipient of the resources: they held friends in higher regard
than enemies (Howard et al., in preparation), and friends and siblings in higher regard than
strangers (Olson & Spelke, 2008). In unstructured observations, older siblings have been found
to provide more spontaneous guidance, explanation, and positive feedback to their younger
siblings compared to older, unrelated children (Azmitia & Hesser, 1993). However, this was not
controlling for more solicitation and positive responses from younger children to their sibling
teachers rather than unknown teachers. Thus far, experimental research with children has not provided evidence for a specific sensitivity to kin and relatedness, especially relative to their expectations for friends.

Despite a delayed explicit reasoning about kin concepts, signs of understanding caregiving relationships, emerge in infancy and toddlerhood. Caregiving relationships are not inherently kin, but they may be the fundamental relationships that infants track and use to connect and build the social networks around them from an early age. For example, in a third-party context, infants at 12-16 months demonstrate different expectations for how an adult should respond to a crying baby depending on their attachment to their own caregiver (Johnson, Dweck, & Chen, 2007; Johnson, Dweck, Chen, Stern, Ok, & Barth, 2010). More specifically, infants with a secure attachment to their caregivers looked longer when an adult avoided and moved away from a crying baby, and conversely, infants with an insecure attachment to their caregivers looked longer when an adult responded by approaching the crying baby (Johnson et al., 2010). Using videos of real people rather than animations, researchers replicated this main pattern of results—infants at 4- and 12-months-old looked longer when a woman ignored rather than responded to a crying baby (Jin, Houston, Baillargeon, Groh, & Roisman, 2018). Although not exclusive to biological kin, caregiving most often occurs among kin relations, so tracking pseudo-parent-child relationships may be a precursor to later building social networks of family relationships and identifying kin and related others. We began an exploration of caregiving because of the previous literature and experimental methods available showing that infants form expectations about caregiving events (Johnson et al., 2007, 2010), so we could adapt these paradigms to test new questions, such as whether infants infer social connections among babies
cared for by the same adult or adults who care for the same baby based on caregiving events \emph{(Paper 1)}. Caregiving events were thus a promising avenue for first experiments.

\textbf{Current research: Theory and hypotheses}

Across the research fields reviewed above, the evidence thus far does not clearly answer how kinship understanding develops in childhood nor how it factors into children’s social expectations and transactions. Studying kin relations could inform and unite multiple theories in cognitive psychology: first, how social value may integrate into the rewards of a naïve utility calculus, and second, whether and how relatedness or some form of a kinship index impacts welfare tradeoff decisions. Both frameworks support plausible theories for how human social decisions are made and how we predict how others are going to behave. Studying how kinship and relatedness fits into these frameworks could help us to better understand how to translate findings from experiments on children’s social decisions in lab settings with unknown or unfamiliar social partners to more realistic contexts, where children interact with known individuals: family and friends.

Furthermore, caregiving and relatedness may be a dimension relevant to a candidate core knowledge system that identifies social partners and group members, in addition to dimensions like shared language and dominance (Spelke & Kinzler, 2007). This system would serve to help infants identify social partners for themselves in addition to helping them reason about other’s social partnerships and groups to predict how they will behave. Caregiving and kin relations may be relevant to infants from an early age because many of infants’ first interactions in the world involve kin—either their own interactions or the interactions they observe in their homes. If the first relationships they are tracking are ones that adults identify as kin, infants might quickly
become attuned to dimensions and information diagnostic of these relationships—such as a parent soothing a crying baby or feeding a baby. Then, they may build on these parent-child relationships to track larger networks of social connections: seeing two adults care for the same baby could suggest partnership between the two adults, seeing one adult who cares for two different children could suggest a relationship between the children, and so on. Though caregiving and relatedness are not the only likely relevant social dimensions that infants could build social networks upon—reciprocal partnership is another likely dimension (Nowak, 2006)—I propose that relatedness is a plausible and likely dimension, given the adaptiveness of identifying and helping kin, supported by broad cross-species, and the common exposure of human infants to family in their first few years. As with other core knowledge systems, humans could then build upon the more inflexible, species-wide ability to track kin by combining with other core knowledge systems and using human-unique abilities like language to develop more complex, richer understanding of social networks and relationships. For example, modern day humans have social networks that have grown into hundreds and even thousands of individuals, most of whom we can identify by face, name, and how they are socially connected to ourselves and to others (though we also rely on tools such as Facebook, at times).

If a core knowledge of social partners involves understanding caregiving relationships, then infants from the earliest ages tested should be sensitive to caregiving events, such as a caregiver soothing a crying baby. It is possible that infants are sensitive to comforting interactions between caregivers and babies even without piecing together kinship structures, but to build social structures that adults later map kinship concepts onto, certain primitive ideas must be understood first, and caregiving relations seem like a prime candidate for a primitive. Thus, I predict that infants should be sensitive to qualities and behaviors that identify who caregivers
are, and they should make inferences about caregivers—such as who might be a better or worse caregiver, what traits are associated with being a caregiver, etc. I propose that infants will make inferences about caregivers and caregiving contexts, with an ability to track third-party caregiving interactions that does not necessarily generalize to other social contexts. With age, children should continue to identify kin and being kin should factor into their social decisions, though exactly how kinship weighs into social interactions remains an open question. I predict that closer kin should be more valued than more distant kin, however, due to practical limitations of experimental methods, the present experiments begin with kin versus non-kin comparisons rather than testing varying degrees of kin relatedness. Welfare tradeoff theorists posit that additional features of the people involved in a social interaction—reciprocity value, formidability, etc.—in addition to features of situations—stakes, who is watching, etc.—all combine to influence a decision (Delton & Robertson, 2016). As children develop the ability to move and interact more independently with social partners as well as use language to express their social preferences, children’s social worlds will expand and early inferences that centered on kin will consequently expand and be able to aid children in navigating their social worlds. Thus, kinship is one of many variables that may affect decisions, but children should demonstrate some sensitivity to kinship status.

The present dissertation begins to test for sensitivity to kinship as evidence for a core knowledge domain of social partners centered on caregiving relations in infancy and childhood in three papers: Paper 1 tested infants’ inferences about likely affiliative interactions in caregiving contexts—where an adult soothed a baby—and compared these to non-caregiving contexts—peers laughing together. Paper 2 further explored infants’ early inferences about caregivers, demonstrating that infants from five-months-old are sensitive to the behavior of
caregivers, preferring an adult who responds to rather than avoids a baby’s cry. Paper 3 explored children’s understanding of kin versus non-kin relationships in childhood and whether they expect limited resources to be preferentially shared with kin over non-kin.

Current research: The three papers

Paper 1 (Spokes & Spelke, 2017)

If kin relations are at the center of a core domain of social partners, then sensitivity to and reasoning about kin relations should be present even in infancy. Initial evidence has found that infants’ style of attachment to their own caregivers influences how they interpreted third-party caregiving events (Johnson et al., 2007, 2010), suggesting that infants’ familiarity with a social context like caregiving may facilitate reasoning about similar third-party scenarios. Paper 1 explored how infants reason about a type of kin relation prominent in all societies: the caregiving relation between parents and their babies (Spokes & Spelke, 2017). In a series of six experiments using animated events, we tested whether 15- to 18-month old infants (N = 112) organized observed social relations into larger social networks, inferring the relationship between two social beings based on their relations to a third party, both in a caregiving context (Experiments 1, 2, 4, 5, 6) and non-caregiving context (Experiment 3).

In Experiments 1 and 2, we asked whether infants infer that two babies who were comforted by the same adult will affiliate with another. Infants watched animated scenes in which a baby cried, signaling a need for caregiving, and was then comforted by an adult’s approach and synchronized movement. Two babies were comforted by the same adult and one by a second adult. At test, infants saw affiliative interactions between two babies who had been
soothed by either the same or different adults, and they looked significantly longer to affiliation between babies who were soothed by different adults, \( F(1, 30) = 6.51, p = 0.016, \eta^2_p = 0.18 \).

However, when presented with a new social context involving all adults who respond to other adults’ laughter in Experiment 3, infants did not show the same expectation for affiliation between adults with a shared social partner. This experiment suggests that infants may be more sensitive to tracking social relationships in caregiving contexts given the same amount of social information.

In Experiment 4, infants still tracked adult-baby caregiving networks, expecting two babies with the same caregiver to affiliate, when all characters were the same size and only voices signaled age. Across Experiments 1, 2, and 4, infants who did not themselves have siblings \((N = 23)\) looked longer to affiliation between babies soothed by different adults relative to babies soothed by the same adult—pseudo-sibling relationships \((t(22) = 1.94, p = 0.033, d = 0.40)\). Moreover, in Experiments 5 and 6, infants inferred that two adults who comforted the same crying baby would affiliate with one another, relative to a third adult who comforted a different baby, demonstrating that infants track not only babies who emit cries but also the adults who respond to them.

Ongoing experiments with younger infants showed that expectations of affiliation between parties to comforting interactions may not emerge until 15- to 18-months: 11- to 12-month-olds show inconsistent looking patterns to the same animated events shown to older infants (Spokes & Spelke, in preparation). At nine months, infants did not differentiate between such events, even after additional familiarization. It is not clear, however, whether this developmental change reflects the emergence of a basic understanding of baby-adult caregiving.
relationships or gains in the attentional and memory capacities needed to keep past interactions among five characters in mind at test.

Together, Paper 1 and ongoing research with younger infants (Spokes & Spelke, in preparation) demonstrated that infants can track caregiving relationships and use that information to infer affiliative relationships between babies who were soothed by the same adult and adults who soothed the same baby. However, infants did not make the same inference about shared social connections after seeing an adult respond to another adult’s laughter, a non-caregiving context. These experiments thus demonstrate that infants make inferences about third-party social networks when shown caregiving events, but not necessarily other, similar social interactions. These experiments also contributed the first evidence that infants infer social relations between individuals who have never interacted before based upon their mutual social connection to a third individual.

These results are consistent with a core social cognition that has a foundation in kin relations and with the ability to track and remember social relationships with minimal information being first present for caregiving, kin-like relations. Though how infants interpreted the relationships in the present experiments remains an open question, the adults who most frequently respond to a baby’s cry are the baby’s kin. Infants in these experiments also have 15- to 18-months of experience in the world, and thus inferences regarding caregiving may have been learned rather than present from birth. In order to explore infants’ earliest intuitions, experiments with younger infants are necessary. However, the present experiments require infants to track five individuals and three social relations in order to make inferences about potential shared connections, and 9- to 12-month-olds already show different patterns of looking
than 15- to 18-month-olds, so *Paper 2* explores a novel study design to test inferences about caregiving in younger infants at five months.

*Paper 2 (Spokes, Venkatesan, & Spelke, in preparation)*

Infants benefit from identifying people in their environments who are their caregivers and who are likely to be helpful to them, but they also benefit from tracking other people’s caregivers and social connections to better predict and understand their behavior. Indeed, infants have an early emerging ability to track caregiving interactions and infer social connections from witnessing these caregiving events (*Paper 1*). From observing third-party caregiving events, infants may also be able to discern who may be more helpful, better caregivers, and infants may attend to these people to garner their support. *Paper 2* tested whether 5-month-old infants make inferences about caregiving events that require fewer characters and social relationships to follow the events. More specifically, we tested whether infants prefer a responsive versus unresponsive caregiver. We predicted that infants would differentiate between the two adults—one who comforts a crying baby and one who does not—and would prefer to engage with the one who was more comforting.

We showed infants (*N* = 16) animated videos of a crying baby with one adult who responds by approaching the baby and one by avoiding the baby in alternating trials (Experiment 1). Then, at test, when we showed infants the two adults side-by-side, they looked longer toward the previously responsive adult, *M* = 0.608, *SD* = 0.199, *t*(15) = 2.17, *p* = 0.047, *d* = 0.56, 95% CI [0.502, 0.713]. This longer looking may indicate a social preference for the responsive adult but could also be a preference for an ‘approacher’ over an ‘avoider’ more broadly.
To distinguish between these interpretations, in Experiment 2, we presented infants with animated scenes of adults responding to a noisy object rather than a crying baby. When infants \((N = 16)\) saw the two adults respond to a noisy object instead of a crying baby, they no longer looked longer toward the responsive adult at test, \(M = 0.485, SD = 0.218, t(15) = 0.27, p = 0.79, d = 0.069, 95\% \text{ CI} [0.37, 0.601]\).

To test whether the preference for a responsive adult extends to additional social contexts, in Experiment 3, we then presented infants \((N = 28)\) with scenes of either a fussing or laughing baby, and again, one adult approached and one avoided. When infants viewed either a fussing or laughing baby during familiarization events, they also did not look longer to the responsive adult at test, \(M = 0.527, SD = 0.19, t(27) = 0.75, p = 0.46, d = 0.14, 95\% \text{ CI} [0.453, 0.6]\), suggesting that responding to a baby’s cry uniquely leads to a looking preference for a responsive adult. These results are consistent with recent findings using realistic videos rather than animations and found that 4- and 12-month-old infants respond differently to a woman’s responsive or unresponsiveness to a baby’s cry but not a baby’s laughter (Jin et al., 2018). However, they raise interesting questions about why a response to a baby’s cry might be more diagnostic of a caregiving relationship between a parent and child and not a baby’s fuss or laugh, because parents respond to all sorts of emotions, needs, and calls from their children. One possibility is that a cry is more diagnostic and reliable: when an infant cries, their parent may be the most likely to respond, but if an infant laughs or fusses, any nearby person may want to or happen to respond.

Thus, these experiments suggest that a sensitivity to caregiving events and which adults in an infants’ environment might be better caregivers could be present in the first 6 months.

Infants who cannot yet express their social preferences using language or even through
approaching others themselves already orient their gaze toward adults who are more comforting in response to another baby’s cries. These results are consistent with a core knowledge domain of social partners that could incorporate caregiving information in addition to other signals of potential positive social partners like helpfulness (Hamlin et al., 2010), shared language (Kinzler et al., 2007), and dominance (Thomsen et al., 2011).

*Paper 3 (Spokes & Spelke, 2016)*

Despite early emerging inferences about kin-like relationships in infancy, children’s explicit understanding and reasoning about kinship may not emerge until much later in childhood. *Paper 3* tested three- to five-year-old children’s understanding of siblings, friends, and strangers in addition to testing their expectations for social interactions and resource sharing. If kin is a relevant social category in childhood, children should not only recognize kin versus non-kin boundaries but also make inferences about kin, predicting an in-group preference for sharing with kin over non-kin. Previous research exploring kids’ social judgments found that at around 3.5-years-old, when given many resources in a hypothetical story, children allocated more to friends over strangers, siblings over strangers, and then equally between friends and siblings (Olson & Spelke, 2008). Thus, with plentiful, low-value resources, children did not seem to benefit kin over non-kin. This sharing context held relatively low stakes for children for two reasons: they had plentiful resources and the social relationships considered were third-party, fictional characters, unrelated to the children. *Paper 3* explored whether children’s behavior changes when the stakes are raised across both factors: having limited resources—one item to share (Experiments 1, 2, 3)—and testing how children would behave toward their own siblings, friends, and children they have never met before (Experiment 2).
We presented children with storybooks (Experiments 1-2) or vignettes on a computer (Experiment 3) where children dictated how a central character might distribute a single item to a sibling versus friend, sibling versus stranger, and friend versus stranger. Our primary measure was to whom the children chose to deliver the resource. In Experiment 1 ($N = 96$), we found that three-year-old children gave the single resource to friend over stranger, and four-year-old children gave the single resource to sibling and friend over stranger. However, in choosing between sibling and friend, all children were at chance levels despite there being only one resource. Furthermore, children answered more questions correctly about the distinction between sibling and stranger as well as friend and stranger but did not answer any questions about friend versus sibling above chance levels, suggesting they may not have a strong distinction between these relationships.

In Experiment 2 ($N = 108$), we further raised the stakes by having children distribute a resource to their own friends and family instead of hypothetical characters, predicting they may then show a kin preference in giving. Three- to five-year-old children colored in a character that we inserted into the story, asking questions about their own siblings, friends, and children they have never met (“strangers”). We found that all children shared the one resources with sibling over stranger, three- and four-year-olds shared with friend over stranger, but children at all ages still shared roughly equally between friends and siblings. Thus, even in cases where children considered their own family and friends, they did not prefer to benefit kin over non-kin. Children showed similar patterns in their responses to questions testing their knowledge about the relationships: answering more questions correctly for sibling versus stranger than sibling versus friend, even when the same questions were asked about the different pairs across children. Children may consider friends as more similar to siblings than other relationships at three- to
four-years-old. By age five, children answered all questions correctly, suggesting that explicit reasoning about kin relations may not emerge until five years of age.

In Experiment 3 ($N = 48$), we used face morphology software to present three- to five-year-old children with siblings that resembled one another and asked whether a protagonist would help or share with a sibling or friend. We found that five-year-old children, but not three- and four-year-old children, expected more help and sharing to occur with siblings than friends. This expectation may have been due to the either the sibling resemblance strengthening the effect or the more varied prosocial contexts: helping instead of simply sharing resources.

These experiments together present the foundation for exploring kin understanding and expectations for social interactions involving kin in children. Children did not demonstrate a consistent kin over non-kin preference across social contexts and experiments, which is still consistent with a welfare tradeoff psychology that includes additional features which may counter a kin preference, specifically in these experiments, reciprocity value of friends—a feature of the people involved—and low stakes—a feature of the situation (Delton & Robertson, 2016). The results are still consistent with kinship as one of many variables that affect social decisions, but they fail to provide much evidence for kin-tracking in children until around age five, when children answered questions about kin and non-kin distinctions correctly (Experiment 2) and began predicting help toward kin over non-kin (Experiment 3). Given that adults tend to show a kinship bias in high stakes situations (Rachlin & Jones, 2008; Madsen et al., 2007), further experiments that present children with higher stakes scenarios to test whether they benefit kin over non-kin could provide more support for the effect of relatedness on social behavior in childhood.
Paper 1: The Cradle of Social Knowledge: Infants’ Reasoning about Caregiving and Affiliation

Abstract

Considerable research has examined infants’ understanding and evaluations of social agents, but two questions remain unanswered: First, do infants organize observed social relations into larger structures, inferring the relationship between two social beings based on their relations to a third party? Second, how do infants reason about a type of social relation prominent in all societies: the caregiving relation between parents and their babies? In a series of experiments using animated events, we ask whether 15- to 18-month-old infants infer that two babies who were comforted by the same adult, or two adults who comforted the same baby, will affiliate with one another. We find that infants make both of these inferences, but they make no comparable inferences when presented with the same visible events with voices that specify a peer context, in which one adult responds to another laughing adult. Thus, infants are sensitive to at least one aspect of caregiving and organize relations between infants and adults into larger social structures.

Keywords: caregiving, social cognition, social development
Introduction

From an early age, infants understand and evaluate social agents based on their actions and interactions. Infants selectively interact with people who cooperate with or help one another (Hamlin, Wynn, & Bloom, 2007), who share the infant's preferences (Mahajan & Wynn, 2012), and who speak with the accent of the infant's social partners (Kinzler et al., 2007). Infants also demonstrate early proficiencies in making inferences about others’ affiliative behaviors. Before the end of the first year, infants infer that characters will affiliate with others who have helped them (Kuhlmeier et al., 2003) or expressed shared food preferences (Liberman, Kinzler, & Woodward, 2013), and they infer that members of social groups will act alike (Powell & Spelke, 2013). Nevertheless, two questions have received little attention from investigators of early social cognitive development. First, can infants organize observed social relations into larger structures, inferring an affiliative relationship between two social characters based on their relations to a third party? Second, do infants understand events in which an adult comforts a baby as social interactions that can support social inferences?

Despite the ubiquity, universal properties, and evolutionary importance of kinship relations (e.g., Murdock, 1949; Kemp & Regier, 2012; Hamilton, 1964; Nowak, Tarnita, & Wilson, 2010), children's explicit understanding of kinship develops slowly. Five-year-old children apply terms such as grandmother to childless women of advanced age over youthful mothers of a parent (Landau, 1982), and many younger children judge that friends are as likely as siblings to have the same grandmother (Spokes & Spelke, 2016). Nevertheless, implicit knowledge about basic parent-child relations may be a foundational aspect of social understanding, as infants’ earliest and most important social interactions commonly occur with immediate kin.
Parent-child interactions have three prominent features that distinguish them from other affiliative social interactions. First, they are asymmetric: given adults' greater knowledge, skill, and power, parents act for the benefit of their children without expecting or receiving comparable reciprocation. Second, parent-child exchanges often center on acts of comforting, nurturance, and aid: although unrelated adults may respond to infants’ positive social overtures, parents are expected to respond to positive overtures and also to infants' needs and cries, both in human and non-human primate groups (Cheney & Seyfarth, 1990). Third, parent-child relations figure in a network of family relations. Two parents of a single child typically are partners, and two children with the same parent typically are siblings.

Recent research provides evidence that infants are sensitive to asymmetric relationships in a different context: that of dominance. By 6-9 months, infants infer that members of numerically larger groups will dominate members of smaller groups (Pun, Birch, & Baron, 2016). At 10 months, infants infer that the larger of two characters will win a competitive interaction (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011). By 15 months, infants show nuanced inferences about social rank and dominance across multiple contexts: if one character dominates another character by taking a desired location, for example, infants infer that the same character will prevail in a competition over objects, even if the two characters are equal in size and appear outside any group context (Mascaro & Csibra, 2012; 2014). Moreover, infants' memory for dominance relations is modulated by the structure of multiple social pairs: they show better memory for relations between familiar pairs of individuals that are consistent with a linear dominance structure (Mascaro & Csibra, 2014). Nevertheless, no study has tested whether infants attribute dominance relations to pairs of individuals who interact for the first time, based on the individuals' relations to others within a dominance hierarchy.
Regarding parental care, one set of studies provides evidence that 12- to 16-month-old infants make inferences about caregiving interactions between two characters of unequal size (Johnson, Dweck, & Chen, 2007; Johnson, Dweck, Chen, Stern, Ok, & Barth, 2010). Infants were familiarized with an event in which two characters moved together and then became separated, after which the smaller character emitted a baby's cry. On test trials, the larger character either returned to the crying baby or continued to move away from the baby. Infants with secure attachment styles, but not those with insecure attachment styles, looked significantly longer at the latter event, suggesting they inferred that the larger character would return to the crying baby (Johnson et al., 2007). In further studies, infants with secure attachment styles also looked longer at test events in which a baby approached an unresponsive character rather than a responsive character (Johnson et al., 2010). In contrast, infants with ambivalent or avoidant attachment styles showed the reverse effect (Johnson et al., 2010). Thus, infants’ inferences concerning the behavior of adults toward babies and babies toward adults are modulated by infants' social perceptions and motivations toward their own caregivers. These findings show that infants find animated adult-baby comforting interactions to be socially meaningful, although they do not reveal how richly infants interpret these interactions. Here, we use these animated events to ask whether infants are sensitive to the interconnectedness of adult-child relations within a social network.

Sensitivity to interconnected sequences of social actions has been shown in studies of infants' evaluations of characters who help or hinder other characters. Infants show systematically different preferences for a helper character, depending on whether the character that it helps has previously engaged in prosocial or in antisocial behavior toward a third character (Hamlin, Wynn, & Bloom, 2011). Caregiving is a moral obligation, like helping, which is
centered on aid, so infants may reason about caregiving interactions in a similar manner to helping. In addition, infants at 16 months can track and infer conflict between two groups of characters: If they see characters cooperate with others within their group and then see some members of each group participate in inter-group conflict, infants infer that other members of the two groups will engage in intergroup conflict as well (Rhodes, Hetherington, Brink, & Wellman, 2015). No study reveals, however, whether infants' reasoning about the structure of social networks supports inferences about affiliation between characters who have never been seen to interact directly. In particular, we do not know whether infants make inferences about potential social affiliation between novel pairs of individuals, based on the prior interactions of those individuals with other parties.

The present experiments address this question in 15- to 18-month-old infants. We show infants several baby-adult interactions like those of the responsive adult in Johnson et al.'s studies using size and voice to indicate adult-baby interactions, and we test whether infants use these interactions to interpret future interactions involving novel pairs of individuals. When infants view two crying babies who each are comforted by the same adult, do they infer a social relationship between those babies and infer that they will affiliate with one another in the future? When they view two adults who each comfort the same crying baby, do they infer a social relationship between those adults and similarly infer that the adults will affiliate? Experiments 1, 2, 5, and 6 address these questions and provide evidence for both inferences. If infants infer affiliation in these cases, however, further questions arise. First, is this inference specific to interactions between babies and adults or is it more general? Experiment 3 begins to address this question by presenting characters of all the same size and all with adult voices, providing initial evidence for specific inferences about baby-adult interactions. Second, what information defines
a context in which infants infer a network of baby-adult relations: Do infants respond to comforting interactions with baby cries and adult coos only when the adult is of greater size, and/or when infants and adults can be grouped together by their spatial positions or perceptual features? Experiments 4 and 6 address these questions.

**Experiment 1**

The present experiments used animated displays involving abstract social characters and a preferential looking method (after Johnson et al., 2007). In Experiment 1, 15- to 18-month-old infants were familiarized with a series of events involving five animated characters with eyes (Figure 1.1 and Video S1.1). Three characters were small and similar in appearance to the baby in Johnson et al. and emitted baby cries (hereafter, "babies"). Two characters were larger and similar in appearance to the adult in the same study and emitted adult coos (hereafter, "adults"). In Johnson et al., the single baby and adult were similar in shape but differed in size and color. In Experiment 1, all the characters differed in shape and color, and adults again were larger than babies. To make these five-character events more compelling and memorable, however, the adults on each side always responded to the baby on the same side, and they had somewhat similar shapes and colors (see Figure 1.1). Thus, the side baby characters shared some perceptual features with the adult characters who comforted them, as is typical for members of the same family. The central baby was paired with each of the two adults for half the infants, however, and so was not perceptually more similar to one of the adults or side babies.

Infants were familiarized with three comforting events in which each baby cried, one adult approached the baby, who quieted, and then both characters moved gently in a synchronous "rocking" pattern. The babies on the two sides were soothed by different adults, and the central baby was soothed by the same adult as one of the other two babies. On each test trial, the three
babies appeared without the adults, and one of the two side babies approached the central baby, upon which that pair of characters “danced” together in a synchronous, circling motion (after Powell & Spelke, 2013; Video S1.2). In prior studies of infants, these motions were found to convey social affiliation between the characters (Powell & Spelke, 2013). Babies soothed by the same adult or by different adults danced together on alternating test trials; infants’ looking time to these events was measured and compared. If infants infer that two babies who are comforted by the same adult are socially related¹ in some way, then they should not be surprised to see these babies affiliate with one another. Therefore, infants should look longer when a baby approaches another baby who was comforted by a different adult.

Figure 1.1. Scene of the animated stimuli presented to infants in Experiments 1 and 2.

Materials and Methods

Participants

¹ By “social relatedness” we do not imply that infants infer familial relations between the characters. We consider how infants might interpret the relationship between the baby and adult characters in the General Discussion.
Participants were 16 full-term infants (8 girls and 8 boys) ranging in age from 15 to 18 months (mean age: 16.79 months; range: 15.53-18 months) from the Cambridge and Boston area. A sample size of 16 was predetermined based on adequate counterbalancing and previous infant research (e.g., Hamlin et al., 2007; Liberman et al., 2013), and data collection stopped once this number was reached. Infants received a gift after the study, and parents were reimbursed for their travel. An additional 3 infants were tested but excluded because of fussiness.

Materials

Infants saw an animated display with five social characters with distinctive geometrical shapes and colors (Figure 1.1; Video S1.1). The two larger, adult characters appeared at the top of the screen, above three smaller, baby characters. Each character entered the display individually, paused at specific location, and then jumped while making the same computer-generated bouncing noise. This initial sequence introduced each of the figures as an agent capable of self-propelled motion. Next, infants saw two sets of three familiarization trials (Video S1.1). At the start of each trial, two baby characters moved sequentially to the bottom of the screen and closed their eyes. Then the remaining baby, with eyes open, pulsated and cried, and one of the two adults responded to the cry by moving toward the baby in distress as if to soothe it, whereupon the baby stopped crying, the adult made a brief soothing noise, and the two rocked back and forth in unison. For all infants, babies on the sides of the display were comforted by the adult on the same side, who also was similar (but not identical) to the baby character in shape and coloring. Half of the infants saw the central baby comforted by the adult on each side. Each of the three babies cried and was soothed by an adult in the three familiarization trials, with the sides of the adults and the two outer baby characters and the order of the first two familiarization
trials counterbalanced across subjects. The third familiarization event therefore presented the central baby being soothed by an adult who had previously soothed another baby.

After the familiarization trials, the adult characters disappeared, and infants saw three rounds of two test trials involving only the three baby characters (Video S1.2). In alternating test trials, one of the side babies approached the central baby, and the two babies moved to a new location of the display where they danced together by making small, semicircular movements around a large, circular path, in synchrony with a rhythmic sound. The second test trial consisted of the same events, but now the other baby approached and danced with the central baby. Thus, the test trials demonstrated alternating social affiliation between babies who previously were soothed by the same adult and babies who previously were soothed by different adults. A chime and moving star drew infants’ attention back to the center of the screen before each test trial. The order of the expected and unexpected test events was counterbalanced across participants.

Procedure

All familiarization and test trials were infant-directed, such that an infant’s cumulative looking to the display was measured until the infant looked away for 2 consecutive seconds or looked for a maximum of 45 seconds. Infants had to look for a minimum of 0.5 seconds. One coder, unaware of condition, watched infants from a live video feed and coded infants’ looking continuously for the entire experiment. An experimenter, unable to see the stimuli, initiated the start of each trial at the last audible noise in each event. Trials started toward the end of the animated events to emulate previous studies of infant social cognition, where coding began when animations ended (e.g., Johnson et al., 2007; 2010; Powell & Spelke, 2013; Liberman et al., 2013; Pun et al., 2016). For familiarization events, trials began after an adult made a soothing noise, prior to the adult and baby shape rocking back and forth. For test, each trial began after the
figures’ last motions and sounds (i.e., the fourth sound; Video S1.2). A second independent, condition-blind observer coded a random 25% of subjects’ looking times from video, and the inter-rater correlation was 0.985. (For additional methods, see Supplementary Materials.)

Predictions and analyses

The primary question concerned whether infants who had viewed only the interactions of the babies with the adults would infer affiliation between the two babies who were soothed by the same adult. If they did, then we predicted that they would show systematically different looking on test events presenting affiliation between babies who had been soothed by the same vs. different adults. We tested this prediction in two ways. First, we performed a 2 (Test Event) by 3 (Trial block) repeated-measures ANOVA, testing for a main effect of test event. As a further analysis, we then performed a two-tailed paired t-test on infants’ looking times on the first pair of test trials: i.e., the first time they saw the interactions between the pairs of test characters.

Results

Familiarization trials

A trial type (first, second, or third baby) by trial block (first, second) repeated-measures ANOVA on looking times during the familiarization trials revealed only a main effect of trial block, $F(1, 15) = 7.12, p = 0.018$, $\eta_p^2 = 0.32$, reflecting decreasing attention over the familiarization period. There were no other main effects or interactions.
Figure 1.2. Looking times for expected and unexpected test events in Experiment 1 (n = 16), involving affiliation between babies who were comforted by the same/different adult(s). In the first test pair, infants looked longer to the unexpected event (*P < 0.05), but there was no main effect of infants’ looking to the two events (ns). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Test trials

Figure 1.2 presents the principal findings from this analysis. The ANOVA revealed only a main effect of trial block, $F(2, 30) = 3.48, p = 0.044, \eta^2_p = 0.19$, reflecting decreasing attention over the test session. There were no other main effects or interactions: in particular, no main effect of Test Event.

On the first block of test trials, infants looked longer to the test event involving an affiliative interaction between two unrelated babies, $t(15) = 2.235, p = 0.041$, two-tailed, $d = 0.56$; eleven infants looked longer at the first test event of affiliation between two babies soothed by different adults, three infants looked longer to affiliation between two babies soothed by the same adult, and two infants showed no preference (i.e., less than 0.5 seconds difference; See Supplementary Materials for additional methods), $p = 0.029$, two-tailed binomial test. Thus,
infants looked longer at the test event involving babies who had been soothed by different adults on the first test trial, but they did not maintain this pattern over the rest of the test session.

In summary, the primary analysis of Experiment 1 provided no evidence that infants made inferences about affiliation between baby characters soothed by the same adult, but the analysis of infants’ longer looking patterns on the first test pair suggested that such an effect may be real but short-lived. To pursue that suggestion, we replicated Experiment 1 on an independent sample of infants.

**Experiment 2**

**Materials and Methods**

The method of Experiment 2 was identical to that of Experiment 1. Participants were 16 new infants of the same age (9 girls and 7 boys; mean age: 16.88 months; range: 15.67-18.77 months). An additional 3 infants were tested but were excluded because of experimenter error (1), fussiness (1), or parental interference (1). The principal predictions and analyses were the same as in Experiment 1, except that a one-tailed test was used in a confirmatory analysis of the first-trial effect from Experiment 1. Further analyses compared the findings of the two experiments and tested for differences for infants with and without siblings. The inter-rater correlation between the live coder and a second independent coder for a random 25% of subjects’ looking times was 0.97.

**Results**

**Familiarization trials**

Infants showed no differential looking patterns at the three crying and comforting interactions: the 3 (trial type) by 2 (trial block) repeated-measures ANOVA revealed no main effects or interactions in Experiment 2 ($p < .25$). Across Experiments 1 and 2, a 3 (trial type) by
2 (trial block) by 2 (experiment) repeated-measures ANOVA showed a main effect of trial block, \( F(1, 30) = 7.03, p = 0.013, \eta^2_p = 0.19 \), reflecting decreasing attention, and no other main effects or interactions.

\[ \text{Figure 1.3.} \] Looking times for expected and unexpected test events in Experiment 2 \((N = 16)\), involving affiliation between babies who were comforted by the same/different adult(s). In the first test pair and across test events, infants looked longer to the unexpected event \(*P < 0.05\). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

**Test trials**

Figure 1.3 presents the principal findings of this experiment. The ANOVA revealed main effects of trial block, \( F(2,30) = 4.54, p = 0.019, \eta^2_p = 0.23 \), reflecting decreasing attention, and test event, \( F(1, 15) = 5.68, p = 0.031, \eta^2 = 0.28 \), showing longer looking to the presentations of an affiliative interaction between babies who were soothed by different adults. Ten babies looked longer at the test events with babies soothed by different adults, four babies showed the opposite pattern, and two babies showed no preference \( (p = .029, \text{one-tailed binomial test}) \). As in Experiment 1, infants looked longer in the first test trial pair to the events presenting an affiliative interaction between two unrelated babies \( (t(15) = 2.327, p = 0.017, \text{one-tailed}, d = \)
0.58). Eleven babies showed this effect, and five babies showed the opposite effect, \( p = .038, \) one-tailed binomial test).

Preliminary analyses of the combined data from Experiments 1 and 2 revealed no main effects of gender, test event order, or the adult character that served as the shared adult for two babies (triangle vs. oval), and no interactions. Accordingly, a 2 (experiment) by 3 (trial block) by 2 (test event) repeated measures ANOVA compared infants’ looking patterns across the two experiments. This analysis revealed main effects of experiment, \( F(1, 30) = 5.08, p = 0.032, \eta^2_p = 0.15, \) with overall greater attention in Experiment 2; trial block, \( F(2, 60) = 7.72, p = 0.001, \eta^2_p = 0.21, \) with decreasing attention across pairs of trials; and test event, \( F(1, 30) = 6.51, p = 0.016, \eta^2_p = 0.18, \) with longer looking to the events presenting affiliation between the babies soothed by different adults. There also was a trial block by test event interaction, \( F(2, 60)= 3.54, p = 0.035, \eta^2_p = 0.11, \) reflecting the fact that the effect of test event occurred primarily in the first trial block. There were no other interactions.

**Effects of sibling experience**

Further analyses, based on the combined data from Experiments 1 and 2, were undertaken to investigate whether infants' personal experience with siblings influenced their reactions to the test events. Previous studies have found that individual differences within infants’ own families predicted their interpretations of comforting events (Johnson et al., 2007; 2010). If infants interpret the present events as familial relations, the test events could be seen as pseudo-sibling relations, so having experience with sibling relationships could potentially drive the expectations seen in the test events. Of the 32 infants in these two experiments, 17 infants did not have any siblings according to families’ reports. A 2 (siblings versus no siblings) by 3 (trial block) by 2 (test event) repeated-measures ANOVA, performed on all 32 infants, revealed the
same principal findings as the first combined analysis, with no main effects or interactions involving the presence/absence of siblings (for further results, see Supplementary Materials).

**Discussion**

Across two experiments, 15- to 18-month-old infants looked longer to affiliation events between babies soothed by different adults, indicating that these events were more novel or surprising. This finding suggests that infants take account of past comforting interactions between babies and adults when interpreting future affiliation of babies with one another. More generally, infants appear to infer connections between two individuals who have not interacted directly, based on each individual's past interaction with the same third party. This effect occurred both for infants with siblings and for those without siblings (see Supplementary Materials). Although infants’ responses to adult-child interactions that are similar to the present events are modulated by aspects of their relationship to their own parents (Johnson et al., 2007; 2010), we find no evidence for modulation by sibling relationships in the present studies.

Does infants' reasoning about the social relations presented in Experiments 1 and 2 depend on inferences that are specific to adult-child interactions, or on inferences that apply to any social relationship? In Experiment 3, we began to address this question by altering the nature of the social interactions presented during familiarization. Instead of an adult comforting a crying baby, we presented events in which one adult character approached and interacted with a second adult character of the same size, who initiated the interaction by laughing in a manner suggestive of affiliative interactions between adult peers.

**Experiment 3**

Experiment 3 used the same events and methods as Experiments 1 and 2, but removed all cues to an adult-child relationship presented in those experiments. On the familiarization trials,
three characters again initiated an interaction by vocalizing ("callers") and two characters answered their calls ("responders"). The sizes of the two responders were reduced without changing their shapes, however, so that all characters were approximately equal in size. Because size no longer distinguished the three initiators of the interaction from the two responders, the textures of the responding adults were altered to create a different visual cue that distinguished these roles. Moreover, callers emitted positive adult vocalizations (laughter) instead of baby cries; the callers therefore did not appear distressed, and the responders’ approach did not appear to calm or comfort them.

The familiarization events otherwise were the same as in Experiments 1 and 2: The two side callers each were approached by the responder on the same side, with similar shape and coloring, and the central caller was approached by each of the two responders for half the infants. The test events were exactly the same as in Experiments 1 and 2. If infants’ social inferences in Experiments 1 and 2 stemmed from general inferences about any social relationships, then looking patterns should be the same in Experiment 3. In contrast, if infants' inferences were more specific to baby-adult relations or to comforting interactions, then looking patterns in Experiment 3 might differ.

**Materials and methods**

The method was the same as that of Experiments 1 and 2, except as follows. The sample size was predetermined to be equal to the union of the first two experiments in order to compare performance to all 32 infants from Experiments 1 and 2, and data collection stopped once this sample was collected: 32 full-term infants (16 male and 16 female; mean age: 16.40 months; range: 15.5-18.37 months). An additional 4 infants were tested but excluded because of fussiness
(1) or parental interference (3). A second independent coder measured from video a random 25% of subjects’ looking times, and the inter-rater correlation with the original coder was 0.99.

Figure 1.4. Scene of the animated stimuli presented to infants in Experiment 3.

Infants saw the same animated displays as in Experiments 1 and 2 except for three changes to the familiarization trials (Figure 1.4 and Video S1.3). First, the two larger figures that represented adults were presented at the same size as the other characters. Second, because callers and responders no longer were distinguished by a size cue, we introduced a texture cue to distinguish the characters playing these two roles: the responders were given a texture pattern that distinguished them from the three callers. Third, the callers each made the sound of an adult female laughing instead of the sound of a baby's cry; the duration of the laughing calls was matched to the baby cries in the previous experiments. The displays were otherwise unchanged. Critically, the test displays were identical to those of the previous experiments (Video S1.2).

Infants again saw two sets of three familiarization events followed by three sets of two test trials. The principal analyses were the same as the combined analyses of Experiments 1 and 2; they tested whether infants infer positive social interactions between the central character and the side character who had previously interacted with the same social partner. In addition, a 2 (experiment: 1-2 vs. 3) by 3 (trial block) by 2 (test event: same social partner vs. different social
partner) ANOVA tested for differences between infants’ patterns of looking at the test events that followed baby-adult interactions (Experiment 1-2) vs. adult-adult interactions (Experiment 3). Finally, two analyses were performed on the looking times of the first trial block, when the pairs of test characters interacted for the first time. A one-tailed $t$-test asked whether the infants in Experiment 3 showed the same first-trial looking difference as in Experiments 1 and 2, and a 2 (experiment) by 2 (test event) ANOVA compared the size of this difference across the two studies.

**Results**

**Familiarization trials**

Infants showed approximately equal looking at all the familiarization trials in this experiment. A 3 (trial type) by 2 (trial block) repeated-measures ANOVA on looking times to the familiarization events revealed no main effects or interactions ($ps > .05$). A further 2 (Experiment: 1-2 vs. 3) by 3 (trial type) by 2 (trial block) repeated-measures ANOVA revealed a main effect of trial block, $F(1, 62) = 7.47, p = 0.008, \eta_p^2 = 0.11$, qualified by a triple interaction between experiment, trial type, and trial block, $F(2, 124) = 3.79, p = 0.025, \eta_p^2 = 0.06$. Overall, infants decreased their attention to familiarization events across trials, but they did so at different rates. For the first two trial types, involving the side pairs of social agents, infants decreased their looking to the second showing of each of these events more in Experiment 3 (with peer interactions) than in combined Experiments 1 and 2 (with caregiving interactions). However, in the third trial type, involving a responder (adult soother or peer) that was already paired with a different caller, infants in Experiments 1-2 showed a steeper decrease in looking across trial blocks, whereas infants in Experiment 3 showed sustained looking. Despite these differences,
there was no main effect of experiment, so infants looked at familiarization events equally across experiments.

Figure 1.5. Looking times for expected and unexpected test events in Experiment 3 (N = 32), involving affiliation between characters with the same/different social partner(s). Infants did not look longer to either test event in the first test pair or across test pairs (ns). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Test trials

Figure 1.5 presents the principal findings for this experiment. The 3 (trial block) by 2 (test event) repeated-measures ANOVA revealed a main effect of trial block, $F(2, 62) = 7.94, p = 0.001, \eta^2_p = 0.20$, reflecting decreasing attention across the test trials, and no other main effects or interactions. Across the three test pairs, 15 of 32 infants looked longer to the unexpected test events compared to 17 who showed the opposite pattern ($p = 0.57$, one-tailed binomial test). Infants showed no differential looking to the test events presenting interactions between socially related vs. unrelated adults. A paired-samples t-test revealed no difference between infants' looking at the test events on the first trial block ($t < 1$); 12 babies looked longer at the first test
event between characters with different social partners, 17 babies showed the opposite pattern, and three babies showed no preference ($p = 0.77$, one-tailed binomial test).

Further analyses parallel to the preliminary analyses performed on the combined test data from Experiments 1 and 2 revealed no main effects of gender or test event order. There was a main effect of which shape interacted with the central character (triangle vs. oval), $F(1, 24) = 6.7, p = 0.016, \eta^2_p = 0.22$, with infants looking longer overall in test events when the shared social partner was the oval character. We therefore performed the principal analysis with and without this factor, and obtained no effects of test event in either analysis (for further results, see Supplementary Materials).

A 2 (experiment) by 3 (trial block) by 2 (test event) ANOVA, comparing the findings of Experiment 3 to those of Experiments 1-2 combined, revealed a main effect of trial block, $F(2, 124) = 15.56, p < .001, \eta^2_p = 0.20$, with decreasing attention across test trials, qualified by an experiment by trial block by test event interaction, $F(2, 124) = 3.82, p = 0.025, \eta^2_p = 0.06$. To further investigate this interaction, a follow-up 2 (experiment: 1-2 vs. 3) by 2 (test event) ANOVAs performed on infants' looking times for each trial block showed an interaction effect of test event by experiment on infants' looking on the first test pair: $F(1, 62) = 5.338, p = 0.024, \eta^2_p = 0.08$ (see Figure 1.6).
Figure 1.6. Looking times for expected and unexpected test events in Experiments 1-3 in the first test pair ($N = 64$). There was an interaction between the difference in infants’ looking to expected and unexpected test events in Experiments 1 and 2 and in Experiment 3 in the first test pair ($*P < 0.05$). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

**Discussion**

When size and vocal cues to baby-adult caregiving relations were replaced by cues suggestive of adult peer interactions, infants showed no differential looking to affiliation between individuals with a shared social partner. Although infants in Experiment 3 saw exactly the same test events as those in Experiments 1 and 2, they showed no looking preference for the events showing a social interaction between unrelated individuals. The prior familiarization in Experiment 3, which presented all the individuals as adults who interacted with other parties but were not comforted by those parties, markedly diminished infants' differential looking at the test events. Infants’ early reasoning about social affiliation evidently is enhanced in social contexts presenting interactions between a crying baby and an adult who approaches and soothes the baby.
The findings of Experiment 3 also address alternative explanations for the findings of Experiments 1 and 2 that appeal to infants' responses to low-level features of the animated test displays. First, the test displays in all three experiments presented familiarization events in which adults approached infants either by moving straight downward or by moving downward to the left or right. These events were followed by test events in which the side character who shared a social partner with the central character approached from the same left or right direction that was presented during familiarization, rendering this direction of motion superficially more familiar. Such familiarity could have accounted for infants’ looking at test in Experiments 1 and 2, but if it had, then the same patterns of looking should have been observed in Experiment 3, which presented exactly the same motions as the other experiments.

A second potential explanation appeals to differences in the familiarity of different characters’ features. The two characters on each side of the screen shared the quality of being either pointy or smooth in shape, and they were always paired together in familiarization events. The central character only interacted with one other character in familiarization that was either pointy or smooth, and then interacted with both pointy and smooth characters at test. Infants might have looked longer at the test event presenting affiliation between infants soothed by different adults not because they took account of the prior social interactions of the test characters with the same third party, but because one of the test events involved the central character in an interaction with a character who had a similar shape to that character’s previous social partner. If familiarity of shape underlay infants’ responses in Experiments 1 and 2, however, then those effects should have been observed in Experiment 3, in which the two pairs of side characters were similar not only in shape but in size. In contrast to this possibility, infants showed differential looking at the test events only in the first two experiments, presenting social
interactions that infants of this age view as related to parental care (Johnson et al., 2007). Experiments 5 and 6 present further evidence that infants’ responses are not explained by the familiarity of the motions or features of the characters in the test events.

Experiments 1-3 raise questions about infants’ interpretation of caregiving events. One question concerns the role of size differences in infants’ interpretation of social interactions as involving infants and adults. Studies of dominance reveal that differences in size are sufficient to elicit dominance inferences (Thomsen et al., 2011), but that these differences are not necessary: infants infer that one character will dominate another in future interactions if the two characters’ past behavior is indicative of this dominance relation, even when the characters are equal in size (Mascaro & Csibra, 2012; 2014). Moreover, studies of infants’ face perception reveal that infants are sensitive to age in faces, and that this sensitivity persists even if the sizes of the images of child and adult faces do not differ (Heron-Delaney et al., 2016). In Experiment 4, we ask whether infants’ inferences about comforting interactions are similarly robust in the absence of size cues. We presented the events of Experiments 1 and 2 with one change: as in Experiment 3, all five characters were equal in size.

**Experiment 4**

Experiment 4 investigated whether infants respond to comforting interactions, and infer social relations among infants who are comforted by the same social partner, when the babies and their comforters do not differ in size and only differ in whether they emit baby cries or adult coos. Although size cues can help to convey asymmetrical social relationships such as the relation of a parent to a child or of a dominant to a subordinate character, previous research suggests that infants use behavioral cues to social interactions even in the absence of size cues (Mascaro & Csibra, 2012; 2014). Not only do 12-month-old infants represent dominance
relations when presented with social interactions in which the dominant and subordinate characters have the same size (Mascaro & Csibra, 2012), but infants as young as 7 months also represent positive interactions within different social groups in events involving as many as six characters when all characters are equal in size and each is perceptually distinct from the others (Powell & Spelke, 2013). Thus, we tested infants' responses to the comforting interactions of Experiments 1 and 2 with characters of equal size.

This experiment was identical in displays and procedure to Experiments 1 and 2 with one exception: the adult characters were equal in size to the baby characters (Video S1.4). As before, infants were familiarized with events in which each baby cries, and one of the two adults responded by approaching and rocking with the baby, making an adult coo noise and ending its cries. Then infants were tested with the same events as in Experiments 1-3 (Video S1.2). If infants represent the social interactions as involving caregiving, and if they perceive caregiving interactions in the absence of differential character size, then they should look longer at test events involving affiliation between babies soothed by different characters, as in Experiments 1 and 2. In contrast, if infants require a size cue to represent caregiving, then they should look equally at the two test events, as in Experiment 3.

**Materials and Methods**

Participants were 16 infants of the same age as in Experiments 1-3 (7 girls and 9 boys, mean age, 16.78 months, range: 15.67-18.47 months). An additional 2 infants were tested but excluded because of fussiness. The principal predictions and analyses were the same as in Experiment 3. Further analyses, parallel to those in Experiment 3, compared the findings of the different experiments. A second independent coder coded a random 25% of subjects’ looking times from video, and the inter-rater correlation with the original live coder was 0.98.
Results

Familiarization trials

A 3 (trial type) by 2 (trial block) repeated-measures ANOVA on looking times during the familiarization events revealed no main effects or interactions ($p_s > .05$). A 3 (trial type) by 2 (trial block) by 3 (experiment 1, 2, present) repeated-measures ANOVA showed a main effect of trial block, $F(1, 45) = 7.34$, $p = 0.01$, $\eta^2_p = 0.14$, reflecting decreasing attention over time, and no other main effects or interactions.

Figure 1.7. Looking times for expected and unexpected test events in Experiment 4 ($N = 16$), involving affiliation between babies who were comforted by the same/different adult(s). Across test events, infants looked longer to the unexpected event ($P < 0.05$), though infants did not look longer to either event in the first test pair. Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Test trials

Figure 1.7 presents the principal findings of this experiment. A 3 (trial block) by 2 (test event) repeated-measures ANOVA revealed a main effect of test event, $F(1, 15) = 5.16$, $p = 0.038$, $\eta^2_p = 0.26$: overall, infants looked longer to test events showing affiliation between babies soothed by different adults. Across all three test pairs, 11 infants looked longer to the unexpected
event, four looked longer to the expected event, and one showed no preference ($p = 0.018$, one-tailed binomial test). Infants showed no reliable looking distinction between the two test events during the first test pair ($t(15) = 1.13, p = 0.28$); 10 infants looked longer to the event presenting affiliation between babies who had been comforted by different adults, and six showed the reverse pattern ($p = 0.11$, one-tailed binomial test). Additional analyses revealed no main effects or interactions of gender, test event order, or which adult comforted the central character (triangle vs. oval) on infants’ looking to test events.

A further analysis served to compare infants’ looking patterns in this experiment to those of Experiments 1 and 2. A 3 (experiment) by 3 (trial block) by 2 (test event) ANOVA revealed main effects of trial block, $F(2, 90) = 5.5, p = 0.006, \eta^2_p = 0.11$, and test event, $F(1, 45) = 11.56, p = 0.001, \eta^2_p = 0.20$, with greater looking on earlier trials and to test events of affiliation between babies soothed by different adults. There were no other main effects or interactions: in particular, no effects involving the factor of experiment. There was also no trial block by test event interaction, in contrast to the analysis of Experiments 1 and 2 alone. Thus, infants in this experiment showed the same overall pattern of longer looking to the social interaction between the babies soothed by different adults, with suggestive but non-significant differences in the temporal course of that effect.

A further 2 (experiment) by 3 (trial block) by 2 (test event) ANOVA comparing Experiment 4 to Experiment 3 revealed main effects of trial block, $F(2, 92) = 3.12, p = 0.049, \eta^2_p = 0.06$, and test event, $F(1, 46) = 6.15, p = 0.017, \eta^2_p = 0.12$, as well as a test event by experiment interaction, $F(1, 46) = 5.14, p = 0.028, \eta^2_p = 0.10$. Infants in Experiment 4 looked longer at the different-partner test events than those in Experiment 3. This interaction, which is similar to that found in the analysis comparing Experiment 3 to Experiments 1 and 2, isolates the
change in the sound cue (adult laughter rather than baby crying), rather than the change in the size cue (same-sized social partners rather than partners of different sizes) as the critical variable accounting for the negative findings of Experiment 3.

**Effects of sibling experience**

Finally, we analyzed looking patterns for all infants tested in Experiments 1, 2, and 4, who do not have siblings: a total of 23 infants. A 2 (siblings versus no siblings) by 3 (trial block) by 2 (test event) repeated-measures ANOVA of all 48 infants revealed a main effect of trial block, $F(2, 92) = 5.42, p = 0.006, \eta^2_p = 0.11$, showing decreasing attention, a main effect of test event, $F(1, 46) = 11.03, p = 0.002, \eta^2_p = 0.19$, with infants looking longer to unexpected events. There were no other main effects or interactions: crucially, no effects of the presence vs. absence of siblings. Analyses focused on the subset of infants with no siblings revealed the two principle effects observed across Experiments 1, 2, and 4: longer looking to affiliation between babies soothed by different adults, both on the first test pair and overall (see Supplementary Materials).

**Discussion**

In Experiment 4, infants looked longer to affiliation events between babies who had been comforted by different adults, despite the absence of any size cues to aid in processing the baby-adult relations. Statistical analyses provided evidence for patterns of looking in Experiment 4 that were similar to those in Experiments 1 and 2, and different from those in Experiment 3, even though Experiments 3 and 4 presented nearly identical displays except for the vocalizations. Thus, as with dominance behaviors (Mascaro & Csibra, 2012), infants used behaviors to interpret comforting interactions between baby and adult characters when no size cue to age was present. The negative findings from Experiment 3 are not explained by the presentation of characters of equal size.
Nevertheless, the looking patterns of infants in Experiment 4 emerged somewhat differently over time. Instead of showing a robust looking pattern in the first test trial pair, infants’ looking to the two types of events began to diverge across the three test pairs and reached significance overall. Although the triple interaction of Experiment, Test Event and Trial block was not significant, analyses focused on the first trial block suggest that size cues may be helpful in signaling and tracking the relationships among the five characters in Experiments 1 and 2. Nevertheless, size cues are not necessary in order for infants to make inferences about the social interactions between the baby and adult characters.

Experiment 4 also provides evidence against a potential alternative account of the negative findings of Experiment 3. Because Experiment 3 presented five same-sized callers and responders whereas Experiments 1 and 2 presented callers and responders that differed in size, infants’ superior performance in Experiments 1 and 2 could have been observed not because they involved adult-infant interactions but because the characters in those studies were more visually discriminable. The findings of Experiment 4 show that it is the differences in age and/or emotional state (crying babies rather than laughing adults) rather than the difference in size that produced the positive findings in Experiments 1 and 2. This conclusion is consistent with the evidence that infants interpret the comforting interactions in Experiment 4 as they do in Experiments 1 and 2 and in past research (Johnson et al., 2007), as interactions between distressed babies and adults who soothe them.

Two remaining differences between Experiments 1, 2, and 4, on one hand, and Experiment 3, on the other, therefore could account for our differing findings. First, Experiments 1, 2, and 4 presented infants with comforting interactions, whereas Experiment 3 did not. The comforting interactions that infants observed onscreen may link to emotionally important
interactions within the family, eliciting meaningful social processing. Second, Experiments 1, 2, and 4 required infants to infer unseen social relationships between baby characters, whereas Experiment 3 required infants to infer unseen social relationships between adult characters. Infants may recognize the baby characters as similar to them and attend to them more than the adult characters. Thus, infants may excel at tracking and interpreting interactions between babies but not adults. Experiment 5 aimed to distinguish between these two possibilities, by presenting infants with comforting interactions in a task requiring inferences not about babies, but about the adults who respond to them.

**Experiment 5**

Many experiments provide evidence that infants make social inferences about adults who speak the same language (e.g., Kinzler et al., 2007), are helpful to others (e.g., Kuhlmeier et al., 2003), or express similar preferences (e.g., Liberman et al., 2013). No experiment reveals, however, whether infants infer affiliation between two adults who have interacted with the same third party. Experiment 5 tested for this inference in the context of adult-baby comforting interactions, by modifying the familiarization and test events from Experiments 1-4. Whereas Experiments 1, 2 and 4 presented three babies and two adults and assessed infants' inferences concerning social interactions between pairs of babies, Experiment 5 presented three adults and two babies (Figure 1.8; Video S1.5) and assessed infants' inferences concerning social interactions between pairs of adults. We asked whether infants infer, at test, that adults who comforted the same baby will affiliate with one another.
In familiarization, infants saw two sets of three comforting events, in which one of two baby characters cried out, and one of three adult characters soothed the baby by approaching, contacting, making an adult coo noise, and rocking in synchrony. Two adults soothed the same baby, and a third soothed the second baby. At test, infants saw only the three adults, moving in pairs in the same synchronized, affiliative dances as in Experiments 1-4. The test events alternated between events of affiliation between two adults who had soothed the same baby and two adults who had soothed different babies.

**Materials and Methods**

Participants were 16 infants of the same age as in Experiments 1-4 (8 girls and 8 boys, mean age, 16.73 months, range: 15.8-17.7 months). One additional infant was tested but excluded for parental interference. The principal predictions and analyses were the same as in Experiment 1. Further analyses compared the findings of the different experiments. A second independent coder watched a random 25% of subjects’ looking times from video; the inter-rater correlation with the original live coder was 0.977.
Infants saw a similar animated display with five social characters, except there were three larger, adult characters at the top of the screen and two smaller, baby characters at the bottom (Figure 1.8; Video S1.5). After each character entered the display individually as in previous experiments, infants saw two sets of three familiarization trials. At the start of each event, one of the two baby characters moved to the bottom of the screen and closed its eyes. Then the remaining baby, with eyes open, pulsated and cried, and one of the three adults responded to the cry as in Experiments 1, 2 and 4. For all infants, adults on the sides of the display comforted the baby on the same side in the first two comforting events. Half of the infants then saw the central adult comfort each of the two babies. Trial orders and counterbalancing were the same as in all the previous experiments.

After familiarization, only the three adult characters remained. In alternating test trials, one of the side adults approached the central adult, and the two adults moved to a new location lower on the display where they danced together in the same manner as in the test events for Experiments 1-4. All other aspects of the test displays and procedure were the same as in Experiments 1-4.

Results

Familiarization trials

A 3 (trial type) by 2 (trial block) repeated-measures ANOVA on looking times during the familiarization events revealed no main effects or interactions ($p < .05$).
Figure 1.9. Looking times for expected and unexpected test events in Experiment 5 ($N = 16$), involving affiliation between adults who comforted the same or different babies. In the first test pair and across test events, infants looked longer to the unexpected event ($**p < 0.01$; $*p < 0.05$). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Test trials

The principal findings for this experiment are shown in Figure 1.9. A 3 (trial block) by 2 (test event) repeated-measures ANOVA revealed main effects of trial block, $F(2, 30) = 14.03, p < 0.001, \eta^2_p = 0.48$, and test event, $F(1, 15) = 7.76, p = 0.014, \eta^2_p = 0.34$, with decreased looking over time and with longer looking to test events showing affiliation between adults who comforted different babies. There was also a trial block by test event interaction, $F(2, 30) = 3.7, p = 0.037, \eta^2_p = 0.20$. Across all test pairs, 13 infants looked longer at the test event showing affiliation by adults who responded to different babies, and three infants showed the opposite pattern ($p = 0.002$, one-tailed binomial test). Infants showed this pattern on the first pair of test trials: i.e., the first time they viewed the adult-adult affiliative interactions ($t(15) = 3.23, p = 0.003$, one-tailed, $d = 0.64$). In the first test pair, 12 infants showed this pattern, two showed the opposite pattern, and two looked roughly equally, ($p < .001$, one-tailed binomial test).
Additional analyses of between-subjects factors revealed no main effects of gender or which baby the central adult comforted (diamond vs. circle). There was a main effect of test order, $F(1, 8) = 12.02, p = 0.008, \eta^2_p = 0.60$, with infants looking longer to all test events when they saw the expected event first in each test pair. Crucially, there was no test event by test order interaction, $p = 0.49$ (for further results, see Supplementary Materials).

A further analysis compared infants’ looking patterns in Experiment 5 to those in Experiments 1 and 2. This 3 (experiment) by 3 (trial block) by 2 (test event) ANOVA revealed the same main effects of trial block, $F(2, 92) = 16.66, p < 0.001, \eta^2_p = 0.27$, and test event, $F(1, 46) = 12.99, p = 0.001, \eta^2_p = 0.22$, and the same trial block by test event interaction, $F(2, 92) = 7.19, p = 0.001, \eta^2_p = 0.14$. There were no other main effects or interactions: in particular, no effects involving the factor of experiment. Therefore, infants showed the same patterns of looking to affiliation events among adults who soothed the same versus different babies (Experiment 5) as they did to affiliation events among babies soothed by the same versus different adults (Experiments 1 and 2).

A similar 2 (experiment) by 3 (trial block) by 2 (test event) repeated-measures ANOVA compared Experiment 5 to Experiment 3: the other experiment testing inferences about affiliation between adults. This analysis revealed main effects of trial block, $F(2, 92) = 20.06, p < 0.001, \eta^2_p = 0.30$, and test event, $F(1, 46) = 5.16, p = 0.028, \eta^2_p = 0.10$, qualified by a marginal interaction of test event by experiment, $F(1, 46) = 4.03, p = 0.051, \eta^2_p = 0.08$, and by a stronger, triple interaction of trial block, test event and experiment, $F(2, 92) = 3.63, p = 0.03, \eta^2_p = 0.07$. Infants looked longer at the test events showing affiliation between unrelated adults in Experiment 5 than in Experiment 3 on the first pair of test trials, and marginally longer overall. There were no other main effects or interactions. Infants’ patterns of looking in Experiment 5
thus differed from those observed in Experiment 3, while closely corresponding to the patterns observed in Experiments 1 and 2.

**Discussion**

In this experiment, infants looked longer to affiliation events between adults who cared for different babies, relative to adults who cared for the same baby. Infants’ inferences about affiliation by adults who engaged in comforting interactions were similar to their inferences about affiliation by the babies who were the recipients of such comforting interactions (Experiments 1, 2, and 4). Moreover, infants responded to interactions between adults who had previously approached crying babies somewhat differently than they responded to adults who had previously approached laughing peers (Experiment 3). When interpreting which adults might interact, infants therefore used past adult-baby comforting events to interpret novel relationship dyads.

These findings provide evidence against two alternative interpretations of the findings of Experiments 1-4. First, they show that the negative findings of Experiment 3, relative to the positive findings of Experiments 1 and 2, were not caused by lack of interest in adult characters. Infants’ inferences about affiliation between the adult characters were as strong in Experiment 5 as were their inferences about affiliation between the baby characters in previous experiments. Second, Experiment 5 provides further evidence against the possibility that infants’ test trial looking patterns in Experiments 1, 2, and 4 stem from differences in the relative familiarity of the motions presented on those test trials. In Experiments 1-4, the side character at test who had previously shared a social partner with the central test character approached the central character from a direction that was also presented during familiarization. Thus, the test-trial approach motions of the character who previously shared a social partner were more familiar than the test-
trial motions of the character who did not across experiments. In Experiment 5, in contrast, the reverse is the case: the approach motion direction of the character who did not share a social partner with the central character was more familiar at test, because two of the three characters moved in that direction to approach the babies during familiarization. Thus, the relative familiarity of the test patterns of motion does not account for infants’ responses across this series of experiments.

Experiment 5 suggests that infants encode and interpret comforting interactions not only as informative about babies, whose crying prompts the interaction, but also about adults, whose approach and rocking serves to soothe the babies and end their cries. When presented with caregiving interactions, infants determine, remember, and form inferences not only about the party who expresses emotion, but also about the party whose approach and interaction modulate that emotion. Indeed, we find no difference between infants’ inferences about actors and recipients of comforting interactions. Infants thus seem robustly sensitive to caregiving interactions and use them to understand larger social networks of adults as well as babies.

A final experiment was conducted to test the robustness of these inferences. In all of the preceding experiments, social interactions among the five characters were supported by relationships of perceptual similarity: each side baby whose crying or laughing initiated each social interaction, and each corresponding side adult who comforted that baby, were similar to one another in shape and coloring. Although the negative findings of Experiment 3 show that these feature relations were not sufficient to produce inferences about affiliation among characters with a shared social partner, the relations nevertheless may be necessary, and we presented them for two reasons. First, people who care for one another often are members of the same family, and family members tend to resemble one another. It is possible, therefore, that
infants use family resemblances, in part, to infer which characters will affiliate with one another. Second, the events presented during familiarization, involving five distinct, novel characters engaged in three distinct social interactions, likely placed high demands on infants’ memory. Both visual and spatial cues could have served to lessen these demands.

Nevertheless, infants may interpret and remember caregiving interactions even in the absence of such feature similarity. In past research, infants have been shown to infer that members of a single social group will engage in the same actions not only when group members had similar appearance but when they did not, although, infants’ looking patterns suggested that interactions between perceptually heterogeneous social group members were more difficult to process or remember (Powell & Spelke, 2013). Experiment 6 tested for this ability.

**Experiment 6**

Experiment 6 introduced the same social scenarios as in Experiment 5, with changes in the shapes of the characters that reduced their feature differences, and with changes in the pairings of characters that eliminated any feature similarity between the pairs of side characters (Figure 1.10; Video S1.6). Experiment 6 also introduced a change in procedure, aimed to aid infants in remembering the characters and their social interactions: it included three more re-familiarization scenes, in which each adult character soothed one baby character, before the second and third blocks of test trials. As in Experiment 5, we tested whether infants infer, at test, that adults who comforted the same baby will affiliate with one another.
Materials and Methods

Participants were 16 infants of the same age as in Experiments 1-5 (8 girls and 8 boys, mean age, 16.67 months, range: 15.67-18.5 months). Three additional infants were tested but excluded due to fussiness (2) or parental interference (1).

The materials were the same as in Experiment 5 except as follows. To eliminate featural similarity between the pairs of side characters, the edges of all the pointed figures were rounded, the orange diamond was rotated, and the pairings of the side figures from the previous experiments were reversed (Figure 1.10; Video S1.6). Familiarization events were the same as in Experiment 5. At test, the side characters alternately approached the central character by moving horizontally, and then the two characters moved vertically together rather than on a familiar diagonal motion before beginning the affiliative dance. All other materials and animations were the same as in Experiment 5.

The introduction, familiarization, and first two test trials proceeded in the same order as in Experiment 5. After the first two test trials, infants were shown each of the familiarization trials one more time (re-familiarization) in an effort to compensate for the increasing demands on
memory that the removal of featural cues likely produced (Powell & Spelke, 2013). The first two re-familiarization events were presented for a set amount of time, proceeding to the next trial after 5 seconds, and the third was infant-directed, and proceeded after the infant looked away for two seconds or a maximum looking of 45 seconds. After re-familiarization, infants saw two more test trials. They then saw another re-familiarization followed by the final two test trials. The principal predictions and analyses were the same as in Experiment 5. Further analyses compared the findings of the different experiments. A second independent coder watched a random 25% of subjects’ looking times from video; the inter-rater correlation with the original live coder was 0.91.

**Results**

**Familiarization trials**

A 3 (trial type) by 2 (trial block) repeated-measures ANOVA on looking times during the familiarization events revealed no main effects or interactions ($ps > 0.05$). Infants’ looking to re-familiarization was only measured after the third event, so their looking times to the two re-familiarization blocks were compared to looking on the third and sixth trials of familiarization. A 4 (trial block) repeated-measures ANOVA on looking times during those four trials revealed only a main effect of trial block, $F(3, 45) = 2.97$, $p = 0.042$, $\eta^2_p = 0.17$, reflecting decreasing attention.
Figure 1.11. Looking times for expected and unexpected test events in Experiment 6 (N = 16), involving affiliation between adults who comforted the same or different babies. In the first test pair and across test pairs, infants looked longer to the unexpected event (***P < 0.01; *P < 0.05). Error bars represent within-subjects 95% confidence intervals (Cousineau, 2005).

Test trials

The principal findings of the test trials for this experiment are shown in Figure 1.11. A 3 (trial block) by 2 (test event) repeated-measures ANOVA revealed a main effect of test event, $F(1, 15) = 7.19, p = 0.017, \eta^2_p = 0.32$, with longer looking to test events showing affiliation between adults that comforted different babies. Overall, twelve babies looked longer to the unexpected events, and four looked longer to the expected events ($p = 0.011$, one-tailed binomial test). On the first pair of test trials, infants looked longer to events presenting affiliation between adults who cared for different babies, relative to adults who cared for the same baby ($t(15) = 2.77, p = 0.007$, one-tailed, $d = 0.69$). In the first test pair, 12 infants looked longer to unexpected trials, and four looked longer to the expected trials ($p = 0.011$, one-tailed binomial test), supporting the overall pattern of results.

Additional analyses of between-subjects factors on overall looking to test events revealed no main effects of gender, test event order, or which baby the central adult comforted (circle vs.
square). There was a test event by test order interaction, $F(1, 8) = 21.01, p = 0.002, \eta^2_p = 0.72,$ with infants who saw the unexpected event first showing a greater difference in looking than infants who saw the expected event first (for further results, see Supplementary Materials).

An additional analysis compared infants' looking patterns in Experiment 6 to those in Experiment 5. This 2 (experiment) by 3 (trial block) by 2 (test event) repeated-measures ANOVA revealed main effects of trial block, $F(2, 60) = 13.53, p < 0.001, \eta^2_p = 0.31,$ and test event, $F(1, 30) = 14.34, p = 0.001, \eta^2_p = 0.32,$ and a trial block by test event interaction, $F(2, 60) = 4.43, p = 0.016, \eta^2_p = 0.13.$ There were no other main effects or interactions: in particular, no effects involving the factor of experiment. Therefore, infants showed the same patterns of looking to affiliation events among adults who soothed the same versus a different baby, regardless of the presence or absence of featural resemblances within pairs of characters.

**Discussion**

Despite the absence of featural similarity between baby and adult pairs, infants still inferred which adults were likely to affiliate with one another based on whether they had comforted the same or different babies. Infants inferred that adults who soothed the same baby would be more likely to affiliate with one another than adults who soothed different babies, and they did so in the same manner as in Experiment 5. The changes in characters’ motion during the test and the introduction of re-familiarization trials also did not alter the pattern of infants’ looking. This finding also provides further evidence that infants’ responses to the test events depended on the social behaviors and interactions that were presented in these experiments, rather than on the characters’ colors, shapes or motion trajectories.

**General Discussion**
Five experiments provide evidence that 15- to 18-month-old infants infer third-party affiliation between individuals that have never previously interacted, based solely on their past social interactions with a shared partner. Critically, the infants in Experiments 1, 2, 4, 5, and 6 used information from scenes showing crying babies, with adults approaching and soothing them, to interpret new acts of affiliation. These findings are not explained by preferential responses to baby over adult characters, or to characters who cried over characters who did not: infants used patterns of comforting interactions to infer affiliation not only between two babies who had cried, but also between two adults who had soothed the same crying baby while emitting no such salient vocalizations of their own. Thus, infants who viewed adults who soothed babies made inferences about both parties to this social interaction.

These experiments provide the first evidence that by 15 months, infants infer affiliation between two individuals who have not interacted directly and whose only connection is a mutual social partner. This demonstrates that a relationship between two people is a social currency comparable to other well-studied similarities (e.g., sharing a food preference: Liberman et al., 2014), and shows that infants notice and use this social information when observing others. These findings build upon recent evidence that 16-month-olds infer conflict between two individuals who have not interacted directly but whose partners were in conflict with each other (Rhodes et al., 2015). Predicting affiliation and conflict may emerge around the same age for infants, and future research could compare these types of interactions more directly.

The present experiments nevertheless suggest limits to infants’ inferences about third parties with shared social partners. In Experiment 3, infants did not infer that two adult characters who had previously interacted with the same third party would affiliate with one another. This failure is striking, because the visual displays presented in that experiment were
similar to those of all the other studies and nearly identical to those of Experiment 4. The vocalizations that initiated the social interactions mainly distinguished these experiments: in Experiment 3, the social interactions presented at familiarization were elicited by a laughing adult; in the other studies, they were elicited by a crying baby.

It is tempting to explain the negative findings of Experiment 3 by appealing to the effects of baby cries on infants’ attention. Three such explanations might be offered. First, infants may view the baby's cry as a negative signal, and this signal may heighten their attention to the ensuing events, leading to better processing of social information. This explanation accords with evidence that infants show a negativity bias in processing social information (Vaish, Grossmann, & Woodward, 2008). Second, infants may interpret the cessation of crying as a positive outcome, and they may be predisposed to attend to actions with positive effects when inferring positive social bonds. Third, the adult laughing noise may have puzzled or intrigued infants, who either lost interest or attended longer to the events that it initiated.² Contrary to all three of these explanations, there were no differences in infants’ looking time to the familiarization events presenting a baby’s cry (Experiments 1 and 2) versus an adult’s laughter (Experiment 3). Moreover, infants were no more responsive to test events presenting the infants who had previously emitted the salient cries (Experiments 1, 2, and 4) than to test events presenting the adults who had not (Experiments 5 and 6).

We suggest, therefore, that differences in attention do not account for the present pattern of findings. These findings are consistent, however, with a different family of explanations. Social interactions in which adults soothe crying babies may be especially meaningful to infants, who may be predisposed to view the participants in these interactions as social beings who

² We thank an anonymous reviewer for suggesting this possibility.
participate in a network of relationships (Johnson et al., 2007, 2010). The present experiments add to the evidence that infants track these comforting relations. They build on previous findings by showing that infants form expectations not only about the reaction of an adult to a crying baby but also about the interaction of different adults or babies with one another, based on their shared social partners.

Nevertheless, the present experiments do not reveal what specific meanings infants give to the comforting events. It is possible that infants view socially related characters in these experiments as members of the same family. Infants may view two adult characters who comfort the same baby as parents who live together and care for one another as well as for their baby, and they may view two baby characters who are comforted by the same adult as siblings. Alternatively, all characters may simply be viewed as social beings who help specific others. Infants’ interpretations both of the emotional cries and of the actions that assuaged them remain questions for future research.

Interestingly, infants without siblings made the same inferences as those with siblings, despite their markedly reduced opportunities to observe, as third parties, affiliative interactions between babies with a common caregiver (see Supplementary Materials). This finding, too, could be explained in either of two quite different ways. First, comforting interactions may be interpreted as signaling kinship relations of babies to parents and siblings in a biologically privileged manner, even for infants without any siblings of their own. Alternatively, comforting interactions may not be interpreted as indicative of kinship relationships at all, either in the present studies or in the studies of Johnson et al. (2007, 2010) on which they are based. On one hand, it is possible that the securely attached infants in Johnson et al.’s studies, who expected that their distress would be soothed consistently by their own parents, viewed the animated adult
character as the parent of the baby character, and therefore generalized this expectation to
inferences about those characters. Alternatively, securely attached infants may expect any known
adult caregiver to respond consistently to their own cries, and they may view the adults in the
comforting events only as caregivers, not as kin.

Thus, although infants inferred that the baby characters who were comforted by the same
adult were socially related to each other in some way, the nature of the relationship remains
unknown. Infants may have viewed the baby characters as siblings, cousins, neighbors, day-care
classmates, or casual acquaintances. With or without siblings, moreover, the participants in these
studies likely had multiple opportunities to observe caregiving and nurturing interactions,
including those involving non-kin adults such as day care providers or teachers. Further research
is needed to probe the origins and nature of the social inferences that the present experiments
reveal.

We conclude that infants’ looking behavior depends on the specific social context
presented: a context that adults view as a caregiver soothing a crying baby and that infants in
previous research connected to their own social world (Johnson et al., 2007, 2010). Infants may
also reason about social networks involving adult peer relations, but the present studies suggest
that similar amounts of evidence for social partnerships did not elicit the same inferences about
adult partners of other adults as of adult comforters of infants, at least in the present context. The
findings of Experiment 5 and 6 also cast doubt on the possibility that infants' responses depend
on general predispositions to attend to characters who are similar to the self or who emit salient
cries: they show that infants are sensitive to not only crying babies but the adults who respond to
them, performing social inferences that could serve to establish a network of social relationships
centered on the family. Regardless of whether infants of 15-18 months view baby-adult relations
as specifically relating to kin or more broadly relating to familiar social groups, the experiments present initial evidence for early-developing reasoning about a culturally universal caregiving relation.

The studies raise questions regarding the properties and limits of infants’ reasoning about caregiving relations and their more general understanding of kinship. First, do infants see baby-adult interactions as asymmetrical, as adults do, or do they infer that adults and babies will comfort one another reciprocally? Second, do infants infer that adults who comfort crying babies will nurture them in other ways: for example, to feed and watch over them, as in universal kin-based relations of communal sharing (e.g., Fiske, 1991, 1992)? Third, do infants use experiences within their own families and social interactions to interpret caregiving interactions, as some previous findings suggest (Johnson et al., 2007)? Variations of the present experiments could serve to address these questions.

A further question concerns the specificity of the social actions that infants attribute to the characters they saw. Do infants see these adult-baby interactions specifically as caregiving or more generally as helping? Though baby cries that elicit an action of soothing evoke parent-child relationships for adults, it is possible that infants would make the same inferences for future affiliation given any social context of helping individuals in need. Future experiments, presenting adult characters who express distress and are comforted by other adult characters, could distinguish these possibilities.

Studies of infants' response to comforting interactions between adults might further clarify infants' interpretations of comforting events involving babies and adults that are all the same size (Experiment 4). Previous research on infants' understanding of dominance indicates that relative size cues are not necessary for perception of dominance relations (Mascaro &
Csibra, 2012, 2014), but they do make detection and understanding dominance easier at young ages (Thomsen et al., 2011). Similarly, Experiment 4 provides evidence that size cues are not necessary for infants to infer relations among the participants in comforting interactions, but the slow emergence of this inference across trials suggests that size cues are helpful to infants when they are present (Experiments 1, 2, 5, and 6). Future experiments may usefully investigate the roles of size, vocalizations, and behavior in signaling the generational relationships that are fundamental to caregiving interactions and kinship systems.

Whatever the findings of such experiments, the present experiments broaden the category of helping events to which infants respond. In previous studies of helping, a protagonist had a specific goal— for example, climbing a hill (Hamlin et al., 2007), and other individuals assisted or hindered the protagonist in completing the goal. In the present experiments, a baby character elicited comfort from an adult character simply by crying, without exhibiting any explicit goal. Thus, the present social interactions may fall under the broader category of helping but they possess unique qualities that differentiate them from other forms of helping.

In summary, the present findings provide evidence that children begin at an early age to reason about a social interaction that adults perceive as parental care and comfort. Infants in their second year use this interaction to guide inferences about relations between individuals who have not interacted directly with one another but only with a common adult (Experiment 1, 2, 4) or common baby (Experiment 5, 6). Future research can investigate whether infants show similar inferences concerning these fundamental relations at even younger ages, before they begin to speak, locomote independently, and, therefore, actively to choose their own social partners.
Paper 2: Five-month-old infants prefer those who are responsive to baby cries

Spokes, A. C., Venkatesan, T., & Spelke, E. S. (in preparation). Five-month-old infants prefer those who are responsive to baby cries.
Abstract

Kinship plays a central role in all human societies, despite significant variation in kinship categories and the rules governing co-residence and childcare. A child therefore must learn both their family’s identities and relations and their society’s kinship structure. From infancy, children primarily receive care from parents, siblings, and additional family, so they may be attuned to tracking baby-adult caregiving relations and identifying more responsive, better caregivers as a precursor to later understanding their social networks as kinship networks. We tested whether 5-month-old infants prefer responsive caregivers across three experiments using looking time measures and provide evidence for these abilities and the contexts in which they are relevant. First, infants selectively engaged with an adult who comforted rather than avoided a crying baby (Experiment 1), but this preference disappeared when a siren sounding object replaced the crying baby (Experiment 2). Finally, the effect did not extend to situations where a baby was fussing or laughing rather than crying (Experiment 3). These findings provide initial evidence that infants begin to learn about at least one class of interactions within families in the first year, before they can locomote or use pointing and language to communicate with social partners. Tracking caregiving relations may be an early emerging ability guiding the development of social knowledge.

Keywords: social cognitive development, infant cognition, caregiving
**Introduction**

Across human cultures, kinship systems show important variation, implying that some aspects of kinship structures are learned, possibly early in development, in a manner similar to language learning (Kemp & Regier, 2012). However, kinship systems do have some universal properties. First, kinship relations bring rights and carry obligations: family members receive care and protection from one another and are obligated to provide care and protection, if they can. Second, generation matters: all over the world, people’s rights and obligations within their families extend up generational lines to their parents and down generational lines to their children. Third, gender matters: although household structures differ across societies, in virtually all societies, infants live with and are cared for, in part, by their mothers, and the obligations and rights of family members of one gender are apt to differ from those of the opposite gender. Generation and gender are essential primitives in a model of kinship classification systems (Kroeber, 1909; Greenberg, 1949; Gould & Kronenfeld, 2000; Kemp & Regier, 2012). Children therefore must learn the kinship categories and relations within their own families and their societies to navigate their social worlds.

Although the earliest understanding of kinship relations has received little study, four lines of research support the hypothesis that infants begin to reason about social relationships that resemble kin early. First, infants are sensitive to rights and obligations when they observe social interactions between individuals. For example, 3-month-old infants look longer to a character who helped a protagonist reach its goal relative to a character who hindered the protagonist, and 6-month-old infants show both longer looking and more reaching to the helpful character (Hamlin, Wynn, & Bloom, 2010). Infants in their first two years also show sensitivity to which member of an interaction pair is most dominant, whether because they are larger in size.
(Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011), come from a numerically larger group (Pun, Birch, & Baron, 2016), or showed dominance in a prior context (Mascaro & Csibra, 2012, 2014).

Second, young infants are sensitive to age and gender in unfamiliar individuals. By age 3 to 4 months, infants prefer adults of the same gender as their primary caregiver, whether female or male (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002; Quinn et al., 2008), and they prefer younger and apparently healthier adults to older and apparently less healthy ones (Slater, Von der Schulenburg, Brown, & Badenoch, 1998). Thus, young infants seem to be attuned to universal social relations and personal attributes that structure all human kinship systems.

Third, infants have two prerequisites to reasoning about obligations and sharing rights within families: they are sensitive to the costs of actions taken by one individual to approach a second individual (Liu & Spelke, 2017; Liu, Ullman, Tenebaum, & Spelke, 2017), and they infer the social closeness of one individual to another by analyzing a common pattern of interaction involving the sharing of food (Liberman, Kinzler, & Woodward, 2013).

Finally, children as young as 2.5 years of age reason about the obligations of individuals by tracking helping interactions and refusals (Jara-Ettinger, Tenenbaum, & Schulz, 2015), and toddlers as young as 15 months infer unseen relations within a group of individuals by tracking acts of comforting by adults to babies (Spokes & Spelke, 2017).

Based on evidence with children, one theory proposes that infants and children use a naïve utility calculus that includes a social agent’s actions and mental states to evaluate the agent’s prosocial actions (Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016). Consistent with this theory, infants expect an individual to take the most direct path to its goal (Gergely & Csibra, 2003) and to prefer an individual that it took a greater personal cost to reach (Liu et al.,
Children also evaluate another people’s prosocial actions as nice or mean based on how difficult it was for the actor to complete the action (Jara-Ettinger et al., 2015b). A naïve utility calculus accounts for an agent’s costs and the value the agent assigns to goals.

Nevertheless, the above studies have held constant or left unspecified any prior social relation between individuals engaging in the social transactions. In real social interactions, such prior relations matter, especially relations of kinship. An adult will take a greater cost for his own child than for an unrelated child, and a child will seek more interaction and greater care from a family member than from a stranger. Thus, to make sense of their social environment, infants and young children will need to consider relations characteristic of what adults identify as kinship. These relations have also been characterized as communal sharing relationships (Fiske, 1992).

Past research provides suggestive evidence that they do. Infants in their second year are sensitive to comforting interactions when they view animated events involving geometric forms of different sizes that initially move together and then are separated, prompting the smaller form to emit a baby’s cry (Johnson, Dweck, & Chen, 2007; Johnson, Dweck, Chen, Stern, Ok, & Barth, 2010). When the larger character responds to this cry either by returning to the smaller character or by moving further away, 12- to 16-month-old infants draw on their own experiences with their caregivers in responding to these outcomes. In particular, infants who were securely attached to their parents expected the adult character to return to the crying baby character, whereas those who were insecurely attached did not (Johnson et al., 2007, 2010). Though caregivers are not exclusively kin, they are typically related, most often as parent and child.

At 15- to 18-months of age, infants can integrate evidence of social connections formed through caregiving interactions—a large shape with facial features that responds to a crying baby
with approach, rocking, and a soothing noise—to form expectations about novel social pairs: they expect affiliation between two adults who soothed the same baby or two babies soothed by the same adult but not between adults who are similarly approached by the same peer partner (Spokes & Spelke, 2017).

In the first study, infants saw animated displays with five characters: two adults and three babies. After seeing that one adult soothed the cries of two babies, and the other soothed one, infants looked longer at test to affiliation between babies who were soothed by different adults, relative to affiliation between babies who were soothed by the same adult. In contrast, a second study showed that infants who saw the same motions in characters that were all adults, equal in size, shown laughing together, did not make the same inference of affiliation between adults who interacted with the same third party. A third study showed, moreover, that the positive findings with adult and baby characters were obtained even if all characters were the same size and were distinguished only by their vocalizations (adult coos and baby cries). Thus, infants track caregiving interactions of the sort that they may witness within families but not casual peer interactions of the sort they may witness between a parent and a shopkeeper or other acquaintance (Spokes & Spelke, 2017).

In two further studies, infants inferred affiliation between adults when the displays showed three adults and two babies, with two adults soothing the same baby, and one soother a different baby. Infants showed the same expectations when some of the baby-adult pairs had similar shapes and colors—as family members may also resemble one another—or when baby-adult pairs did not share visual similarities (Spokes & Spelke, 2017). Indeed, the most robust findings came from these last two studies, testing these inferences about affiliative relations between adults, not babies. Thus, infants may preferentially seek to identify and track the adults
in a caregiving interaction, rather than the babies. This preference in turn may reflect their attention to potential caregivers.

Do the abilities and predispositions shown in the above studies arise only after infants’ first birthday, or are they present earlier? Toddlers by 15 months are mobile, and most of them encounter other toddlers in playgroups or daycare. Young infants, however, are immobile: they cannot actively choose their caregivers, but if they attend to them and track caregiving interactions, they are in a position to learn about relations and roles within their social networks, many of which adults identify as kin relations, roles, and networks. Do infants in their first year track these relations?

To date, only one line of research has investigated sensitivity to caregiving and kinship in younger infants: 12- and 4-month-old infants looked longer to videos of a woman who ignores and moves away from a crying baby rather than responding by approaching and comforting it (Jin, Houston, Baillargeon, Groh, & Roisman, 2018). Furthermore, eight-month-old infants selected to watch the ignore events more often than the comforting events when choosing between two touch screens of the events (Jin et al., 2018). These studies suggest that infants have an expectation that in third-party interactions, an adult is more likely to respond to a crying baby than ignore it, but no studies have yet tested whether infants evaluate adults for their responsiveness (or unresponsiveness).

One barrier to addressing this question has been the high cognitive demands that five-character studies of comforting interactions place on infants. The present experiments attempt to lessen the cognitive demands, and to investigate younger infants’ understanding of caregiving interactions using animated events. We tested 5-month-old infants in a simpler paradigm that does not yet test inferences of caregiving networks, but that might provide a foundation for later
studies that do. Infants were presented with one baby character and two adults who participated in two alternating events. In one event, the baby cried and one adult responded by approaching and comforting the baby; in the other event, the baby cried and the other adult responded by moving away. Instead of focusing on infants’ expectations of these outcomes, we focused on their social preferences, asking whether infants selectively attended, in a final preference test, to the adult who previously comforted the baby. If infants are sensitive to which people around them are more responsive, potentially better caregivers, we predicted that after the caregiving events have ended, and they are just shown the two adult characters, they would show a preference for the adult who was previously responsive to another baby’s cry.

**Experiment 1**

Experiment 1 tested whether 5-month-old infants preferentially orient toward animated characters (colored shapes with schematic faces) that behaved toward a crying infant either responsively—by approaching that baby, or unresponsively—by withdrawing from that baby, as in Johnson et al. (2007), irrespective of the participants’ attachment security. Adapting displays from Spokes & Spelke (2017), we presented a display of two large shapes (“adults”) and one small shape (“baby”) and tested infants’ preferences between a responsive adult who approached a crying baby and an unresponsive adult who moved away from a crying baby (Figure 3.1).
Figure 3.1. Schematic of animated stimuli presented to infants in Experiment 1 (Left) and Experiment 2 (Right) with arrows depicting the adults moving toward or away from the crying baby (Experiment 1) or noisy object (Experiment 2). Experiments 1-3 used the same presentation at Test.

In one scene, the baby cried, and an adult comforted the baby, thus exemplifying a responsive caregiver. In a second event, the same baby cried, and the other adult moved away, thus exemplifying an unresponsive adult. The responsive and unresponsive adult characters moved the same distances: all that differed was the direction of their motion (toward or away from the crying baby).

After repeating these two events, we then, at test, presented infants with the two adult shapes in a preferential looking time test event. We predicted that if infants have a preference for the responsive adult over the unresponsive adult, they would attend longer to the responsive caregiver, as in past research (e.g., Hamlin et al., 2010; Kinzler, Dupoux, & Spelke, 2007), and
this attentional preference would manifest by longer looking at the character that previously acted as the responsive caregiver.

**Methods**

**Participants**

We tested 16 full-term 4.5- to 5.5-month old infants (8 girls and 8 boys; mean age 4.98 months; range 4.53-5.37 months) from the Cambridge Boston area. A sample of 16 was pre-registered on Open Science Framework, and data collection stopped once this number was reached. After the study, infants received a gift, and parents were reimbursed for their travel. We tested and excluded an additional seven infants due to experimental error (2), technical difficulties/lost video (2), and infant inattention due to crying (3) according to pre-registered criteria.

**Materials**

Methods and hypothesis-driven analyses were pre-registered on the Open Science Framework prior to data collection [link to be updated upon acceptance]. Infants saw an animated display with three social agents with distinctive colors—two large diamonds distinguished by color (pink and purple), “adults,” and one small green circle, “baby”—all with eyes (Figure 3.1). Each of the three characters entered the display individually, paused at a specific location, and then jumped while making the same computer-generated bouncing noise. This initial sequence introduced each of the figures as an agent capable of self-propelled motion.

In familiarization, infants then saw two different events. At the start of each event, one adult moved to the side of the screen and closed its eyes. Next the baby cried. In the “responsive” event, an adult approached the baby, stopped next to it, pulsed once, and the baby stopped its cry. In the “unresponsive” event, the other adult moved an equal distance away from the baby, pulsed
once, and the baby stopped its cry. Infants saw two sets of these alternating events: responsive, unresponsive, responsive, and unresponsive (counterbalanced across infants). Hence, the infant watched four familiarization events in total.

At test, only the adults appeared on the screen, and they initially bounced up and down once with an accompanying noise to capture infants’ attention. The display then remained still for 10 seconds, after which the adults made a 1.5 second synchronized rocking movement with a noise to recapture participants’ attention. The display then remained still for an additional 10 seconds.

We presented an “attention-getter” video animation of a star spinning to a chiming noise before the familiarization trials started and before the test trial. The sides of the adults’ locations, which color (pink or purple) was “responsive,” and the order of the familiarization trials (responsive and unresponsive) were counterbalanced across subjects.

Procedure

Before each participant began the study, an experimenter calibrated the infants’ looking to aid coders by presenting a toy or puppet to the infant at the four sides of the screen: moving the toy or puppet from on-screen to off-screen. Parents could have their eyes open for calibration, and then were asked to close their eyes for the rest of the testing session and were monitored on video for compliance.

Familiarization trials were guided by infant-directed looking, where the trial advanced when the infant either (a) looked for a cumulative total of 45 seconds or (b) looked away for two consecutive seconds—whichever criterion was met first. Though infants’ looking was coded continuously throughout the session, an experimenter—unable to see the displays and unaware of which adult approached or avoided the baby—initiated each trial at the end of the animated
scene using audio cues. In familiarization, trials began at the end of the animated scene using the audio cue of when the baby stopped crying.

Infants’ looking times to each familiarization were collected for data analysis. Looking times were measured using xhab software during the experiment by a reliable coder who was unaware of which adult approached or avoided the baby. The coder could see only the infant, not any of the displays being presented.

Coding for the test trial was done from video after the session by an experimenter unable to view test displays. Coders recorded frame-by-frame (30 frames/second) looking for the 20-second test trial and reported whether the infant was looking to pink, purple, or neither. The coder began when the infant could first see both adults at test and coded until 600 cumulative frames (or 20 seconds) were analyzed.

**Results**

For test trials, we compared infants’ looking time (in seconds) to the two adults using a one-sample two tailed $t$-test testing the proportion of looking time to the responsive caregiver against the chance level of 50%. The primary results are shown in Figure 3.2. Infants looked longer to the responsive caregiver, $M = 0.608$, $SD = 0.199$, $t(15) = 2.17$, $p = 0.047$, $d = 0.56$, 95% CI [0.502, 0.713].
Figure 3.2. Proportion of 5-month-olds infants’ looking time to the responsive, approaching adult at test in Experiment 1 ($N = 16$), Experiment 2 ($N = 16$), and Experiment 3 ($N = 28$), involving one adult who previously approached and one who previously avoided a crying baby (Exp. 1), a noisy object (Exp. 2), or a fussing or laughing baby (Exp. 3). Infants looked longer to the adult who had previously approached the baby in Experiment 1 than expected by a chance level of 50% ($*P < 0.05$) but did not look longer to the adult who previously approached a noisy object or fussing/laughing baby in Experiments 2 and 3.

Exploratory analyses of the effect of gender using an ANOVA with looking time to each adult (responsive vs. unresponsive) as a within-subjects variable and gender as a between subjects variable revealed no effect of gender. We also tested for effects of counterbalanced variables using an ANOVA with looking time to each adult (responsive vs. unresponsive) as a within-subjects variable and color of responsive adult, side of responsive adult, and order of familiarization events as between subjects variables. We found a main effect of the color of responsive adult, $F(1, 11) = 5.04, p = 0.046$, where infants looked longer to both adults at test when the approaching shape was purple rather than pink, and no additional effects.
Exploratory analyses of familiarization events revealed no difference in infants’ looking to the two responsive events ($M = 17.34$ seconds, $SD = 9.04$) versus the two unresponsive events ($M = 22.38$, $SD = 12.63$): the 2 (Trial Type) repeated-measures ANOVA revealed no main effect of trial type, $F(1, 15) = 3.018$, $p = 0.103$.

**Discussion**

Consistent with our hypothesis, infants had a preference for the responsive adult over the unresponsive adult, and they preferentially looked to the character that previously acted as the responsive caregiver. These results support the hypothesis that as early as 5-months of age, infants not only track caregiving but also use the caregiving history to evaluate adults as potential social partners for themselves.

The first experiment raises a lot of open questions about what drives infants’ preference for the responsive caregiver. First, infants’ looking at test may be an artifact of longer looking to responsive or unresponsive events during familiarization, either a familiarity or novelty preference, respectively. However, we did not find differences in infants’ looking to the responsive versus unresponsive familiarization events.

Furthermore, does this longer looking have to do with preferring a better caregiver, a more prosocial agent, or possibly simply any agent who approaches rather than avoids an object or person? Experiment 2 tested whether the effect from Experiment 1 was a preference for an “approacher.”

**Experiment 2**

Infants’ looking to the responsive adult in Experiment 1 could have occurred because infants show a social preference for the responsive adult, but it could also be explained by a preference for an agent who approaches rather than avoids any object. Experiment 2 tested this
interpretation by presenting infants with two adults who respond to the noise of an inanimate object. We made minimal changes to the displays to present the “baby” as an inanimate object: we scrambled the shapes (Figure 3.1), the circle emitted a siren noise, and its motions were adapted to be more robotic.

If infants in Experiment 1 preferred to look at the character who approached the baby rather than avoiding the baby because they like approachers, we would expect their preference at test to persist in Experiment 2. However, if the preference is social in nature, we would expect no preference when the adults are approaching or avoiding an inanimate object in Experiment 2, or possibly, even a preference for a character who avoids a noisy object.

Materials and Methods

Participants

We tested 16 full-term 4.5- to 5.5-month old infants (8 girls and 8 boys; mean age 4.89 months; range 4.5-5.5 months) from the Cambridge Boston area, according to our pre-registered methods and analyses plan on Open Science Framework. Data collection stopped once this number was reached. After the study, infants received a gift, and parents were reimbursed for their travel. We tested and excluded an additional seven infants due to technical difficulties/equipment error (2), parental interference (2), and infant inattention due to crying (3) according to pre-registered criteria.

Materials and Procedure

We used the same methods as Experiment 1 with the following changes: instead of a small green circle with eyes that emitted a baby cry, there was an inanimate object that emitted a siren noise, created using the same shapes in a scrambled arrangement such that it did not resemble a face (Figure 3.1). In addition, motions that signaled the baby’s agency were removed:
during pre-familiarization, the object was always present and remained motionless rather than entering on its own and jumping like the other animate characters, and during familiarization, the object rocked back and forth rather than pulsating. The movements and animations of the two large, adult shapes, remained the same as in Experiment 1, including the test trial, which only included those two shapes.

Infants again saw one pre-familiarization, where the two agents entered, followed by two sets of alternating events: responsive, unresponsive, responsive, and unresponsive (counterbalanced across infants), equaling four familiarization events total. Infants then saw the same 20-second test trial as Experiment 1. Between-trial “attention-getter” animations and counterbalancing was the same as Experiment 1.

Results

The primary results are shown in Figure 3.2. Infants looked to the responsive caregiver at chance levels, $M = 0.485, SD = 0.218$, $t(15) = 0.27, p = 0.79, d = 0.069, 95\% \text{ CI } [0.37, 0.601]$.

Exploratory analyses of between-subjects factors revealed no main effects of participant gender or counterbalanced factors (color of responsive adult, side of responsive adult, and order of familiarization events), $ps > .26$. During familiarization events, there was no difference in infants’ looking to the two responsive events ($M = 27.56\text{ seconds}, SD = 21.55$) versus the two unresponsive events ($M = 29.21, SD = 16.27$), $F(1, 15) = 0.13, p = 0.72$.

A one-tailed, two-sample $t$-test comparing proportion of infants’ looking to the approaching character across experiments revealed a marginal effect, $t(29.76) = 1.66, p = 0.054$ of longer looking to the approaching character in Experiment 1 than Experiment 2. However, using a 2 (Experiment: 1 vs. 2) by 2 (test adult: responsive vs. unresponsive) repeated-measures
ANOVA, there was no main effect of experiment nor experiment by test adult interaction ($ps > .15$).

Infants’ looking to the four familiarization events did not differ across Experiments 1 and 2, $F(1, 30) = 3.15, p = 0.086$, and if anything, infants looked slightly longer to familiarization events in Experiment 2 ($M = 56.77, SD = 33.61$ seconds) than in Experiment 1 ($M = 39.73, SD = 18.66$ seconds).

**Discussion**

Infants did not show a preference for the adult who approached over avoided the siren-emitting object. Thus, the preference for the approaching adult in Experiment 1 was not simply due to a preference for an approacher. Infants looked longer to the approacher at test only when they had previously approached a crying baby rather than an alarming object.

Though infants tend to be more interested in people than objects, the different looking pattern in Experiment 2 cannot be explained by reduced attention during familiarization events with the siren noise: infants watched the familiarization events as long in Experiment 2 as Experiment 1.

Experiment 1 still leaves open what about the events drives infants’ preference for the character who approaches a crying baby. Do infants prefer any adult who is responsive to a call from a baby—whether a cry, giggle, or other solicitation? Alternatively, an infant’s cry may be special in both drawing infants’ attention but also warranting inferences about the social relationship between a baby who cries and an adult who responds to that cry. Experiment 3 addressed this question by presenting infants with a baby who either repeatedly giggles or repeatedly fusses, followed by adults who either approach or avoid the baby. If infants are
sensitive to caregiving across multiple caregiving contexts, then infants should prefer the adult who previously approached the baby at test.

**Experiment 3**

Experiment 3 tested whether infants’ preference for a character who approaches a crying baby in Experiment 1 generalizes to other caregiving contexts: ones in which the baby either giggles or fusses rather than crying. The same stimuli from Experiment 1 were used with the exception that the baby emitted either a giggle or fussing sound instead of crying.

**Materials and Methods**

**Participants**

We tested 28 full-term 4.5- to 5.5-month old infants (14 girls and 14 boys; mean age 5.03 months; range 4.53-5.5 months) from the Cambridge Boston area. This sample size was predetermined by a power analysis based on Experiment 1 ($N = 16$) and pilot testing ($N = 9$) showing that at least 28 subjects (27.01 and 27.9, respectively) would be necessary to detect an effect at effect sizes $d = 0.55$ and 0.56 with power = 0.8. We pre-registered this sample size on the Open Science Framework prior to data collection, and data collection stopped once this number was reached. After the study, infants received a gift, and parents were reimbursed for their travel. We tested and excluded an additional six infants due to experimenter error (1), parental interference (2), and infant inattention due to crying (3) according to pre-registered criteria.

**Materials and Procedure**

We used the same methods as Experiment 1 with one change: instead of a baby cry, the small shape emitted either a baby fuss or baby giggle noise (between-subjects). All other animations and methods remained the same.
Results

The primary results are shown in Figure 3.2. Infants looked to the responsive caregiver at chance levels, $M = 0.527, SD = 0.19, t(27) = 0.75, p = 0.46, d = 0.14, 95\% CI [0.453, 0.6]$. 

Exploratory analyses of between-subjects factors revealed no main effects of counterbalanced factors (color of responsive adult, side of responsive adult, and order of familiarization events), $p_s > 0.17$. There was a main effect of participant gender, $F(1, 23) = 10.29, p = 0.0039$, with males looking longer at test than females. During familiarization events, there was no difference in infants’ looking to the two responsive events ($M = 16.47$ seconds, $SD = 11.33$) versus the two unresponsive events ($M = 18.31, SD = 14.6$), $F(1, 27) = 0.52, p = 0.48$.

A 3 (Experiment: 1, 2, 3) by 2 (Test character: responsive vs. unresponsive) ANOVA comparing experiments revealed no significant main effects or interaction. Follow-up two-sample $t$-tests comparing proportion of infants’ looking to the approaching character across experiments revealed no differences in infants’ looking to the approaching adult between Experiments 1 and 3 ($t(30.09) = 1.32, p = 0.20$) and Experiments 2 and 3 ($t(27.88) = 0.63, p = 0.53$). The same pattern was found using 2 (Experiment: 1 vs. 3 and 2 vs. 3) by 2 (test adult: responsive vs. unresponsive) repeated-measures ANOVAs: there were no main effects of experiment nor experiment by test adult interaction ($p_s > .13$ and $> .51$, respectively).

Exploratory analyses comparing infants’ looking to familiarization events across experiments using a 3-way (Experiment: 1, 2, 3) ANOVA revealed a main effect of experiment, $F(2, 57) = 4.02, p = 0.023$, driven by infants looking longer to familiarization in Experiment 2 ($M = 56.77, SD = 33.61$ seconds) than Experiments 1 ($M = 39.73, SD = 18.66$ seconds) and 3 ($M = 34.78, SD = 22.35$ seconds).

Discussion
When baby’s make a less potent call: either giggling or fussing, infants no longer show a preference for the adult who approaches rather than avoids the baby. Thus, baby cries, and adults’ responses to a crying baby may be unique in their meaning for the relationship between the crier and responder. This pattern is consistent with recent findings that 4- and 12-month-old infants look equally to videos of a woman who either ignores or responds to a laughing baby (Jin et al., 2018). Infants may form the same preference for a responsive adult given more instances or more meaningful instances the approaching and avoiding events to a fussing or giggling baby.

**General Discussion**

By 5-months-old, infants do track social interactions that adults identify as caregiving—an adult responding to a crying baby by moving toward rather than away from the baby, followed by the baby stopping its cries. In Experiment 1, infants looked longer at test to an adult who had previously been responsive rather than avoidant of a baby’s cries. This effect is social in nature, as infants do not form a preference for the approacher when they approach a noisy object instead of a crying infant (Experiment 2). However, this preference did not generalize to other calls from the baby: in Experiment 3, infants did not prefer an adult who was responsive rather than avoidant of a baby who either giggled or fussed.

These results provide initial evidence that infants in their first year are sensitive to basic caregiving interactions, but their inferences may be limited to certain contexts—ones involving infant cries. When watching similar animated events where a small and big shape become separated, followed by either a baby cry or laugh, infants attended more to scenes with a baby crying than laughing (Biro, Alink, Huffmeijer, Bakermans-Kranenburg, & van IJzendoorn, 2015). Four- and 12-month-old infants looked longer to an adult woman who ignores a crying baby rather than comforting it, but they looked equally to these behaviors if the baby laughed.
Similar effects were replicated when infants chose which videos to watch via touch screens—they watch the ignore event more often but only when the baby cried instead of laughed (Jin et al., 2018). Thus, infants may be most attuned to social interactions centered on a baby that involve a baby crying, which serves as a salient signal to themselves and others.

The present experiments provide a foundation from which further questions can be tested regarding what infants’ understand about caregiving interactions and what expectations they have for caregivers. Furthermore, infants’ preferences for the responsive caregiver in Experimenter 1 may be a more general preference for someone who approaches a social agent after any call. Experiment 3 suggests that this may not be true at the broadest sense—infants did not prefer an adult who responded to a baby’s laugh or fuss, so they do not simply prefer to look at someone who approaches another individual after being called. However, it is still possible that infants would prefer a character who approaches any other character in more serious need—whether a baby or another adult. A baby fuss may not signal a serious enough need but perhaps an adult crying would show the same pattern as an infant cry. By 3 months, infants do show a preference for those who help another complete a goal that they cannot complete on their own (Hamlin et al., 2010), so they may be sensitive to any helper of someone in need. In contrast, it is possible that those cases would not elicit a preference for the approacher, and instead, the calls of a crying infant may be a unique case in which infants attribute helper status at a minimal social interaction and themselves prefer that approacher/helper. Infants in their first six months may draw inferences about social contexts more similar to their own—responding to a crying baby rather than a crying adult.

Given infants’ sensitivity to the primitive components necessary to construct kinship networks—helpfulness and dominance in social interactions, possible precursors to rights and
obligations (Hamlin et al., 2010; Pun et al., 2016), age and gender of individuals (Quinn et al., 2002, 2008), costs of actions and implications for social value (Liu & Spelke, 2017; Liu et al., 2017), and inferring novel social relationships (Rhodes et al., 2015; Spokes & Spelke, 2017)—and their nuanced social responses to caregiving even in their first 4-months (Jin et al., 2018), the present experiments provide the first tests of infants’ preference for caregivers based on their responses to a baby’s calls in their first year. We found that 5-month-old infants prefer an adult who previously responded to a baby’s cry by approaching rather than avoiding the baby, and thus, infants in their first year can and do attend to different caregiving interactions in third-party contexts. Five-month-old infants evaluated adults who did and did not provide comfort to a crying baby. Infants exhibited these abilities before being able to crawl or walk to physically approach their own social partners themselves, or to communicate with their social partners by means of language.

These experiments give plausibility to the hypothesis that infants in their first year begin to learn the structure of their families and their own place within the family. Nevertheless, much more work is needed to test this hypothesis, and the present methods may serve for this purpose. For instance, do infants believe that parents are more obligated to care for their children than are unrelated adults? If infants see that two adults each care for their own babies, and then one baby cries, and both adults—one previously having cared for that baby and one having not interacted with that baby—refuse care, do infants fault the parent more? If infants have an intuitive sociology guiding their reasoning that integrates social value and partnerships, we would predict that infants would be more surprised to see a caregiver refuse their obligation relative to an equally unhelpful, unrelated adult. Infants intuitive sociology may be centered on kin
relationships, as kin are the people who spend most time with infants in their first few years, and if so, their intuitions should follow the signatures of how kin interact with one another.

Further, are infants’ inferences about family obligations modulated by age? If infants see an adult and a baby both refuse care to a crying baby, do infants fault the adult more and thus look longer to an adult refusing caregiving duties more than a baby who refuses caregiving duties? Lastly, are infants’ inferences about family relations modulated by gender of the caregiver? If infants see caregivers of different genders, do they have different expectations for who is more likely to respond to a crying baby—male or female?

The present experiments provide methods that could serve to address these further questions, and the present findings create a foundation for additional research that can narrow in on how infants in their first year respond to and reason about people and relationships. Throughout life, identifying and orienting toward adults who are nurturing and helpful is an adaptive ability for all members of our social species, and it may be particularly important for infants. The present experiments suggest that infants may begin to develop these abilities at an early age.
Paper 3: Children’s Expectations and Understanding of Kinship as a Social Category

Abstract

In order to navigate the social world, children need to understand and make predictions about how people will interact with one another. Throughout most of human history, social groups have been prominently marked by kinship relations, but few experiments have examined children's knowledge of and reasoning about kinship relations. In the current studies, we investigated how 3- to 5-year-old children understand kinship relations, compared to non-kin relations between friends, with questions such as, “Who has the same grandmother?” We also tested how children expect people to interact based on their relations to one another, with questions such as “Who do you think Cara would like to share her treat with?” Both in a storybook context and in a richer context presenting more compelling cues to kinship using face morphology, 3- and 4-year-old children failed to show either robust explicit conceptual distinctions between kin and friends, or expectations of behavior favoring kin over friends, even when asked about their own social partners. By 5 years, children’s understanding of these relations improved, and they showed some expectation that others will preferentially aid siblings over friends. Together, these findings suggest that understanding of kinship develops slowly over the preschool years.

Keywords: social cognition, kin preference, development, social categories, resource sharing
Introduction

Humans categorize people as members of multiple groups, based on diverse commonalities including family, race, religion, ethnicity, economic class, and gender. We form social categories even in situations in which groups are arbitrary or randomly assigned (Tajfel et al., 1971). Recent research reveals that age, gender, race, ethnicity, and language are salient social categories for infants and young children, who show preferences for members of their own group (e.g., Kinzler et al., 2010). Nevertheless, one important social distinction has received little attention in current investigations of children’s social cognitive development, despite its social importance for children worldwide: the distinction between kin and non-kin.

Investigators in anthropology, sociology, and human biology have explored the rich dynamics of familial relations. According to long-accepted principles of evolutionary theory, individuals achieve indirect benefits to their inclusive fitness when their kin survive and reproduce (Hamilton, 1964; cf. Nowak et al., 2010). Thus, humans could be predisposed to track and help kin members. Consistent with this theory, human adults encoded kinship to the same extent as sex and age in a memory confusion paradigm (Lieberman et al., 2008), and they show evidence of a kin detection mechanism that influences opinions and behaviors related to sibling altruism and incest disgust (Lieberman et al., 2007).

Little research has explored children's knowledge and reasoning about kinship relations, however, and most experiments that have done so suggest that sensitivity to kinship develops slowly. At 5 years, children are apt to apply kinship terms to people on the basis of their typical perceptual features rather than their kinship relations (Landau, 1982). For example, 5-year-old children, asked to determine which person is a "grandmother," typically chose a person who looked old but was pictured without children and grandchildren over a person who looked
younger but was pictured with children and children’s children (Landau, 1982). Furthermore, children first demonstrate a clear understanding of biological knowledge of life and death between the ages of 5 and 7 years (Carey, 1985; Inagaki & Hatano, 2002), so the underlying biological nature of something like blood relations may not develop until late in childhood. Nevertheless, children may have earlier intuitions about the social nature of kin relations.

In addition to understanding the meaning of different social relations, children need to understand and make predictions about how people will interact with one another, in order to navigate the social world. One domain that is central to human social relations and cooperation is resource sharing. Even before age two, infants are biased toward equal distributions of resources (Schmidt & Somerville, 2011; Sloane et al., 2012, Somerville et al., 2012). Children tend to share resources with others equally when they are able to (e.g., Olson & Spelke, 2008), taking into account the value of a resource when calculating equality (Shaw & Olson, 2013). By age six, children tend to dislike those who do not share equally (Shaw et al., 2012). Nevertheless, children override a preference for equality and accept unequal resource distributions when there is evidence that the recipient is more deserving due to prior behavior or social group status (e.g., Sloane et al., 2012).

Moreover, both adults and young children expect others to share resources according to principles of direct and indirect reciprocity (Greiner & Levati, 2005; Gurven, 2006; Wedekind, 2000; Wedekind & Braithwaite, 2002). Adults have demonstrated a bias to work harder in order to benefit others more closely related to them (Madsen et al., 2007), although young children have not shown a clear preference to benefit kin (Olson & Spelke, 2008). In these studies, 3.5-year-old children were introduced to dolls that were siblings, friends, or strangers with a protagonist doll and helped the protagonist divide up nine resources across trials. Children
tended to give more to those who had shared with the protagonist or with others previously, providing further evidence of their sensitivity to direct and indirect reciprocity. Children also gave more to the protagonist's siblings or friends than to strangers, but they gave roughly equally to siblings and friends. However, resources were plentiful enough to be distributed to everyone, and they were relatively low in value (Olson & Spelke, 2008).

Here we investigate further how children understand the relation between siblings as compared to friends or strangers, and how they expect people to interact based on their relations to one another. Will children distinguish among close relations when they must divide up resources of lower availability and therefore higher value? Furthermore, will children demonstrate different sharing behavior when distributing resources among their own close relations rather than in hypothetical, third-party scenarios, or when presented with realistic photographs of faces showing a strong family resemblance rather than with dolls? Finally, will children’s understanding track with their expectations for social interactions?

In Experiment 1, we tested 3- and 4-year-old children’s conceptual understanding and resource sharing choices for fictional characters in a storybook and examined whether their predictions of sharing toward kin, friends, and strangers were influenced by the value of the resource. In Experiment 2, we tested whether children distinguish kinship from friendship when asked about their own siblings and friends, and we expanded the age of children tested to include 5-year-old children. In Experiment 3, we further investigated 3-, 4-, and 5-year-old children's expectations for social interactions, using physical similarity to enhance kinship cues and probing children's social inferences across a more diverse set of social contexts. Taken together, these studies shed light both on 3- to 5-year-old children’s conceptual understanding of kinship and on the ways in which their prosocial decisions are, and are not, affected by kinship.
**Experiment 1**

The first study investigated children’s expectations for sharing of resources in third-party social interactions among kin, friends, and strangers. The resources varied in value, based on their plenitude or scarcity. This study also tested children’s conceptual understanding of siblings, friends, and strangers. Children read an interactive storybook in which a protagonist character travelled to different locations and interacted with her sibling, her friend, and a child whom she had never met before. Children were asked factual questions about the different characters to probe their understanding of these social relationships. Then, they were asked to predict with whom the protagonist would share a resource.

**Materials and Methods**

**Participants**

Ninety-six children from the Cambridge and Boston area participated in this study, with 48 children at each of two ages: 3.5 years (26 female, 36.23-47.43 months, mean age = 41.46 months) and 4.5 years (24 female, 48.27-60 months, mean age = 53.39 months). Children received a gift after their study, and parents were reimbursed for their travel. This study was carried out in accordance with the recommendations of the Committee on the Use of Human Subjects in Research at Harvard University with written informed consent from a parent or legal guardian of all subjects and verbal agreement from participants.

**Materials**

We presented participants with fictional characters in a storybook using all hand-drawn, cartoon-like pictures colored with marker. Each story focused on one protagonist who interacted with her sister, friend, and a stranger in different scenes. The storybook consisted of one warm-up sequence followed by three scenes each composed of an introductory questions phase and a
sharing phase. Thus, children were introduced to four scenarios: one warm-up scenario with
animal characters and three test scenarios with human characters and social interactions. In the
introductory phase, children were shown the protagonist in a new location, with two other
characters. The other characters were described and named, and their relation to the protagonist
was indicated: a sister (henceforth, sibling), friend, or a girl she had never met before
(henceforth, stranger). Children's understanding of the relations then was probed through two
questions focused on the two characters' relationship (described below).

In the sharing phase, participants were introduced to a new situation in which the
protagonist now had a valuable resource (e.g., a trip to the beach) to share with one of the two
other characters. In all contexts, there was only one resource, so the protagonist could only share
with one of the two characters. Children were given drawings symbolizing the resources to be
distributed in the storybook: a green pet toy, a cupcake, a seashell, and a banana. The same
storybook was used across resource conditions, but the drawings were described as representing
differently valued objects across conditions.

Procedure

Children were first told they were going to read a story about a protagonist, Cara, and her
adventures. Then children began the warm-up phase of the study, in which the protagonist was
presented with two animals: a dog and a cat. The experimenter asked children two questions
about the animals (“Which one likes to play fetch?” and “Which one purrs when you pet it?”). Children were always given positive reinforcement for their answer, whether correct or incorrect. After these questions, the next page in the storybook showed the protagonist with a resource. The warm-up involved a pet toy that was described as being liked by both cats and dogs. The experimenter then gave the child the drawing of the toy and encouraged the child to help the
protagonist decide which animal to give it to. Children were encouraged to place the item in front of the animal they chose. If children wanted to give the resource to both animals, they were told to choose one since they only had one toy to give.

After the warm-up phase, the story advanced to the first block involving people interacting with the protagonist. Each block began with the introductory phase, which first showed the protagonist in a new location: the park, the beach, or the zoo. Children were encouraged to discuss activities for the protagonist to do at the new location in order to keep them engaged in the storybook. The next page in the storybook for each block showed the protagonist with two other characters described as her friend and sibling, friend and stranger, or sibling and stranger. The warm-up phase always came first, but the order of the three social scenarios and pairs was counterbalanced across participants.

After children were introduced to the pair of characters, they were asked two questions about their specific relations to the protagonist. For friend and sibling, the questions were: “Which girl has the same grandparents as Cara?” and “Which girl could Cara meet for the first time at school?” The questions for friend and stranger were: “Which girl has Cara played with many times before?” and “Which girl does Cara not know much about?” For sibling and stranger, children were asked, “Which girl has the same last name as Cara?” and “Which girl has Cara never seen before?”

The next page in the storybook for each block showed the protagonist with a newly acquired resource, as in the warm-up phase. The displayed picture was the same across conditions, but the resource was described differently based on whether the condition is a high- or low-value resource condition. Resource value was manipulated along the dimension of accessibility to the protagonist. In the low-value versions, the protagonist has access to the item
or experience frequently or infrequently. In the high-value condition, the protagonist has a one-time-only (and thus extremely infrequent) opportunity to access the resource. There were two versions of the low-value resource script, and an example of each follows:

Cara brought a very special treat with her to the park. This is her favorite treat, and it is very delicious. *It is very hard to find and Cara hardly ever gets to eat this treat.* Who do you think Cara would like to share her treat with?

Cara brought a very special treat with her to the park. This is her favorite treat, and it is very delicious. *It is very easy to find and Cara eats this treat a lot.* Who do you think Cara would like to share her treat with?

An example of the high-value resource script is:

There is going to be a special day at the park with a visiting carnival that has lots of fun treats, games, and rides, just like this special cupcake that Cara has. The carnival will only be there for one day, and Cara can only bring along one person with her, so the person she chooses gets to go and enjoy the treats, games, and rides, but the person she does not choose never gets to go. Who do you think Cara would like to invite along with her?

In the low-value resource conditions, the drawings of the cupcake, seashell, and banana are the objects to be shared in the short vignette, so the participants are encouraged to give the
object to the one they believe the protagonist would choose. In the high-value resource condition, the protagonist got to bring along one person to the once-in-a-lifetime experience, and the drawings were described as tickets, and participants were encouraged to give the item to the one they thought the protagonist would like to bring along, thus they need not know the word “ticket” to still understand they give the item to the one she preferred to bring along.

Participants thus used the drawing of the resource to help the protagonist chose a preferred recipient. After their choice, the resource was moved behind the storybook, and a new block began with the protagonist at a new location.

Results

To test children’s understanding of kin, friend, and stranger relations as well as their expectations for interactions among people in these relations, their responses to each question and their choice for resource sharing were analyzed using a binomial distribution. Children’s answers to the comprehension questions were coded as a 0 (incorrect) or 1 (correct). For the resource distribution questions, children scored a 1 for choosing to share with the predicted character: sibling in sibling versus stranger, friend in friend versus stranger, and sibling in sibling versus friend.

Conceptual Understanding Questions

For conceptual understanding questions, we first analyzed children’s correct responses within each recipient pair using their average score on the two questions per recipient pair. A 2 (age group) by 3 (recipient pair) repeated measures ANOVA revealed significant main effects of recipient pair, $F(2, 188) = 16.1, p < 0.001$ and age group, $F(1, 94) = 12.72, p = 0.001$. There was no significant interaction. Follow-up analyses comparing children’s accuracy by age group revealed that 4-year-old children answered with greater accuracy than 3-year-old children, $t(94)$
= 3.55, \( p = 0.001 \). Additional analyses comparing children’s responses across recipient pairs revealed that children answered more questions correctly for kin versus stranger and friend versus stranger than for kin versus friend (\( F(1, 94) = 16.56, p < 0.001 \); \( F(1, 94) = 25.92, p < 0.001 \)), but they did not show different performance when comparing kin versus stranger to friend versus stranger questions, \( F(1, 94), = 1.21, p = 0.27 \).

Next, children’s responses on each question were analyzed separately by age using one-sample two-tailed \( t \)-tests, with chance performance at 0.5 as they chose between two characters with one correct answer (Table 3.1). Correcting for multiple comparisons using Bonferroni correction for two questions in each test block, \( p \)-values should be considered significant when \( p < 0.025 \) for these analyses; all \( p \)-values are given in Table 3.1. Four-year-old children answered correctly on both questions for the sibling versus stranger, and 3-year-old children answered one correctly (never seen) and one incorrectly (last name). Children at 3- and 4-years-old answered both questions correctly for friend versus stranger. However, all children erred on questions contrasting sibling with friend.

**Table 3.1. Children’s Conceptual Understanding Responses in Experiment 1**

<table>
<thead>
<tr>
<th>Question</th>
<th>3-year-olds</th>
<th>4-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kin vs. Stranger</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which has the same last name as X?</td>
<td>ns ( p = .042 )</td>
<td>***K ( p &lt; .001 )</td>
</tr>
<tr>
<td>Which has X never seen before?</td>
<td>***S ( p &lt; .001 )</td>
<td>***S ( p &lt; .001 )</td>
</tr>
<tr>
<td><strong>Friend vs. Stranger</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which has X played with many times?</td>
<td>**F ( p = .003 )</td>
<td>***F ( p &lt; .001 )</td>
</tr>
<tr>
<td>Which does X not know much about?</td>
<td>***S ( p = .003 )</td>
<td>***S ( p &lt; .001 )</td>
</tr>
<tr>
<td><strong>Kin vs. Friend</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which has the same grandparents as X?</td>
<td>ns ( p = .78 )</td>
<td>ns ( p = .25 )</td>
</tr>
<tr>
<td>Which could X meet for the first time at school?</td>
<td>ns ( p = .57 )</td>
<td>ns ( p = .042 )</td>
</tr>
</tbody>
</table>

*Table 3.1. Children provided responses about a sibling (K for kin), friend (F), and stranger (S). Three-year-olds answered one question correctly (***\( P < 0.001 \)) and one incorrectly for kin versus stranger, both question correctly for friend versus stranger (**\( P < 0.005 \)), and both questions incorrectly for kin versus friend. Four-year-olds answered all questions correctly for kin and friend versus stranger (***\( P < 0.001 \)) but both incorrectly for kin versus friend.*
Resource Sharing Questions

Children showed no clear judgments of differential sharing based on resource value: the 2 (resource value) by 3 (recipient pair: sibling vs. stranger, friend vs. stranger, sibling vs. friend) repeated-measures ANOVAs, conducted at each age, revealed no main effects or interactions (all ps > 0.05).

Due to the minimal impact of the resource value manipulation, we collapsed across cost-level and analyzed children’s responses to each test pair using one-sample two-tailed t-tests with chance performance set to 0.5 (Figure 3.1). Three-year-olds chose friend over stranger, \( t(47) = 2.42, p = 0.019 \), but not kin over stranger, \( t(47) = 0.86, p = 0.39 \); 4-year-olds chose kin over stranger, \( t(47) = 2.77, p = 0.008 \), and friend over stranger, \( t(47) = 2.42, p = 0.019 \). At neither age did children choose kin over friend or the reverse (both ts < 1).
Figure 3.1. Children’s sharing choices in Experiment 1. Children \(N = 48\) allocated a resource to one character in each dyad. Three-year-old children chose to share with a friend over stranger \((*P < 0.05)\), and 4-year-old children chose to share with a sibling over stranger \((**P < 0.01)\) and friend over stranger \((*P < 0.05)\). Error bars represent one standard error.

**Additional Analyses**

In light of children's poor performance on the comprehension questions, further analyses focused on the performance of subsets of children who might be expected to have a greater understanding of kinship relations. First we compared the responses in the sharing task for children with the same age or older siblings \(N = 47\) as compared to children with younger or no siblings \(N = 49\). For children at age 3-4 years that have a younger sibling, that sibling is an infant or toddler, so the child-aged sibling in the storybook may not relate as directly to their own
experience. Nevertheless, the performance of children in these two categories did not differ, $F(1, 94) = 0.03, p = 0.86$.

Next, we analyzed the performance of the subset of children who answered all six conceptual understanding questions correctly, $N = 22$ (4: 3-year-olds; 18: 4-year-olds, mean age = 52.63 months). First, we compared these children’s resource sharing choices to children who did not answer all questions correctly, and the 2 (all correct vs. not all correct) by 3 (recipient pair) RM ANOVA revealed a main effect of answering all comprehension questions correctly, $F(1, 94) = 7.05, p = 0.009$, showing that these children chose in the predicted direction significantly more often. There were no other main effects or interactions. Further analyses showed that children who answered all conceptual understanding questions correctly expected favor to go to kin over stranger, $t(21) = 3.78, p = 0.001$, and friend over stranger, $t(21) = 2.98, p = 0.007$. They also tended to favor kin over friend, but this tendency was not significant, $t(21) = 1.79, p = 0.088$.

**Discussion**

Across all levels of resource cost, 3- and 4-year-old children showed explicit understanding and differential expectations for resource sharing between siblings and strangers and between friends and strangers, but not between friends and siblings. Children distinguished well between familiar people, whether friends or siblings, and unfamiliar people. In contrast, children did not show the tested distinctions between familiar people within vs. outside the family. Overall, these findings replicate previous findings that children divide plentiful resources equally between siblings and friends (Olson & Spelke, 2008), in roughly the same manner as they do in the current study with limited resources. We did not find differences across scenarios that varied resource value according to accessibility, though this may indicate either that children
are insensitive to cost manipulations or that scarcity, the dimension along which cost was manipulated, does not effectively convey value to children of this age.

We did not find that children with siblings were more likely to favor kin over friends than were other children, though this binary categorization of sibling relations may not be sufficiently sensitive. The quality of a child's relationship with a sibling might be a better predictor of sharing with kin in the present experiment than the experience of having a sibling. Future research examining individual differences in sibling relationships could explore this possibility further.

Children’s answers to the comprehension questions suggest a different reason for their equal division between siblings and friends: children may be unsure about the conceptual distinction between the two. It is possible, however, that children understood this distinction but had trouble answering the specific questions asked, because they did not understand the term “grandmother” or the significance of surnames. Consistent with this possibility, children who passed all the comprehension questions also failed to show a robust favoring of kin, although they showed a non-significant trend in that direction. Thus, even children who understand the distinction between kinship and friendship may fail to favor kin over friends.

Experiment 2 begins to investigate this possibility in two ways. First, we included more comprehension questions using well-known kin terms such as “mom” as well as questions with no kin terms. Second, we asked children about their own friends and siblings, rather than the friends and sibling of hypothetical characters. Despite children's failure to favor kin over friends in the present study and in previous studies presenting hypothetical characters (Olson & Spelke, 2008), it is possible that young children would choose to favor kin over non-kin when they consider how they would distribute resources to their own friends and relatives. To test this possibility, Experiment 2 presented children with first-person, hypothetical scenarios involving
themselves and their own sibling or friend, as well as a stranger. In each of three episodes within a story, children were told that they received a resource and were asked how they would distribute it. The cupcake and banana both represented shared activities in the low-resource conditions—eating, and feeding animals together, respectively—but the seashell was given in whole as a gift. In order to better equate the three social scenarios, we replaced the seashell with a shovel in Experiment 2 and modified the social scenario to be about building a sandcastle together, a shared activity.

**Experiment 2**

The second experiment investigated children’s expectations for sharing in hypothetical first-person social interactions among their own kin and friends. Children read an interactive storybook in which they were the protagonist, who travelled to different locations and interacted with their own sibling, their own friend, or a stranger. Children were asked questions about the different relations as well as with whom they would choose to share a resource. We tested children’s conceptual understanding of social relations with additional questions. To specifically test their knowledge of kin compared to non-kin—friends and strangers—the same questions pertaining to kin were asked across pairs with each type of relation. Because 4-year-old children made many errors on the conceptual questions in Experiment 1, we included 5-year-old children in this experiment to compare their performance to that of younger children.

**Materials and Methods**

**Participants**

One hundred eight children from the Cambridge and Boston area participated in this study, with 36 children aged 3.5 years (18 female, 36.07-47.57 months, mean age = 42.76 months), 4.5 years (18 female, 48.17-59.97 months, mean age = 53.08 months), and 5.5 years
(18 female, 60.17-71.3 months, mean age = 66.07 months). All participants had at least one sibling in order to make the first-person storybook realistic and relevant. Children received a gift for their participation, and parents received a reimbursement for their travel. This study was carried out in accordance with the recommendations of the Committee on the Use of Human Subjects in Research at Harvard University with written informed consent from a parent or legal guardian of all subjects and verbal agreement from participants.

**Materials**

This study used an adapted version of the storybook from Experiment 1 that incorporated the participant as the protagonist. There was one storybook for male and one for female participants. The protagonist in each story was drawn without color in the storybook; participants first colored in a cutout version of the protagonist to represent themselves in the storybook. Participants also selected colored cutout drawings of the additional three characters representing a sibling, friend, and stranger from among six possible characters: three males and three females. Participants with a sibling of their same gender had a storybook with all gender-matched characters. If participants only had one or more siblings of the opposite gender, they could select either gender for a friend, and the stranger was gender-matched to the sibling. Participants chose the two characters that represented a sibling and a friend, and the experimenter added the third character to represent the stranger. These characters were inserted into the story at relevant times using Velcro.

The warm-up sequence, including the practice questions and sharing trial involving the cat and dog, was the same as Experiment 1 except that it was narrated such that the participant was the protagonist. The experiment consisted of three test blocks, each with an introductory phase followed by a sharing phase. In all three scenarios, the sharing phase involved both a shared
object and a shared activity. The drawings of the resources were the same as in Experiment 1 except that a shovel now replaced the seashell, which did not lend itself readily to a shared activity.

**Procedure**

This study began with participants coloring in a picture of a boy or girl to represent them, which they then used in order to pretend that they were in the storybook. Once children had finished coloring, they were told that other people they knew would also be in the storybook. The experimenter then presented children with drawn, laminated pictures of three boys or girls, depending on the gender of their sibling. The experimenter obtained sibling information from the parents or guardians prior to the study during the consent process. Children were encouraged to choose one picture to be their sibling in the story. Children with multiple siblings were encouraged to choose one to be in the storybook. After children made a selection, they were told that a friend would be in the storybook too, and they were asked to choose from one of the remaining pictures. If children had a gender-matched sibling, they also had a gender-matched friend and stranger. If children had a sibling of the opposite gender, they were allowed to choose a friend of either gender, but the stranger was matched to the gender of the child’s sibling. The three pictures that represented the sibling, friend, and stranger were incorporated into the storybook by sticking them onto the pages using Velcro.

Once children had the three pictures chosen and their picture colored for themselves, they began the storybook. The first page showed the same character they had colored in, and they were invited to pretend that they were in the storybook. Children were encouraged to place their drawing into the storybook. The story then progressed through the warm-up sequence and
practice trial as in Experiment 1 with adjustments in narration to render the story as a first-person narrative.

The test blocks consisted of the protagonist, in this case the participant, going to a new location and interacting with two of the three other characters: a sibling, a friend, and a stranger. As in Experiment 1, the introductory phase consisted of showing the protagonist at the new location and discussing that new place. Then, the protagonist was shown with two of the characters, children were reminded of who they were (“your sister/brother,” “your friend,” “a girl/boy you have never met before”), and children were asked questions about these people. Each question was followed by, “Would it be [X] or [Y]?” with the experimenter pointing and labeling the two options by their relationship to the child. Children were asked the same two questions that were used in Experiment 1 during each test block, rephrased into first-person questions, as well as two additional questions. The new questions were: “Which has the same mom as you?” “Which has a different mom than you?” “Which lives in the same house as you?” “Which lives in a different house than you?” The added questions for friend and stranger were: “Which would you invite to your birthday party?” and “Which have you never invited over to play before?” Because the kin concept questions were of specific interest, the questions in the kin and friend as well as the kin and stranger pairs were counterbalanced across children. Question order within test blocks and order of relation pairs were also counterbalanced across participants.

For the sharing phase of each test block, children were shown their own protagonist character with a newly acquired resource: a cupcake, a shovel, or a banana. Children were then told they had one additional item that they could share with one of the two people there with them. The cupcake was described as a treat to eat at the park. Children were told the shovel could be used to build a sand castle with the person they choose, and the banana was for feeding.
animals at the zoo, and they could bring one person along with them to feed the animals. As in Experiment 1, participants received a drawing of the item and were encouraged to give it to their chosen recipient in the story. After they made a decision, the item was placed behind the storybook, and the story proceeded to the next test block.

**Results**

The same analyses were conducted for Experiment 2 as for Experiment 1. For the resource distribution, children scored a 1 for choosing to share with the predicted character: sibling rather than stranger, friend rather than stranger, and sibling rather than friend. For comprehension questions, children’s answers were coded as a 0 (incorrect) or 1 (correct). We used two-tailed one-sample t-tests to test whether children’s responses were significantly above chance performance of 0.5 (Figure 3.2). This experiment included storybooks with the child as the protagonist and their own siblings and friends (versus all female characters in Experiment 1). We thus included sex as a variable in the analyses to test for potential sex differences.
Conceptual Understanding Questions

For conceptual understanding questions, we first analyzed children’s accuracy for questions within each recipient pair using their average score on the four questions. A 3 (age group) by 3 (recipient pair) repeated measures ANOVA analyzing their responses revealed a significant main effect of age group, $F(2, 105) = 23.32, p < 0.001$, showing increasing accuracy with age, and no other main effect or interaction. Follow-up analyses comparing children’s accuracy by age group revealed a significant difference in responses between 3- and 4-year-olds,
Next, children’s responses at each age were analyzed for each question using two-tailed one-sample $t$-tests with chance performance at 0.5 as they chose between two characters with one correct answer (Table 3.2). To correct for multiple comparisons using Bonferroni correction for four questions in each test block, $p$-values should be considered significant when $p < 0.0125$ for these analyses; all $p$-values are given in Table 3.2. All questions asked for kin versus stranger were also asked for kin versus friend for different children.
Table 3.2. Children’s Conceptual Understanding Responses in Experiment 2.

<table>
<thead>
<tr>
<th>Question</th>
<th>3-year-olds</th>
<th>4-year-olds</th>
<th>5-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kin vs. Stranger (n = 18 per question)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which has the same last name as you?</td>
<td>ns $p = .057$</td>
<td>ns $p = .16$</td>
<td>**K $p = .002$</td>
</tr>
<tr>
<td>Which have you never seen before?</td>
<td>**S $p = .002$</td>
<td>**S $p = .002$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Which lives in the same house as you?</td>
<td>***K $p &lt; .001$</td>
<td>***K $p &lt; .001$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which lives in a different house than you?</td>
<td>**S $p = .002$</td>
<td>ns $p = .014$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Which has the same grandparents as you?</td>
<td>ns $p = 1.0$</td>
<td>**K $p = .002$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which could you meet for the first time at school?</td>
<td>ns $p = .65$</td>
<td>**S $p = .002$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Which has the same mom as you?</td>
<td>ns $p = 1.0$</td>
<td>ns $p = .014$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which has a different mom than you?</td>
<td>ns $p = .65$</td>
<td>ns $p = .014$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Friend vs. Stranger (n = 36)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which have you played with many times?</td>
<td>***F $p &lt; .001$</td>
<td>***F $p &lt; .001$</td>
<td>***F $p &lt; .001$</td>
</tr>
<tr>
<td>Which do you not know much about?</td>
<td>ns $p = .017$</td>
<td>***S $p &lt; .001$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Which would you invite to your birthday party?</td>
<td>*F $p = .006$</td>
<td>***F $p &lt; .001$</td>
<td>*F $p = .006$</td>
</tr>
<tr>
<td>Which have you never invited over to play?</td>
<td>ns $p = .32$</td>
<td>***S $p &lt; .001$</td>
<td>***S $p &lt; .001$</td>
</tr>
<tr>
<td>Kin vs. Friend (n = 18 per question)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which has the same last name as you?</td>
<td>ns $p = 1.0$</td>
<td>ns $p = .057$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which have you never seen before?</td>
<td>ns $p = .16$</td>
<td>ns $p = .16$</td>
<td>***F $p &lt; .001$</td>
</tr>
<tr>
<td>Which lives in the same house as you?</td>
<td>ns $p = .16$</td>
<td>**K $p = .002$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which lives in a different house than you?</td>
<td>ns $p = .057$</td>
<td>**F $p = .002$</td>
<td>***F $p &lt; .001$</td>
</tr>
<tr>
<td>Which has the same grandparents as you?</td>
<td>ns $p = .65$</td>
<td>ns $p = .65$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which could you meet for the first time at school?</td>
<td>ns $p = 1.0$</td>
<td>ns $p = .16$</td>
<td>**F $p = .002$</td>
</tr>
<tr>
<td>Which has the same mom as you?</td>
<td>ns $p = .65$</td>
<td>ns $p = .057$</td>
<td>***K $p &lt; .001$</td>
</tr>
<tr>
<td>Which has a different mom than you?</td>
<td>***F $p = .002$</td>
<td>***F $p &lt; .001$</td>
<td>***F $p &lt; .001$</td>
</tr>
</tbody>
</table>

Table 3.2. Children provided responses about a sibling (K for kin), friend (F), and stranger (S). Three- and 4-year-olds answered only some questions correctly, and 5-year-olds demonstrate a clear understanding of the distinctions between relations in answering all questions correctly (*$P < 0.0125$; **$P < 0.0025$; ***$P < 0.001$; corrected for multiple comparisons).

Three-year-olds answered three questions correctly for kin versus stranger that were answered incorrectly when asked about kin versus friend, and they correctly knew one answer.
for kin versus friend but not kin versus stranger (Table 3.2). Four-year-olds were correct on half of the questions for kin versus stranger but only two questions for kin versus friend. Five-year-olds answered all of the questions correctly.

In questions about a friend versus stranger, 3-year-olds answered two questions correctly (played with, birthday) and two incorrectly (not know, never invited). Four- and 5-year-olds were correct in answering all questions.

**Resource Sharing Questions**

Three- and 4-year-old children chose to share with siblings over strangers ($t(35) = 2.092, p = 0.044$; $t(35) = 5.29, p < 0.001$) and with friends over strangers ($t(35) = 5.29, p < 0.001$; $t(35) = 3.95, p < 0.001$) but not with siblings over friends ($ps > 0.05$). Five-year-old children chose to share with siblings over strangers, $t(35) = 2.092, p = 0.044$, but not with friends over strangers or with siblings over friends ($ps > 0.05$).

The 2 (sex) by 3 (age group) by 3 (recipient pair: sibling vs. stranger, friend vs. stranger, sibling vs. friend) repeated-measures ANOVA on the measure of children’s resource sharing preferences revealed a main effect of recipient pair, $F(2, 204) = 6.82, p = 0.001$, showing that children chose to share differentially depending on the social contrast. Follow-up analyses comparing children’s choices for each recipient pair revealed their stronger sharing preference for the predicted character (sibling in sibling vs. stranger and sibling vs. friend; friend in friend vs. stranger) in sibling vs. stranger, $F(1, 102) = 8.58, p = 0.004$, and friend vs. stranger, $F(1, 102) = 9.39, p = 0.003$, as compared to sibling vs. friend, but their sharing preferences did not differ between sibling vs. stranger and friend vs. stranger, $F(1, 102) = 0.15, p = 0.70$. There was a significant recipient pair by age by sex interaction, $F(4, 204) = 3.82, p = 0.005$, showing that boys and girls demonstrated different sharing patterns according to recipient as they grow.
Three-year-olds show sex differences in preference for two recipient pairs (sibling vs. stranger and sibling vs. friend), whereas 4-year-olds differ by sex for only one recipient pair (friend vs. stranger), and 5-year-olds do not differ for any recipient pair (Supplementary Table 3.1 in Supplementary Material).

**Additional Analyses**

To look further into the findings for children who answered all questions correctly in Experiment 1, 3- and 4-year-old children who answered a majority of conceptual understanding questions correctly (10 of 12) in this experiment were analyzed for their sharing choices. Only 9 of those children answered all questions correctly, but there were twice as many questions as Experiment 1, so the criteria for correct responses was relaxed. Children with 10 of 12 correct, $N = 28$, (7: 3-year-olds; 21: 4-year-olds, mean age = 50.8 months) expected favor to go to kin over stranger, $t(27) = 6.60, p < 0.001$, and friend over stranger, $t(27) = 4.36, p < 0.001$, but not to kin over friend, $t(27) = 0.37, p = 0.71$. Thus, Experiment 2 failed to confirm the non-significant trend toward a preference for kin over friend shown by children who passed all the comprehension questions in Exp.1.

**Discussion**

Overall, young children showed a preference to share with their own siblings and friends over children they had never met before, but they shared roughly equally with their own sibling and friend. Three- and 4-year-old children showed a similar pattern of sharing with their own relations in Experiment 2 as they did in third-party scenarios in Experiment 1, except that 3-year-olds now also chose to share with a sibling over a stranger. Although 3- to 4-year-old children continued to make some errors on the comprehension questions, failures of comprehension do not account for their failure to favor kin over strangers.
Five-year-old children showed weaker patterns: They expressed a significant but small preference for sharing with their own siblings over strangers and no preference for sharing with friends over strangers or with siblings over friends. In general, five-year-old children showed less preferential sharing with known over unknown social partners. This finding may result from the new social environments such children encounter as they start school and interact with unfamiliar children whom they are encouraged to treat fairly and nicely—in this experiment, children similar to the stranger. Though the present study did not collect information on children’s school experience, future research could address whether the difference in performance between younger and older children in this study was related to school experience. At 5 years, children's performance on the comprehension questions revealed the clearest understanding of the distinction among the three types of relationships, even as children's performance on the resource distribution questions suggested a de-emphasis of these distinctions in sharing contexts.

Experiment 2, like Experiment 1, provided no evidence for an in-group bias toward a family member over a non-family friend, suggesting children do not consider family to be a privileged in-group, even when children make resource-sharing decisions about their own siblings. However, this experiment tested only one domain of social interaction: resource sharing. It is possible that children would be more sensitive to family as a group in other social contexts. For example, adults are more likely to favor their close relatives in specific social contexts involving aid in serious times of need (Burnstein, Crandall, & Kitayama, 1994). Experiment 3 addressed this question by examining children’s expectations for social interactions across a more diverse set of social settings involving both helping and sharing.
A further limitation of Experiments 1 and 2 concerns the use of hand-drawn illustrations to represent people. Even though the children in Experiment 2 were asked to pretend that they and their actual friends and siblings were participants in the story, the depicted scenarios may not have been compelling in demonstrating cues to relatedness. In the next experiment, pictures of actual children were used and faces were morphed such that siblings resembled one another. With this manipulation, we return to the third-party narrative structure of Experiment 1 and ask whether children expect other children to favor kin over non-kin in sharing and giving contexts.

Experiment 3 investigated further children's expectations for social interactions across multiple contexts to see whether their preferences from the first-person scenarios of Experiment 2 replicated or differed when children were presented with a third-person task with enhanced cues to kinship and a wider range of social scenarios. We focused primarily on the relationship comparison for which children did not show a clear preference to favor one person over the other: sibling versus friend.

**Experiment 3**

In this Experiment, we tested 3-, 4-, and 5-year-old children's expectations for third-party social interactions between siblings and friends, as in Experiments 1 and 2, using new cues to kinship and new methods. We used face morphology software to present more compelling cues to sibling relations in a third-party context. Given the stable developmental improvement in conceptual understanding questions presented in previous experiments, we did not include any conceptual understanding questions and instead added additional questions regarding expectations for social interactions. Additional social interactions were added because children did not show strong preferences in resource sharing contexts in the previous experiment, and adults have demonstrated kin preference in specific contexts that call for more costly help.
(Burnstein et al., 1994; Essock-Vitale & McGuire, 1985). Rather than manipulate resource cost, we presented contexts that called for helping or sharing, asking whether children thought the protagonist character would more readily come to the aid of a sibling than of a friend.

**Materials and Methods**

**Participants**

Forty-eight Cambridge and Boston area children participated in this study: 16 3.5-year-olds (8 female, mean age = 41.87 months), 16 4.5-year-olds (8 female, mean age = 52.73 months), and 16 5.5-year-olds (8 female, mean age = 66.45 months). All participants had at least one sibling. Children received a gift for their participation, and parents were given a travel reimbursement. This study was carried out in accordance with the recommendations of the Committee on the Use of Human Subjects in Research at Harvard University with written informed consent from a parent or legal guardian of all subjects and verbal agreement from participants.

**Materials**

We presented children with two different sets of faces on a computer, described as a protagonist, his or her brother or sister (henceforth, sibling), and his or her friend. The stimuli consisted of photographs of real children, one of which was created using morphing, so to maintain high quality of the images, stimuli were presented on a computer, though the vignettes were still presented to children like stories. For each trial, children were introduced to three characters and explicitly told how the central character was related to the other two characters (as a friend or sibling). Then children were asked whom they thought the central character might prefer to interact with across four different prosocial scenarios involving helping and sharing in the context of short vignettes.
Procedure

Children were told they were going to hear some stories. For each trial, three children’s faces appeared on the screen with the protagonist in the center and two individuals on either side of the protagonist. One character’s image had been created by morphing the protagonist’s face with a third, unseen child’s face such that the character resembled the protagonist as a sibling would. Within a trial, all three characters were of the same sex. There were two sets of characters, one set of girls and one of boys, each presented in two trials for a total of four trials. Two trials involved prosocial interactions resembling sharing—the protagonist could give one recipient a cookie or lend one recipient a bike. The other two trials involved helping: the protagonist could assist one recipient in completing a puzzle or math homework (See Supplementary Materials for full vignettes). Each triad of characters—the protagonist and the two relations—was presented on two trials. The orders of picture sets and test questions were counterbalanced across children as well as which side the sibling was on and which character’s image had been morphed to be the sibling. Two more sets of characters appeared on four additional trials testing other social comparisons, but we do not present their findings here, because they always followed the present trials and their findings are not readily interpretable (see the Supplementary Materials).

The experimenter introduced the protagonist first by name, pointing at the central picture, and then introduced the first outer character by name, pointing to his or her picture. Then, children were told the two characters had a lot in common and were given one other piece of information about their relationship (e.g., they went to the same school (friend) or lived in the same house (sibling)). Next, children were told how the characters were related: respectively, as friends or as brothers/sisters. Finally, children were introduced to a hypothetical scenario in
which the protagonist had to make a decision as to whom he or she would choose to share with or help. An example was:

One day at school, Timmy is working on a dinosaur puzzle and Charlie is working on a train puzzle. Peter likes dinosaurs and trains. Who do you think Peter will help with their puzzle – Timmy or Charlie?

Children were encouraged to point to the picture of the child they thought the protagonist would choose. After making a choice, the experimenter proceeded to the next trial and introduced or reintroduced the next set of characters. When characters were reintroduced a second time in new stories, the experimenter would remind children of who each character was and how the protagonist was related to the other two characters while pointing to each one. For example:

Do you remember Peter? Peter and Charlie both live in the same house. They are brothers. Peter and Timmy both go to the same school. They are friends.

Next, a new hypothetical scenario was introduced and children were asked how they thought the protagonist would behave. The vignettes were presented in one of four counterbalanced orders.

**Results**

Children’s responses on each trial were coded as choosing the sibling (1) or friend (0). The 3 (age group) by 4 (question) repeated-measures ANOVA on children’s selections revealed no
significant main effects or interactions (all $ps > 0.05$), though there was a marginal main effect of age group, $F(2, 45) = 2.42, p = 0.10$.

Each age range was then analyzed for an overall preference for sibling over friend. Children’s four choices were summed and analyzed using a two-tailed, one-sample $t$-test with chance performance set to 0.5 (Figure 3.3). Children did not expect protagonists to choose their siblings over their friends at three years of age ($M = 0.45, SD = 0.26$), $t(15) = -0.72, p = 0.49$, or four years of age ($M = 0.44, SD = 0.31$), $t(15) = -0.81, p = 0.43$. Five-year-olds did expect the protagonists to favor kin over friends ($M = 0.63, SD = 0.22$), $t(15) = 2.24, p = 0.041$. 
Figure 3.3. Children’s social choices in Experiment 3. Three- and 4-year-old children \((N = 32)\) did not show a clear social preference between sibling and friend, but 5-year-old children \((N = 16)\) did choose for the protagonist in the vignettes to favor a sibling over friend \((P < 0.05)\).

Children’s responses followed the same pattern for both sharing and helping prosocial scenarios. Error bars represent one standard error.

Discussion

Despite increasing the salience of sibling relations using facial morphology, 3- and 4-year-old children did not expect preferential prosocial behavior toward siblings over friends. In contrast to younger children and to the findings of Experiment 2, however, 5-year-old children now expected the protagonist to favor their sibling, with a non-significant trend suggesting that an expectation of prosocial behavior toward kin seems to develop by around 5 years. The presence of shared face morphology between the sibling characters may have increased the salience of the sibling relation at this age. Alternatively or in addition, the inclusion of more social contexts may have triggered an increased expectation for favoring kin in five-year-old children. Younger children may not yet have a clear understanding of kinship or friendship, or, alternatively, they may understand distinctions among these relations but not have robust sharing preferences among them.

General Discussion

We found that 3-, 4-, and 5-year-old children overall showed a preference for sharing with siblings and friends over strangers (children they have never met), but they did not have a strong preference between a sibling and a friend. Children expected the same sharing behaviors when distributing limited resources as they do for plentiful resources, replicating past research (Olson & Spelke, 2008). Thus, children did not privilege family members as an in-group, or at least not in resource sharing scenarios comparing family members (siblings) to known social partners outside the family (friends) (Experiments 1 and 2). When siblings are made more salient and
social contexts were more varied, 5-year-olds, but not 3- and 4-year-olds, did expect third party protagonists to favor their siblings over their friends (Experiment 3).

Children’s understanding of these social pairs: sibling and friend, sibling and stranger, friend and stranger, improved with age, as 5-year-old children's performance revealed a clearer understanding of the distinction among the three types of relationships than 3- and 4-year-olds’. Children showed good understanding for friend versus stranger contrasts by ages 3 or 4 (Experiment 1 and 2, respectively) and good understanding for sibling versus stranger contrasts by ages 4 or 5 (Experiment 1 and 2, respectively). For sibling versus friend contrasts, only 5-year-old children answered most questions correctly.

Five-year-old children's performance revealed a clearer understanding of the distinction among siblings, friends, and strangers, even as their resource distribution beliefs suggest a de-emphasis of these distinctions in sharing contexts. At least when sharing scenarios are depicted in illustrated storybooks, specifically, the oldest children were less biased against sharing with strangers.

Although children organize their social world in a variety of ways, grouping individuals by gender, accent or language, and race, the present studies suggest that family relations are not clear to children from a young age. Children distinguish people who are socially related to one another (family members, friends, neighbors) from those who are not (strangers) before they understand the types of relations that connect the people they know. These distinctions begin to emerge at five years in the present studies.

By five years, but not before, children start to expect in-group benefits to be given to kin over familiar and valued non-kin, friends. Several factors could explain the late emergence of this expectation. Children may only develop an explicit kinship bias once they have a clear
understanding of what constitutes kin versus non-kin. The comprehension questions given in Experiment 2 provide evidence that children do not clearly differentiate between friends and siblings conceptually until around age 5. This differentiation may be necessary in order to expect favor to go to kin. Prior to age 5, children confuse familiar relations like friends and family, and thus they may expect favor to go to either party.

Young children differentiate how they share based on the recipient, but they do not show much evidence for a kinship bias until around age five, and even then, it is not a robust preference. In both third- and first-person hypothetical sharing contexts, children expected favor to go to familiar others like friends and siblings over strangers, even with a limited resource. However, at 3 and 4 years, children did not demonstrate a clear expectation for whether a sibling or friend should be privileged when choosing between the two. Young children expected equal treatment of siblings and friends in the distribution of resources that are plentiful (Olson & Spelke, 2008) or scarce (Experiments 1-3). In the present studies, the failure of young children to differentiate between friends and siblings is observed not only when resources have minimal value but when their value is increased, and not only when the story presents characters that are unknown to the child, but also when it depicts the child and his or her own sibling and friend in a hypothetical social scenario (Experiment 2).

Adults are more likely to rely on close kin when needing more costly help (Burnstein et al., 1994; Essock-Vitale & McGuire, 1985), but children are not sensitive to the manipulation of cost presented here. This negative finding may indicate either that children are insensitive to cost manipulations or that the experiment failed to manipulate cost effectively for children.

Children’s resource sharing with siblings may not be the best measure of kinship preference, because their allocation of resources to siblings may depend on additional factors
such as the quality of their relationship or age difference. Sibling competition over resources may also lead them to prefer to share with a friend over a sibling, as according to theories on sibling rivalry, full siblings compete so long as the benefits outweigh the costs two to one (Hamilton, 1964). Future research could examine whether children show preference for siblings in other areas or whether they show preference for other types of family relations, such as parents. However, this study would need to find a relevant match in familiarity and age (as friend was to sibling) for child-adult relations that are not parents (e.g., nanny or teacher). The present studies do not rule out a preference for kin but do demonstrate that children do not have a robust preference for all kin over non-kin, as they do not robustly share with siblings over friends.

In addition to their ambiguity about sharing, 3- and 4-year-old children show some confusion about what defines sibling versus friend relationships. By the time children are 5 years old, they demonstrate a better understanding of each relationships, and they also show biases for family over others in some social contexts (Experiment 3), although not in all contexts (Experiment 2).

Why do children confuse friends and siblings when answering questions like, “Who has the same mom as you?” One answer may be that children do not have a clear representation for each type of relationship: friend, sibling, stranger, and that this develops with more experience as they age. Alternatively, children may have representations for these relations, but the specific cues they use to identify and distinguish between them do not work as effectively in modern society. If children distinguish family from friends on the basis of the information that was most reliable in our evolutionary past, one should consider how human groups and social relations were organized then in order to know how to define the groups. One theory posits that family members were defined by communal sharing relationships, in which members are treated as
equally and share benefits altruistically among members (Fiske, 1992). However, friends in modern times also show many features that once defined only family relations. For instance, a child is likely to have their friends over to their house, share food with them, and see their own parents acting in a nurturing and protective manner toward their friends. These are all behaviors that children would have only seen directed toward siblings and other family members historically. Thus, what defines the idea of a sibling for a small child may be activated by the type of relationship they have with their friends now. The line between friend and sibling may be blurred in their experience and conceptions, and the distinction may not become explicit and clear until around 5 years of age, when further experience, likely including school experience, may start to clarify these social group boundaries. Before then, both may be seen as communal sharing relationships.

Children also have vastly greater social experiences to draw upon at age five relative to age three. Socialization pressures could influence 5-year-old children's sharing preferences in encouraging them to reach out to increasingly to new children around their age, in these experiments, strangers. Children are encouraged to share with others not only in their homes but also in contexts with children they may not have met before including schools, museums, daycare, parks, playgrounds, and other public places where they interact with new children. The present experiments were conducted in a lab environment, which may share many features with these other environments—for example, the experimenter is an unfamiliar friendly adult much like a teacher or children’s museum guide—and thus, the lab may elicit socialized patterns of sharing.

A broader aversion to strangers in early childhood could also be driving young children’s more robust preferences for familiar others to strangers compared to that of 5-year-olds. Most
parents encourage their children to avoid strangers, and children of all ages may adhere to this advice equally, however, older children may have different definitions of what individuals may count as a caution-warranting stranger. More specifically, a child their own age that they may not have met before would not be the type of stranger their parents warn them about. Moreover, they may recognize certain contexts in which they should be more or less wary—schools and playgrounds may be safer than airports, parking lots, or amusement parks. Younger children may not have the social experience or skill to differentiate between varying people and contexts, and thus they show a stronger aversion to strangers in our storybook contexts.

Adults’ tendency for altruism toward kin is mediated by emotional closeness (Korchmaros & Kenny, 2001). This finding raises the possibility that children’s equal sharing with friends and family is influenced by this variable as well. Though emotional closeness may have been a factor when children were considering their own relations (Experiment 2), it is less likely to be a factor in the hypothetical third-person scenarios used in Experiments 1 and 3. It is possible, however, that children considered their own relations when making decisions in third party scenarios, and thus emotional closeness or quality of relationship with siblings or friends may still have played a role. Future research could measure or manipulate emotional closeness or relatedness as potential mediating factors in children’s sharing behavior in order to further investigate whether the present findings could be influenced by such factors.

Even if children made no clear distinction between kin and friends in the present experiments, it is possible that they distinguish kin from friends in other contexts. Future research using more sensitive measures of a potential in-group kinship preference, such as implicit measures, might reveal such distinctions. In the present experiments, children are asked explicitly whom they think a character will share with or whom they would like to share with.
Adults show a tendency to favor kin in an explicit context as well as a more implicit measure, such as the amount of time they are willing to hold a physically challenging position in order to win money for someone (Madsen et al., 2007). In that case, adults unknowingly hold the position longer for those more closely related to them. A similar study could be conducted with children to see if they put in more effort for kin when they are not as aware of the costs.

These findings raise additional questions for future research. First, is the slow development of understanding of kinship relations a universal feature of human development, or is it specific to children from western, industrialized societies? It is possible that children in traditional societies, in which people live in extended families and emphasize kin relations, come to understand kin relations more precociously. Second, do young children fail to understand any kin relations, or only sibling relations? Children may be able to distinguish their parents from unrelated but highly familiar adults who care for them. However these questions are answered, the present findings shed light on how children are navigating their social worlds and suggest that there is not a sharp, robust in-group boundary that divides kin from non-kin.
Conclusion and Future Directions

Summary of Findings

In their first two years, infants make inferences about likely affiliative partners in caregiving contexts (Paper 1) and themselves prefer to look toward those who might be better, more responsive caregivers (Paper 2). Infants did not make the same inferences in social contexts that either did not involve caregiving—such as peers laughing together—or did not involve a baby soliciting care by crying, demonstrating that certain contexts centered on caregiving may hold relevance to infants in either capturing their attention, soliciting social inferences, or both.

Despite these early inferences which suggest that infants are attuned to caregivers and caregiving networks, experiments testing the explicit knowledge of kinship in children found that a clear distinction between kin-relations like siblings and non-kin relations like friends may not emerge in children in Boston until five-years-old (Paper 3). Furthermore, children did not distribute resources preferentially to siblings over friends, though they tended to allocate more to friends and siblings than to strangers.

Ongoing Research and Future Directions

Testing Infants their First Year

Paper 1 demonstrated that infants can infer relationships between novel pairs of individuals in caregiving contexts, presenting the first evidence that infants make these inferences in affiliative contexts and extending findings that use evidence of between-group harm to infer future disharmonious interactions (Rhodes et al., 2014). Both lines of research tested infants at 15-months and older, but one open question is whether infants make these
inferences at younger ages, especially given that caregivers play such a significant role in infants’ lives from such an early age. In ongoing research, we ran a series of experiments with 11- to 12-month-old infants, testing whether they expect two adults who soothe the same baby to affiliate, and we found inconsistent looking patterns across experiments (Spokes & Spelke, in preparation). We found an effect reversal and no effect in some conditions (e.g., inferring affiliation between two babies soothed by the same adult). These findings suggest that infants may be able to make inferences about likely affiliative partners in caregiving contexts, but it may be challenging at younger ages to track up to five characters and three social relationships to make such inferences. In concordance with that, we found no evidence of the same inferences when testing nine-month-old infants (Spokes & Spelke, in preparation).

The findings from Paper 1 are consistent with a core knowledge domain of social partners that incorporates inputs about caregiving relationships. Infants’ ability to reason about social connections when presented with caregiving events—an adult responding to a crying baby—but not in other social contexts—an adult responding to a laughing adult peer—suggests that with the same information, infants infer social connections only in the caregiving context. Further research could explore how specific this effect is to caregiving for babies or whether infants would also infer social connections if an adult responded to a crying adult. This would further support early reasoning about caregiving in infancy.

The evidence is consistent with infants reasoning about caregiving—how adults respond to baby cries—and not specifically kin. Additional research should explore what the content of infants’ representations of caregiving relationships involves. For example, kin relations are also thought to be a form of communal sharing, where people do not track help and sharing carefully in exchanges, as compared to in reciprocity partners (Fiske, 1992). Would infants thus have
different expectations for caregiving and non-caregiving social relationships, where resources and help are more equitable between non-caregiving and surprising when they are imbalanced—whereas, among communal sharing groups, there might not be the same expectation? Another testable distinction may be the obligation to help: parents are more obligated to care for their children than are unrelated adults. Do infants have these expectations, and would they be more surprised to see a parent refuse their own baby care than an adult unrelated to the child? The experiments presented in this dissertation provide methods and motivation for testing these open and interesting questions and further exploring infants’ inferences about caregiving.

Additional experiment for Paper 2

This dissertation provided evidence for sensitivity to caregiving through experiments with even younger infants, at five-months-old, that suggests they are sensitive to responsiveness in a caregiver (Paper 2). Paper 2 suggests that infants prefer to orient toward a character previously responsive to a baby’s cry rather than avoidant (Experiment 1), but the effect was not extended to adults responding to a baby’s fuss or laugh (Experiment 3). Though consistent with similar findings that 4- and 12-month-old infants do not draw inferences about caregiving that involves a baby’s laughter (Jin et al., 2018), the lack of extension of the effect in Experiment 3 leaves the finding of Experiment 1 without replication. To ensure the looking pattern in Experiment 1 is robust and replicable, we are conducting an additional experiment as a conceptual replication and extension of Experiment 1. We are presenting infants with the same animated stimuli as in Experiment 1 except that the adult characters are different shapes and colors, and only one adult is present during each familiarization event, where the baby cries and the present adult either moves toward or away from the baby. In addition, we added two adult
female or two adult male voices to the pre-familiarization event, with each adult saying, “Hi, there” to provide more evidence that the characters are animate, adults. We predict that once again at test, when only the two adults are present on the screen, infants will prefer to look at the adult who was previously responsive instead of avoidant of the baby’s cry, and this result would strengthen and extend the finding in Experiment 1 that infants prefer an adult who approaches rather than avoids a crying baby.

The results from *Paper 2* suggest that infants are attuned to third-party caregiving contexts and can evaluate the behavior of adults in response to babies. Together with *Paper 1*, these findings suggest that infants may be using caregiving behaviors to trace social connections and networks, and with this information, they infer what might occur in future events. Furthermore, infants themselves direct more attention toward a responsive adult, which could suggest they are tracking responsiveness to themselves form positive alliances with better caregivers. *Paper 2* measured a looking time preference, but additional measures of social interest used in previous research with infants in their first year could be used in future experiments to confirm that longer looking in this case indicates a social preference—e.g., reaching for a toy from someone who are previously a better caregiver (Kinzler et al., 2007; Mehr et al., 2016), or reaching out to choose the better caregiver (Hamlin et al., 2007).

The research presented in this dissertation creates a foundation for additional research that can narrow in on how infants in their first year respond to and reason about caregiving. I prescribe at least three directions of future research: first, testing whether infants make the same inferences about responses to an adult’s cry and baby’s cry (if infants are reasoning about a parent-child relation, then I would predict they do not extend the same inferences to soothing adults); second, testing whether infants expect reciprocal helping and cooperation among non-
caregiving relations but not among caregiving relations to measure whether they have caregiving-specific expectations that align with communal sharing relationships (Fiske, 1992); and third, incorporating additional social measures of infants’ preference for responsive caregivers such as a choice measure to confirm the looking time pattern is a signal of social preference.

Throughout life, identifying and orienting toward adults who are nurturing and helpful is an adaptive ability for all members of our social species, and it may be particularly important for those who are highly dependent on others for survival, like infants. The ability to track others’ social connections to predict their behavior is also advantageous, and the present research suggests that infants begin to develop these abilities at an early age. These abilities are consistent with a core knowledge system of social partners, which may then be useful when infants develop into children and demonstrate more nuanced social decisions consistent with a mature naïve utility calculus and welfare tradeoff psychology.

Gender and Caregiving

In addition to whether an adult is attentive to a baby’s cries, what other inferences do infants make regarding caregiving? Gender, along with generation, is a universal marker in kinship systems (Kemp & Regier, 2012), and gender is be a candidate feature for identifying caregivers because for most people, gender remains stable through an individual’s lifetime. In ongoing research with 14-month-old infants, we tested whether infants infer that a male or female character is more likely to respond to a crying baby, when character gender is presented using adults’ voices (Spokes, Shutts, & Spelke, in preparation).
Infants have demonstrated an early ability to distinguish between male and female images and voices: at three-months-old, infants with female primary caregivers prefer to look at female faces and show better recognition memory for female than male faces (Quinn et al., 2002, 2008). Infants with male caregivers ($N = 6$) preferred to look at male faces (Quinn et al., 2002). By eight- to nine-months-old, infants looked longer to images or videos of women when they heard female voices across several studies using speech, syllables, still and dynamic images, and matching or mismatching audio and visual sentences (Poulin-Dubois et al., 1994; Patterson & Werker, 2002; Hillairet de Boisferron et al., 2015). Thus, infants in their first year are attuned to the gender of faces and voices, and we tested whether infants may expect one gender to be a more likely caregiver.

We hypothesized two potential outcomes: first, infants may expect the gender of their primary caregiver to respond to the crying baby. This would be consistent with previous research showing that infants prefer to look at faces that match their primary caregiver’s gender (Quinn et al., 2002). Alternatively, infants may expect caregivers to be female, potentially for biological reasons such as women possessing breast milk, a primary food source for infants. In this study, we showed infants two animated characters—a male and female—who spoke to reveal their gender. (Note: the male and female voices were matched on friendliness according to ratings by adults ($N = 24$) who viewed the animations and rated eight candidate voices.) Then, when a small shape, “baby,” starts crying, in alternating scenes, they each responded by approaching the baby. We measured how long infants watched the videos to see if they looked longer—i.e., were more surprised—to see one gender comforting the baby. We also collected parent/guardian reports of who their infants spend time with on a regular basis to determine the gender of their primary caregiver.
In a first experiment, we found that infants with female primary caregivers ($N = 16$) looked longer to male caregiving in the first two caregiving events, $t(15) = 2.34, p = 0.017$, and across all four caregiving events, $t(15) = 1.955, p = 0.0347$. One explanation for this result might be that infants with female primary caregivers look longer to events that involve male voices, but we did not find any differences in looking to the familiarization events that involved a male and female speaking, $t(15) = 0.637, p = 0.5332$. Additional experiments testing infants with male primary caregivers or that are co-parented by two different gender caregivers are ongoing and important in distinguishing between two interpretations of these results: first, infants with female primary caregivers may look longer to male caregiving events because of their experiences with a female caregiver, and they generalize their experiences to expectations for third-party interactions they observe. Second, all infants may expect female caregiving because females provide a resource that men cannot provide—breast milk. If infants with male primary caregivers or that are co-parented by two adults of different genders look longer to female caregiving or look equally to both male and female caregiving, the results would favor the former hypothesis. However, if those infants also look longer to male caregiving, this would support the latter explanation. Future research could also measure children’s feeding experiences to see whether experience being breastfed or bottle-fed influences infants’ expectations for the gender of a caregiver, testing the hypothesis that breastfed infants may be more likely to expect female caregiving.

In addition to testing infants with male or co-parented caregiving, we are conducting a second experiment as replication and extension of the first experiment using new male and female voices to determine whether the effect replicates across multiple male-female voice pairs. This experiment would rule out an alternative explanation for Experiment 1, which could explain
the pattern based on infants’ longer looking to some characteristic specific to the one male’s voice they heard relative to the one female’s voice they heard.

If infants in all conditions look longer to male caregiving, an additional explanation to be ruled out is that infants look longer to events involving male voices relative to female voices. Though infants hear both genders say “Hi, there,” and Experiment 1 did not show differences in looking to male versus female speaking in familiarization, an additional experiment that replaces the crying baby with an object that emits a siren or telephone ringing noise could help rule out this explanation, as we would not predict longer looking to either a male or female responding to an object.

These results also contribute to the literature on infants’ understanding of gender by presenting only voices as cues to gender and showing that infants differentiate between the voices and have different expectations for how the animations of adults act based on voices alone.

Finally, given the importance of gender as a primitive marker of kinship systems, infants’ early inferences about gender and different gendered adults’ caregiving behaviors provides further evidence for an intuitive sociology in infants that tracks social information relevant to caregiving. Tracking gender could facilitate infants’ ability to build the social and family networks around them, and gender is a relatively stable, reliable feature across an individual’s lifetime, so it would be candidate feature used for the basis of behavioral inferences—if infants expect females to be caregivers, and caregivers display a variety of behaviors that are important to an infant, then knowing a new individual is female allows infants to predict they will engage in all of those caregiving behaviors. The present experiments are consistent with infants identifying gender and forming at least one expectation from individuals who are female—they
will respond by approaching a crying baby and soothe that baby. Additional research could explore whether infants draw additional caregiving inferences beyond soothing a crying baby: would infants also expect females to provide food to babies, to teach them, etc.? Evidence that these infants draw these inferences across multiple caregiving inferences would help to define what additional behaviors infants see as caregiving.

**Kin Preference in Childhood**

*Paper 3* suggests that three- to five-year-old children do not show a clear kinship preference in giving contexts. However, adults prioritize kin in cases where the personal cost to them is high, such as donating a kidney or risking injury to rescue someone in peril (Rachlin & Jones, 2008; Madsen et al., 2007). Children either do not have this same altruistic behavior toward kin or the experiments did not successfully simulate a situation that requires personal cost from the children. Given a context that does require high personal cost, children may still benefit kin over non-kin. To distinguish between these hypotheses, we asked whether children would show a preference for kin if they had to incur a personal cost themselves—giving their own time and effort (Spokes & Spelke, under review). Children played a challenging geometry game on the computer to earn stickers as rewards that would be delivered to kin—parents or siblings—or non-kin—friends or strangers, and they decided how long to play the game. We measured how many trials they played, how many they answered correctly, and how long they played. We tested 48 4.5- to 5.5-year-old children and found that 4.5-year-olds played more trials and answered more trials correctly for kin over non-kin, suggesting that at that age, they may show a kin preference in a context that requires them to take a personal cost—their own time and effort (Spokes & Spelke, under review). However, 5.5-year-old children did not exert more time or
effort across measures for kin over non-kin, and this may have occurred for a few reasons: first, perhaps the task was easier for 5.5-year-olds, so the personal cost was lower, and they were equally happy to play for any recipient. Second, perhaps the measure was accurate and 5.5-year-olds do not favor kin. This could be because they are at the age where they begin attending school and are encouraged to befriend same-aged non-kin strangers. *Paper 3* found that in at least some third-party helping and resource-sharing contexts, children predict others will benefit their sibling over friend, which would suggest that 5.5-year-old children may favor the first interpretation of their performance here: the task did was not personally costly enough to elicit a kin preference.

Alternatively, children at this age may prescribe helping of kin in third-party contexts but not engage in helping their own kin over their others when the decisions are about their own social connections, because five-year-olds in Experiment 2 of *Paper 3* and the present method both involve first-person decisions about their own friends. Past research on fairness in resource sharing found that three-year-old children said they should share with someone else equally but then when they divided up the resources, they kept more for themselves (Smith, Blake, & Harris, 2013). A similar divide between prescribed and actual actions of children may explain our conflicting results with five-year-old children. Further research could shed light on these interpretations by making the task more difficult and tracking school experience to better understand 5.5-year-old children’s performance in the task.

*Paper 3* presented an interpretation of the findings that children may not see a clear distinction between friends and siblings until they are five-years-old, however, the present experiment suggests that 4.5-year-olds may be making this distinction in calibrating their effort for parents and siblings over friends and strangers. However, these results combined responses
about parents and siblings, and when directly compared, children did not distinguish between sibling and friend, which may be due to a lack of effect or due to limitations of power due to the sample size. Future experiments with a larger sample could test more precisely for distinctions between the relationships being tested.

These results provide initial evidence that 4.5-year-old children calibrated their time and effort in a task differently according to who received the rewards, but 5.5-year-olds did not (Spokes & Spelke, under review). Children may thus favor kin when the stakes are higher and the costs necessary—their own time and effort—are more meaningful to them. This experiment and Paper 3 provide evidence that relatedness can weigh into social decisions: three- to five-year-old children benefitted a sibling over a child they have never met before (Experiments 1, 2), five-year-old children shared and helped siblings more than friends (Experiment 3), and 4.5-year-old children calibrated their effort in a difficult task to benefit parents and siblings over friends and strangers (Spokes & Spelke, under review). These results demonstrate reasoning about third-party interactions (Experiments 1, 3), which is consistent with children integrating social value into their naïve utility calculus as a potential reward for actions that increases the likelihood for an actor to choose that action. For example, when children predicted whether someone would share with their sibling or an unfamiliar child, the cost of sharing that item would be the same, but children reliably expected the person to share with a sibling, which suggests that the utility for that action was higher. I propose that the utility was higher because the reward of benefiting a sibling is higher than the reward for benefiting a stranger.

This interpretation is also consistent with a welfare tradeoff psychology guiding first-person social decisions—as in Experiment 2 and the present experiment—as well as expectations about others’ interactions. Welfare tradeoff psychology suggests children may see friends as
reciprocity partners, likely to pay back their kindness in future interactions, which could explain the results that children also expect division of resources to be equal between a friend and sibling in Experiments 1 and 2 of Paper 3. Further increasing the personal cost of the social decision would help test if children are operating under welfare tradeoff psychology, as adults show different patterns of helping toward siblings and friends as the cost increases: they are more likely to help siblings and less likely to help friends (Stewart-Williams, 2007).

This line of research testing children’s understanding of kinship and behavior toward kin leads to several interesting questions for future exploration: first, would children show the same inferences as infants if shown animated events of caregiving networks? If so, this would support continuity in the inferences about caregiving networks that we saw in infants, which may suggest that inferences about caregiving are either separate from understanding kin or precede explicit kinship understanding measured through verbal questioning. Second, would there be cross-cultural differences in children’s kinship knowledge and reasoning? Indeed, Benson and Anglin (1987) argue that experience drives children’s understanding of kin relations, so other cultures where children live closer to or with extended relatives may show earlier understanding and sharing with those relations. Third, and key to testing whether children consider kin in terms of degrees of relatedness, how do infants and children think about close versus distant kin? Adults benefit those more closely related to them in a task where they held a difficult physical position to earn rewards for others (Madsen et al., 2007). Using the challenging geometry game (Spokes & Spelke, under review) or a similar paradigm that elicits effort from children, would children be sensitive to degree of relatedness and benefit siblings over cousins, parents over aunts and uncles, etc.? Would these effects hold for children who spend more equal time among their distant and close relatives? One concern with testing degrees of relatedness is that children spend
much more time with close kin as compared to distant kin, but testing children who spend more
time with extended family, potentially through testing children across cultures, would help to
control for familiarity and time spent together.

**Theoretical Implications**

The present dissertation explored whether kinship should join the ranks of a social
dimension that is relevant to human infants and children. We found evidence that infants are
sensitive to caregiving relationships and made inferences about social relationships that involve
caregiving (*Paper 1*), and they categorize caregivers based on evidence of their caregiving
abilities—how they respond to a crying baby (*Paper 2*)—and the gender of a caregiver (Spokes
et al., in preparation). Kinship has been relevant to humans throughout our evolutionary history
(Hamilton 1964), and I propose that the evidence presented in this dissertation supports the
theory that caregiving relations and potentially kin relations are relevant and foundational to the
human psychology of social partners. This evidence involves two components: (1) identifying
kin members and relatedness, and (2) this relationship or degree of relatedness shaping behavior
(and consequently, third-party expectations for others’ behavior). For example, in studying
whether infant and children categorize others based on their language and accent, studies found
that infants differentiate between speakers of two different languages, and they also prefer an
individual who shares their own language or accent (Kinzler et al., 2007).

First, is kinship a social dimension that infants and children identify? The present
dissertation did not directly test infants’ and children’s identification of kin versus non-kin
relations, but some of the experiments provide indirect evidence by showing that infants did
identify caregiving relationships. First, infants expected affiliation between individuals who
either both comforted the same baby or babies who were comforted by the same adult, but they
did not make the same inference for interactions involving adult peers (Paper 1). Infants
differentiated between these social contexts in that they made different inferences, and one
possible interpretation is that they see the caregiving scenes as kin-related and the peer scenes as
non-kin. Future research could more directly test whether infants track kin: one possible
experiment might be to habituation infants to images of either all related individuals or all
unrelated, and then show at test new individuals that either are still kin or not to see whether
infants’ look longer when the images cross kin category versus remain within or outside kin
groups. I predict that infants would be successful at identifying kin groups through these
measures, though careful thought and measurement would be necessary to control for familiarity
in such experiments.

The present dissertation also provided indirect evidence that children identify kin by
around four- to five-years-old through explicit questions that define sibling, friend, and stranger
relationships (Paper 3). For example, four- and five-year-olds knew that siblings live in a house
with them, not either a friend or a stranger. For some questions, such as who has the same
grandparents or mom as they do, children at four-years-old were correct when asked whether it
was a sibling versus stranger and were at chance levels when asked the same question between
sibling and friend. Thus, children appear to be able to answer kin-defining questions, though it
may be easier when comparing kin to more distant social connections such as a child they have
never met before instead of a friend.

The second form of evidence that infants and children factor kin and relatedness into their
social decisions about helping and cooperation would be their differential behavior toward others
of different degrees of relatedness. The present dissertation did not test degrees of relatedness,
but started by exploring distinctions between kin versus non-kin and expectations for others to also treat kin differently than non-kin (i.e., kin membership shaping behavior). Again, infants at 15- to 18-months-old made different inferences in caregiving versus non-caregiving contexts (Paper 1), which is consistent with a kin distinction though still needs further evidence to support whether the inferences are about kin or caregiving. Five-month-old infants preferred an adult who responded to rather than avoided a baby’s cry but not necessarily a noisy object or baby’s fuss or laugh (Paper 2). It possible that when an adult responds to a baby’s cry rather than other baby calls, the parent is the individual obligated to care for that infant, which may mean that infants see an adult who responded to a baby’s cry as a caregiver but do not necessarily see an adult who responds to any baby’s noise as a caregiver. This could be further support that infants are interpreting some individuals as caregivers—who are typically kin—versus non-caregivers.

The evidence for how children’s social decision making regarding kin and non-kin was more complicated: children did not always preferentially share with kin over non-kin. Children demonstrated a consistent preference for a sibling over an unfamiliar child: they benefitted a sibling over a stranger when deciding who to share one resource with (Paper 3: Experiments 1-2). In contrast, children less consistently benefitted siblings over friends. In some contexts, they did: five-year-old children expected others to share and help siblings more than friends (Paper 3: Experiment 3), and 4.5-year-old children calibrated their effort in a difficult task to benefit parents and siblings over friends and strangers (Spokes & Spelke, under review). However, children sometimes were split in helping a sibling versus a friend: three- to five-year-olds expected equal sharing when deciding between a sibling and friend (Paper 3, Experiments 1-2), three- and four-year-olds expected equal helping and sharing between a sibling and friend (Paper
3, Experiment 3), and 5.5-year-old children put in equal effort to win stickers for parents, siblings, friends, and strangers (Spokes & Spelke, under review). Taken together, this pattern is consistent with integrating kin into social decisions through a welfare tradeoff psychology or a naïve utility calculus, which both also posit that children integrate other features of the people and environment into their social decisions: social factors like the likely reciprocity of the recipient (i.e., friends may be more likely to benefit children back than their siblings are) and situational factors like the personal cost of the actions. Furthermore, children are encouraged to divide resources equally, and they tend to divide equally when given the chance (Olson & Spelke, 2008; Shaw & Olson, 2013; Fehr, Bernhard, & Rockenbach, 2008; House, Henrich, Brosnan, & Silk, 2012). They also dislike those who do not share equally (Shaw et al., 2012). Thus, the evidence in the present dissertation suggests that siblings only receive favoritism in certain contexts—those that require a higher cost from children or those that friends may be unlikely to reciprocate on. Kin relatedness is relevant to children’s social decisions, but is one of many factors that affects the mental calculations that go into who and when they help—either through a welfare tradeoff psychology or a naïve utility calculus.

Though the nuances of how kinship influences social decisions relative to other individual and situational factors, the present dissertation reviewed evidence that factors characteristic to individuals, like their kin relatedness, do impact social decisions. A social value variable should be incorporated into the reward component of children’s naïve utility calculus to help them better predict others’ intentions based on their actions (Jara-Ettinger et al., 2016). When children were asked the same questions about who they expected a protagonist to share with, they answered differently based on whether the choices were a sibling versus friend, sibling versus stranger, or friend versus stranger (Paper 3), which suggests they do integrate social
relation information into their calculations for resource sharing. Given that the cost in these situations was constant, the more likely change would be that individuals find more reward in benefitting those who have more social value to them. If someone feels more rewarded helping a friend than a stranger, given equal cost, they should help their friend to maximize utility. The naïve utility calculus thus can incorporate kinship, reciprocity value, and other features of welfare tradeoff psychology (Delton & Robertson, 2016) through changes in reward values.

This dissertation presented evidence for implicit and automatic inferences about caregiving in infancy but a slower developing, explicit reasoning and knowledge about kinship by the time children are five-years-old. The inferences made by infants and children also differ in content: caregiving versus kin. Are infants considering the presentations of caregiving as kin-related or is knowledge of kin something separate that emerges through explicit teaching or other changes and development in childhood? One way to begin testing this question is to measure whether children and adults would show the same implicit and automatic inferences that infants do if given similar tests about caregiving relations. We tested infants’ knowledge using more implicit measures because they cannot yet communicate their thoughts as children and adults can, but children may demonstrate the same abilities and patterns of looking if shown similar displays to infants, and we could test how these inferences connect to their more explicit reasoning about kin. If children and adults still possess the same underlying expectations for caregiving interactions and networks, are these processes separate or does explicit reasoning simply build upon an understanding of caregiving and emerge later? A mature explicit verbal reasoning and knowledge may be separate and unnecessary for improving survival and reproduction. Many non-human species engage in tracking kin and conferring benefits on kin without necessarily understanding the biology of blood relations, shared grandparents, etc., or
more complex kin understanding that we are tested in children. Future research could explore the connection between explicit knowledge about kinship and actual behaviors toward caregivers as well as kin and non-kin to see whether explicit reasoning is necessary or even connected at all to intuitions about kin relatedness and how relatedness affects behavior.

**Final Conclusions**

This dissertation explored how infants and children think about caregiving and kinship relations. We found that explicit knowledge in answering defining questions about kin versus non-kin emerges by around five-years-old (*Paper 3*), though implicit understanding and caregiving inferences were present in infancy (*Papers 1 and 2*). We have shown that children’s differentiation between kin and non-kin varied depending on the non-kin relationship being considered: children had clearer distinctions between siblings and strangers than siblings and friends (*Paper 3*). These experiments provide evidence that advance and connect three proposed theories: (1) a candidate core knowledge domain of social partners that incorporates caregiving and kin relatedness, and kinship factoring into children’s social decision making either through (2) a welfare tradeoff psychology and/or (3) as part of the reward component of a naïve utility calculus. The present research is consistent with both welfare tradeoff psychology and naïve utility calculus, and I did not provide evidence necessarily in favor of one, but rather posit that they may be two frameworks capturing the same underlying psychology and offer how kin relatedness would be incorporated into each in development. Finally, the present experiments provide several methods for studying acquisition of caregiving and kinship knowledge in infants, toddlers, and children through experiments on their behaviors and expectations for social interactions.
The human social world is complex, as is the study of it, but the key to human intelligence may be found in better understanding how we navigate, track, and negotiate kin interactions and relationships.
Appendix A

Paper 1 Supplementary Material

Supplementary Videos

Video S1.1: Experiments 1-2, Familiarization events, https://osf.io/bv57q/
Video S1.2: Experiments 1-4, Test events, https://osf.io/86zuf/
Video S1.3: Experiment 3, Familiarization events, https://osf.io/y92hv/
Video S1.4: Experiment 4: Familiarization events, https://osf.io/fu7rv/
Video S1.5: Experiment 5: Familiarization and test events, https://osf.io/4nhq7/
Video S1.6: Experiment 6: Familiarization and test events, https://osf.io/xc2a5/

Supplementary Analysis of Sibling Effects: Experiments 1, 2, 4

In watching comforting events with pseudo-sibling relations (Experiments 1, 2, and 4), infants with or without siblings themselves did not show significant differences in their looking to test events. To test whether infants without siblings show reliable inferences of greater interaction between babies soothed by the same adult, we further analyzed looking time for infants without siblings separately, comparing their looking to test events both across the full test session and in the first test pair. In Experiments 1 and 2 (N = 17), infants without siblings looked longer to affiliation events between babies soothed by different adults as compared to affiliation events between babies soothed by the same adult on the first pair of test trials, t(16) = 2.56, p = .01, d = .62, and did so marginally across the full test session, t(16) = 1.39, p = .09, d = .34 (one-tailed, paired samples t-tests). In Experiments 1, 2, and 4 (N = 23), infants without siblings looked longer to affiliation events between babies soothed by different adults as compared to affiliation events between babies soothed by the same adult, both across the full test session,
Supplementary Analyses of Gender, Test Order, and Shared Character: Experiments 3, 5, 6

In Experiment 3, analyses of overall looking to test events including gender, test event order, and shared character as between-subjects factors revealed a significant shared character by gender interaction, $F(1, 24) = 5, p = .035, \eta^2_p = 0.17$, qualified by a significant shared character by gender by test event interaction, $F(1, 24) = 4.46, p = .045, \eta^2_p = 0.16$. The interaction shows that females looked longer overall at test than males when the central character laughed and was approached by the triangle in familiarization, and males looked longer overall at test when the central character laughed and was approached by the oval in familiarization. The three-way interaction reflects females’ longer looking to unexpected events at test when the triangle approached the central character in familiarization, relative to males who showed the opposite pattern. We have no explanation for these findings.

In Experiment 5, analyses of overall looking to test events including gender, test event order, and shared character as between-subjects factors revealed a significant test event by gender interaction, $F(1, 8) = 24.94, p = .001, \eta^2_p = 0.76$ (both genders looked longer to unexpected test events but males showed a much greater difference), qualified by a significant test event by gender by test order interaction, $F(1, 8) = 9.84, p = .014, \eta^2_p = 0.55$ (females showed a greater difference in looking between test events when seeing the expected event first and males showed the opposite pattern). There was a significant test event by test order by shared character interaction, $F(1, 8) = 26.75, p = .001, \eta^2_p = 0.77$ (infants who saw the central character soothe the diamond in familiarization showed a greater difference in looking at test
when seeing the expected event first, whereas, infants who saw the central character soothe the circle in familiarization showed the opposite pattern). We have no explanation for these findings.

In Experiment 6, analyses of overall looking to test events including gender, test event order, and shared character as between-subjects factors revealed a test event by shared character interaction, $F(1, 8) = 7.64, p = .024, \eta^2_p = 0.49$, showing that infants who saw the central character soothe the circle in familiarization showed a greater difference in looking to test events than infants who saw the central character soothe the square in familiarization—though overall infants looked longer to unexpected test events. There also was a significant but uninterpretable four-way interaction between test event, gender, test event order, and shared character, $F(1, 8) = 9.06, p = .017, \eta^2_p = 0.53$.

**Supplementary Methods**

Animations were created and played in Keynote '09 software and projected onto a 3.5’ x 4.5’ screen. Parents were seated in chair, holding infants in their laps roughly 60 inches from the screen. Parents were instructed to close their eyes for the duration of the experiment and not to direct infants’ attention. Online coder(s), unaware of condition, viewed infants through a video feed from a camera located directly below the screen (also roughly 60 inches from the infant) and continuously coded throughout the experiment when infants were looking toward and away from the screen.

An experimenter, unaware of condition, controlled the animation from within the testing room and initiated recording of looking to familiarization and test trials based on sounds in the animations. Looking time software indicated when the trial finished, and the experimenter could progress to the next trial. Prior to data collection, the coding software was set to the following
parameters: minimum look of 0.5 seconds, maximum of 45 seconds of cumulative looking per trial, and the trial ends when infants looked away for 2 seconds continuously.

Infants were excluded from the sample by an experimenter unaware of condition for parental interference (parent directed infant attention), experimenter error (experimenter advanced animations prematurely or played incorrect stimuli), fussiness (infant was visibly upset and/or parent determines experiment should end before completion). Infants whose summed looking times across three trials showed differences in looking greater than three standard deviations above or below the mean were considered outliers, and no infants were excluded from the sample for this criteria.

For binomial analyses, we categorized infants as looking longer to an event as long as they showed at least 0.5 seconds difference in their looking to the unexpected versus expected events. If the difference in infants’ looking was less than 0.5 seconds, they were counted as having no preference. For analyses of the first test pair, we looked at infants’ looking just to the first two test events. For the analyses of their looking to all three test pairs, we summed infants’ looking to the three expected and unexpected trials and then categorized their looking based on the summed values.
Appendix B

Paper 3 Supplementary Material

Effects of sex on children’s judgements

As Supplementary Table 1 reveals, the primary effects found in Experiment 2 are evident in children of each sex, with one exception: 3-year-old boys showed a strong preference for friend over stranger and for kin over friend but no preference for kin over stranger. Both because this pattern was not obtained in Experiments 1 or 3, and because it violates transitivity, the three-way interaction effect likely is spurious.

Supplementary Table 3.1: Further analysis of the three-way interaction between age, sex, and recipient pair for Experiment 2

Supplementary Table 3.1. Children’s sharing choices by age and sex.

<table>
<thead>
<tr>
<th></th>
<th>3-year-olds</th>
<th></th>
<th>4-year-olds</th>
<th></th>
<th>5-year-olds</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Kin vs. Stranger</td>
<td>Kin*</td>
<td>ns</td>
<td>Kin**</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>M = .78</td>
<td>M = .56</td>
<td>M = .83</td>
<td>M = .83</td>
<td>M = .61</td>
<td>M = .72</td>
</tr>
<tr>
<td></td>
<td>p = .014</td>
<td>p = .65</td>
<td>p = .002</td>
<td>p = .002</td>
<td>p = .36</td>
<td>p = .057</td>
</tr>
<tr>
<td>Friend vs. Stranger</td>
<td>Friend**</td>
<td>ns</td>
<td>Friend***</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>M = .83</td>
<td>M = .83</td>
<td>M = .67</td>
<td>M = .89</td>
<td>M = .72</td>
<td>M = .50</td>
</tr>
<tr>
<td></td>
<td>p = .002</td>
<td>p = .002</td>
<td>p = .16</td>
<td>p &lt; .001</td>
<td>p = .057</td>
<td>p = 1.0</td>
</tr>
<tr>
<td>Kin vs. Friend</td>
<td>ns</td>
<td>Kin*</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>M = .44</td>
<td>M = .56</td>
<td>M = .56</td>
<td>M = .39</td>
<td>M = .61</td>
<td>M = .56</td>
</tr>
<tr>
<td></td>
<td>p = .65</td>
<td>p = .014</td>
<td>p = .65</td>
<td>p = .36</td>
<td>p = .36</td>
<td>p = .65</td>
</tr>
</tbody>
</table>

Supplementary Table 3.2. Children’s sharing choices in Experiment 2 (N = 108), where children allocated a resource to one character in each dyad, separated by age and sex. To look deeper into the significant recipient pair by age by sex interaction, F(4, 204) = 3.82, p = .005, η² = .07, we further analyzed children’s choices in each age group for each sex using two-tailed one-sample t-tests to test whether children’s responses were significantly above chance performance of .5. Children’s answers were again coded as a 0 or 1, with a 1 for choosing to share with the predicted character: sibling rather than stranger, friend rather than stranger, and sibling rather than friend. For each cell, N = 18 (*P < 0.05; **P < 0.01; ***P < 0.001).
Experiment 3 Sample Kin vs. Friend Vignettes

Sample Kin vs. Friend Vignette 1 (Helping)

This is Peter. Here is another boy that Peter knows. His name is Timmy. Peter and Timmy have a lot in common. They both go to the same school. Peter and Timmy are friends.

Here is another boy that Peter knows. His name is Charlie. Peter and Charlie have a lot in common. Peter and Charlie both live in the same house. Peter and Charlie are brothers.

One day at school, Timmy is working on a dinosaur puzzle and Charlie is working on a train puzzle. Peter likes dinosaurs and trains. Who do you think Peter will help with their puzzle – Timmy or Charlie?

Sample Kin vs. Friend Vignette 2 (Helping)

Do you remember Peter? Peter and Charlie both live in the same house. They are brothers. Peter and Timmy both go to the same school. They are friends.

Charlie and Timmy sometimes have trouble with their math homework. Peter is really good at math. Peter can stay inside and help one of them with their math homework, but then he will miss recess. Who do you think Peter will help with his math homework – Charlie or Timmy?

Sample Kin vs., Friend Vignette 3 (Sharing)
This is Sophie. Here is another girl that Sophie knows. Her name is Megan. Sophie and Megan have a lot in common. They both have the same mom. They both have the same dad. Sophie and Megan are sisters.

Here is another girl that Sophie knows. Her name is Erin. Sophie and Erin have a lot in common. They both have the same teacher. They have the same soccer coach. Sophie and Erin are friends.

There was one morning when Megan and Erin both want to borrow Sophie’s bicycle to ride to school. If Sophie lets them borrow it, she will have to walk to school, and it will take a long time. Who do you think Sophie would let ride her bicycle – Megan or Erin?

*Sample Kin vs. Friend Vignette 4 (Sharing)*

Do you remember Sophie? Sophie and Erin have the same teacher and the same soccer coach. They are friends. Sophie and Megan have the same mom and dad. They are sisters.

At lunch one day, Sophie has extra cookies in her lunch that she is not going to eat. Who do you think Sophie would give a cookie to – Erin or Megan?

*Additional Questions from Experiment 3: Kin vs. Stranger/Neighbor*

Experiment 3 looked further into 3-, 4-, and 5-year-old children's expectations for social interactions across multiple contexts to see whether their preferences from the first-person scenarios of Experiment 2 would replicate or differ when they are given enhanced cues to kinship and are presented with a wider range of social scenarios.
In addition to testing children on kin versus friend scenarios, they were all tested on four additional scenarios comparing two other potential social partners. Five-year-olds were tested on kin versus stranger, due to their less robust social preferences when comparing relations to strangers in Experiment 2. Three- and 4-year-old children were tested on kin versus neighbor. Children at this age consistently expect and chose to share with friends or siblings rather than strangers but do not favor siblings over friends (Experiments 1 and 2; Olson & Spelke, 2008). Previous studies have not addressed whether these distinctions reflect some positive understanding of kinship and friendship (namely, that each of these relationships makes the participants likely to engage in prosocial behavior toward one another) or only a negative understanding of strangers (for example, that strangers are potentially dangerous and should not be followed or spoken to under some circumstances). With an aim of examining kinship rather than stranger avoidance, instead of contrasting siblings to strangers, we contrast siblings to neighbors: children who may be familiar, or if still unfamiliar, associated with broad social groups due to their proximity, but who are not described either as family or as friends.

**Materials and Methods**

**Participants**

Participants were the same 48 children who participated in Experiment 3.

**Materials & Procedure**

In addition to the trials described in Experiment 3, children also answered four questions about another dyad: sibling versus stranger (5-year-olds) or sibling versus neighbor (3- and 4-year-olds). The stranger was described as a child they had never met before. The neighbor was described as a child who lived nearby. Children were asked questions about four social scenarios and asked with whom they thought the central character might choose to interact with in contexts
relating to cooperation and protection. The materials and procedure were otherwise the same as Experiment 3, and the four questions were presented in two blocks of two, with each block coming after questions from Experiment 3. The four sibling versus neighbor/stranger vignettes were also presented in one of four counterbalanced orders. Sample vignettes are included below.

Results

Children’s choices on each trial were coded, with a choice of sibling being coded as 1 and stranger/neighbor as 0. The 3 (age group) by 4 (question) repeated-measures ANOVA on children’s selections did not reveal any main effects or interactions (all $p$s $> 0.05$).

Each age range was then analyzed for an overall preference for sibling over either neighbor or stranger. Children’s four choices (1 for sibling, 0 for neighbor/stranger) were averaged and then analyzed using a two-tailed, one-sample $t$-test with chance performance set to 0.5. Three-year-olds did not expect preference to go to kin over neighbor ($M = 0.47, SD = 0.27$), $t(15) = -0.46, p = 0.65$. Four-year-olds also did not expect preference to go to kin over neighbor ($M = 0.5, SD = 0.27$), $t(15) = 0, p = 1$. Five-year-olds did expect preference to go to kin over stranger ($M = 0.66, SD = 0.27$), $t(15) = 2.30, p = 0.036$.

Discussion

As expected, given the findings of Experiment 2, 5-year-old children expected other children to prefer a sibling to a stranger. Despite increasing the salience of sibling relations using facial morphology, 3- and 4-year-old children did not expect preference toward siblings over neighbors. Children did not give different responses across social scenarios.

Given that children at this age expect preference to a sibling over a stranger, this study suggests that children's differentiation between siblings or friends and strangers in Experiments 1 and 2 may have more to do with their understanding of strangers than with their understanding of
kinship or friendship. Alternatively, they may understand distinctions among these relations but not have robust sharing preferences among them.

**Sample Kin vs. Neighbor/Stranger Vignettes**

**Sample Kin vs. Neighbor/Stranger Vignette 1 (Protection)**

This is Jessica. Here is another girl that Jessica knows. Her name is Molly. Jessica and Molly have a lot in common. A lot of people say that they have the exact same hairstyle. Jessica and Molly are neighbors.

Here is another girl Jessica knows. Her name is Katie. Jessica and Katie have a lot in common. A lot of people say that they have the exact same laugh. Jessica and Katie are sisters.

At recess one day, some older kids started bullying Molly and Katie at different parts of the playground. Jessica wants to go protect one of them from the bullies. Who do you think Jessica would go and protect – Molly or Katie?

**Sample Kin vs. Neighbor/Stranger Vignette 2 (Protection)**

Do you remember Jessica? A lot of people say that Jessica and Katie have the exact same laugh. They are sisters. A lot of people say that Jessica and Molly have the exact same hairstyle. They are neighbors.

One day after school, Jessica is waiting for the bus, and it is really cold outside. Katie and Molly are waiting too, but they forgot to wear jackets that day. Who do you think Jessica would share her coat with – Katie or Molly?
**Sample Kin vs. Neighbor/Stranger Vignette 3 (Cooperation)**

This is Ben. Here is another boy that Ben knows. His name is Andrew. Ben and Andrew have a lot in common. They both have the same pet dog. Ben and Andrew are brothers.

Here is another boy that Ben knows. His name is David. Ben and David have a lot in common. They both have the same toy cars. Ben and David are neighbors.

At recess one day, Ben wants to play on the swing-set. Ben needs a partner to push him while he swings, and he will push them on their turn on the swings too. Who do you think Ben would like to play on the swings with – Andrew or David?

**Sample Kin vs. Neighbor/Stranger Vignette 4 (Cooperation)**

Do you remember Ben? Ben and David both have the same toy cars. They are neighbors. Ben and Andrew both have the same pet dog. They are brothers.

Every year, Ben’s school has a field day with lots of fun games, and Ben needs a partner for this year’s field day. The team that wins the most games wins a big prize and gets to go to an amusement park. Ben really wants to win the prize this year. Who do you think Ben would choose for his partner – David or Andrew?
References


169


Smith, C. E., Blake, P. R., & Harris, P. L. (2013). I should but I won’t: Why young children endorse norm of fair sharing but do not follow them. *PLoS One, 8*(3), e59510. doi: 10.1371/journal.pone.0059510


Spokes, A. C., Shutts, K., & Spelke, E. S. (in preparation). Infants take gender into account in predictions of who is a likely caregiver.


Spokes, A. C., & Spelke, E. S. (in preparation). Expectations about caregiving and affiliation networks in the first year of life.

Spokes, A. C., & Spelke, E. S. (under review). At 4.5 but not 5.5 years, children favor kin when the stakes are moderately high.

Spokes, A. C., Venkatesan, T., & Spelke, E. S. (in preparation). Five-month-old infants prefer those who are responsive to baby cries.


173