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Authors

Liberman, Zoe
Kinzler, Katherine D
Woodward, Amanda L

Publication Date

2018-02-01

DOI

10.1016/j.cognition.2017.10.018

Peer reviewed

HHS Public Access

Author manuscript

Cognition. Author manuscript; available in PMC 2019 February 01.

Published in final edited form as:

Cognition. 2018 February ; 171: 42–51. doi:10.1016/j.cognition.2017.10.018.

The early social significance of shared ritual actions

Zoe Liberman[1], **Katherine D. Kinzler**[2], and **Amanda L. Woodward**[3]

[1]Department of Psychological & Brain Sciences, University of California Santa Barbara

[2]Department of Psychology, Cornell University

[3]Department of Psychology, University of Chicago

Abstract

Many rituals are socially stipulated such that engaging in a group's rituals can fundamentally signal membership in that group. Here, we asked whether infants infer information about people's social affiliation based on whether those people perform the same ritualistic action versus different actions. We presented 16-month-old infants with two people who used the same object to achieve the same goal: turning on a light. In a first study, the actions that the actors used to turn on the light had key properties of ritual: they were not causally necessary to reach the overall goal, and there were no features of the situation that required doing the particular actions. We varied whether the two actors performed the same action or performed different actions to turn on the light. Infants expected people who used the same ritualistic action to be more likely to affiliate than people who used different actions. A second study indicated that these results were not due to perceptual similarity: when the differences in the actors' actions were not marked by properties of ritual, but were instead due to situational constraints, infants expected the actors to affiliate. Thus, infants understand the social significance of people engaging in common, potentially ritualistic actions, and expect these actions to provide information about third-party social relationships.

Keywords

cultural learning; social cognition; infant; imitation; ritual

1. Introduction

Rituals have inherently social functions. In particular, many ritualistic actions derive their meaning based on the *conventionality* of ritual, rather than on the outcome of the action. Therefore, engaging in a group's ritual can signal membership in and demonstrate commitment to that group, increase group cohesion, promote bonds among group members,

Corresponding Author: Zoe Liberman, University of California Santa Barbara, Department of Psychological & Brain Sciences, Building 251, zoe.liberman@psych.ucsb.edu, phone: 805-893-5498.

Supplementary Material

Data: https://osf.io/fegp9/

and even create shared beliefs (e.g., Atkinson & Whitehouse, 2011; Cosmides & Tooby, 2013; Heinrich, 2009; Hobson, Gino, Norton, & Inzlicht, 2017; Humphrey & Laidlaw, 1994; Whitehouse & Lanman, 2014; Wen, Herrmann & Legare, 2016). Although ritual actions are socially stipulated, they tend to be complex and share a few critical features that differentiate them from other (instrumental) actions. Rituals may be (1) causally opaque, meaning it is not clear how the particular actions lead to the desired final outcome (e.g., Legare & Souza, 2012), (2) causally irrelevant, meaning that the actions are unnecessary from a physical causality standpoint for completing the goal (e.g., Herrmann, Legare, Harris, & Whitehouse, 2013), and (3) goal demoted, meaning that someone's goals or motivations behind completing a particular component of an action sequence are not transparent to the observer (e.g., Boyer & Lienard, 2006; Kapitány & Nielsen, 2017; Schjoedt et al., 2013).

Many of the most well known rituals from ancient to modern times are causally opaque: although the rituals have intended effects people cannot report the causal mechanism by which these outcomes would occur, and people typically do not expect to ever understand the mechanism (Legare & Whitehouse, 2011). For example, even when the majority of people in a culture report that engaging in a specific dance will cause rain and help crop production, or that reciting a particular incantation will heal someone who is sick, they likely cannot provide a causal argument for *why* the behavior works, or for *which features* (e.g., timing, location, repetition) are causally necessary to produce the intended outcome. In fact, rituals that are associated with a religious icon or superhuman agent are reported as more effective (Legare & Souza, 2012), further suggesting that people are not using basic physical causal principles to reason about how rituals work. Initial research on humans' understanding of ritual focused on causal opacity: when it is not clear which actions are needed to reach a goal, children imitate all actions with high fidelity (e.g., Horner & Whiten, 2005), and this tendency to overimitate even increases with age (McGuigan, Makinson, & Whiten, 2011).

However, causal opacity is not the whole story. Early in ontogeny, children also understand that even though all steps of a ritual are essential for completing the overall goal, any individual step (1) might not be necessary from a physical causality standpoint (causal irrelevance) and (2) might not have a clearly observable motivation (goal-demotion). Indeed, actions with these two ritualistic properties are imitated more closely than instrumental actions. For example, children copy parts of ritualistic actions they know are unnecessary even when they have an easier way of completing the overall goal (Lyons, Young & Keil, 2007; Lyons, Damrosch, Lin, Macris, & Keil, 2011; Nielsen, 2012), and infants imitate novel actions with higher fidelity when the model's novel action is not clearly motivated by an external constraint (e.g., infants are more likely to imitate a model's head-touch action to turn on a light when the model intentionally chose to use her head but could have used her hands than when the head-touch was motivated by a situational constraint, such as the model's hands being occupied in another task: Meltzoff, 1998; Gergely, Bekkering, & Kiraly, 2002). Increased imitation of ritualistic actions may happen *because* there is no obvious external motivation for completing the action in the particular way: goal-demotion highlights that the ritual is likely performed in its entirety for a reason, even if the motivation behind each specific sub-component of an action is unknown to the observer.

Although the majority of research on early understanding of ritual has focused on imitation, knowing whether or when children imitate rituals does not reveal whether they understand that rituals carry *social significance*, such as marking people as members of a social group. Children's imitation of rituals might be based solely on a desire to learn the ritual itself or to create the desired outcome: rituals do not adhere to rules of physical causality and therefore must be learned through imitation, not through innovation or trial-and-error (Legare & Nielsen, 2015; Nielsen, 2012). Indeed children are more likely to imitate the same ritualistic actions when the actions are presented as group conventions (e.g. "this is how we do it") rather than as instrumental goals (e.g., "this is how to make a necklace"; Clegg & Legare, 2016; 2017; Herrmann, et al., 2013; Legare, Wen, Herrmann, & Whitehouse, 2015, Watson-Jones & Legare, 2015), and infants and children selectively attend to and imitate the actions of ingroup over outgroup members (e.g., Buttelmann Zmyj Daum, & Carpenter, 2013; Kinzler, Dupoux, & Spelke, 2007; Kinzler, Corriveau, & Harris, 2011; Shutts, Kinzler, McKee, & Spelke, 2009; van Schaik & Hunnius, 2016), which may serve as an effective strategy to learn from the most relevant social partners (e.g., Begus, Glia, & Southgate, 2016; Kinzler & Liberman, 2017; Xiao et al., 2017). In fact, when an action is highlighted as conventional, children imitate unsuccessful actions of a group over successful actions of an individual (Wilks, Kapitány, & Nielsen, 2016), suggesting they may prioritize learning "how we do it." Thus, although the tendency to imitate likely enhances learning, it does not necessarily indicate an abstract understanding that the groups' ritualistic actions in and of themselves carry social significance or that completing those actions can signal membership in that social group.

Studies of third-party expectations about rituals with children provide clearer evidence of whether people have an abstract understanding that knowing or completing a group's ritual can serve as a signal of social group membership. Preschool-aged children enforce the use of ritualistic behaviors on third-parties (e.g., Kenward, 2012; Kenward, Karlsson, & Persson, 2011), and they protest when third-parties refrain from engaging in these normative actions (e.g., Keupp, Behne, & Rakoczy, 2013), particularly when the defector is a member of the ingroup (e.g., Schmidt, Rakoczy & Tomasello, 2012). Therefore, children seem to infer that people, specifically people in the same social group, *should* engage in shared ritualistic actions. Thus, children are not merely learning *how* to do the actions themselves, but they also have expectations about the social significance of performing the actions. Indeed, five-year-old children understand that imitation can be used to infer social relationships: they expect people who imitate each other's actions to be friends (Over & Carpenter, 2015).

In the present research, we ask whether infants understand the social significance of people's engagement in the same action. Specifically, we investigate whether infants infer that engaging in the same potentially ritualistic action (rather than engaging in different ritualistic actions) is a signal of an affiliative social relationship. On one hand, infants may imitate ritualistic actions because they want to learn the actions, or because they want to achieve the desired outcome of performing those actions. Indeed, parents provide explicit instruction to infants and young children about how to imitate rituals: They are more likely to scaffold children's imitation of conventional (ritualistic) than of instrumental actions by monitoring their children's actions and providing more explicit instruction (Clegg & Legare, 2017). Early social interactions that highlight the norm of following ritualistic actions with

high fidelity may provide an opportunity for young children to learn that they should imitate these actions, and that the actions carry social significance. That is, in this case, infants may not initially understand that engaging in ritualistic actions of a group provides a signal of membership in that group, but rather first imitate for learning's sake and later learn the social implications of ritual actions through becoming integrated into the group.

Alternatively, children may already have a nascent understanding of the social function of ritual actions, prior to any explicit instruction about how rituals mark group membership. Recent violation of expectation looking time studies provide evidence that infants have a burgeoning knowledge of social structure: they infer that members of a social group will approach the same goal object (e.g., Powell, & Spelke, 2013), and expect people who share socially relevant similarities will affiliate (e.g., Liberman, Kinzler, & Woodward, 2014; Liberman, Woodward, & Kinzler, 2017a; 2017b Liberman, Woodward, Sullivan, & Kinzler, 2016). Thus, infants may make abstract inferences about the social significance of engaging in common ritual actions. We chose to investigate infants' responses to actions where a model used her head (or elbow) to turn on a light (e.g., Gergely et al., 2002). Because specific components of these actions (e.g., using one's head rather than one's hand) are not necessary in order to complete the goal, and yet the actors clearly perform those components intentionally, infants may infer that there is a socially meaningful motivation or reason for the actor to complete the goal in that particular way. That is, two people who intentionally do the same novel action might be engaged in the same ritual (even if it is unclear what the function of their action is), and therefore may be more likely to affiliate.

2. Study 1

In an initial study, infants saw videos of two actors interacting with the same object in order to reach the same overall goal of turning on a light. Each of the actors used one of two actions: she either activated the light by pressing it with her forehead or by pressing it with her elbow. Both of the actions used to turn on the light are causally-irrelevant (in that the light could be turned on with a conventional action, such as pushing with a hand, and therefore using either of these body parts is causally unnecessary) and goal-demoted (there was no clear reason or situational constraint that would have lead the actors to use these irrelevant actions to reach their goal, and, because the room was already lit, there was no clear motivation for why the light should be on (or off) in the first place). The actions also had another component of ritual: Start- and end-state equivalency (see Legare et al., 2015): Because the actors each turn the light on and then off, the start state of the light (off) matched the end state of the light (off), suggesting the action is conventionally rather than instrumentally motivated. Infants were randomly assigned to the Same Actions condition (where actors both used the same action: either turning the light on with their forehead, or their elbow), or the Different Actions condition (where each actor used a different action). In test trials, we measured infants' attention to the actors affiliating and socially disengaging. Because infants tend to look longer at events they find unexpected (e.g., Hespos & Baillargeon, 2008), we used infants' attention to these social interactions to determine whether infants expected people who performed the same action to be more likely to affiliate.

2.1 Methods

2.1.1 Participants—32 sixteen-month-olds (16 female; M_{age} = 16;15, range = 15;19 to 17;19) participated. No additional infants were tested but excluded. Half of the infants (n=16) were randomly assigned to the Same Action condition, and half (n=16) were randomly assigned to the Different Actions condition. According to parental report, participants came from the following racial backgrounds: 44% White, 25% Black, 3% Asian, and 28% Multiracial.

2.1.2 Procedure—Infants were seated on a parent's lap at a small table in front of a large screen. Videos were projected onto the screen and featured life-sized actors interacting with a push-light toy and with each other (Figure 1). The push-light toy was made by attaching a cylinder light (which turned on when pressed) to a translucent green box. In order to make the toy appear interesting, it was decorated with colorful star stickers and rope. Additionally, the toy had bells inside of the translucent box so that it made noise when it was moved, which we reasoned might help infants attend to the box during the videos when the actors were moving it rather than speaking.

During familiarization, the actors sat at a table with the light between them and took turns turning it on and off. Each familiarization movie involved both actors acting on the light. The sequence of events went as follows: the first actor reached for the light and moved it from the center of the table, to directly in front of her. She turned on the light (e.g., using an elbow press), and said, "Oh!." Then, the same actor used the action again (e.g., an elbow press) to turn the light off. Finally, she moved the light back to its starting position centered on the table for the second actor. In the same movie the second actor repeated these steps: she brought the light towards her, turned it on, turned it off, and placed it back in the center of the table. The actor who was not interacting with the light watched the other actor perform her series of actions. What differed between the conditions was how the actors turned the light on and off. Infants in the Same Action condition saw both actors use the same ritualistic action to turn on the light: either both actors turned it on with their heads, or both actors turned it on with their elbows (See Video S1). Infants in the Different Action condition saw one actor turn on the light with her head, and the other turn on the light with her elbow (See Video S2). The order of actors presented and the order of their actions (head versus elbow first) were counterbalanced across subjects. The familiarization movie repeated four times.

All infants then saw the same six test trials where the actors alternated between affiliating and socially disengaging (see Liberman, Kinzler, & Woodward, 2014; Liberman, Woodward, & Kinzler, 2017 for a similar method). In affiliation trials, the actors stood next to one another on the screen, turned toward each other, smiled and waved while saying "Hi!" in high-pitched voices. In disengagement trials, the actors stood next to one another on the screen, turned away from each other, frowned and crossed their arms while saying "Hmp!" in low-pitched voices (Figure 1; Videos S3 and S4). Looking time was coded by trained observers using jHab (Casstevens, 2007). Each trial was coded starting when the movement on the screen ended, and ending when the infant looked away for two consecutive seconds or when 30 seconds had elapsed. One observer coded online during the study, and a second,

independent, observer coded a video of each infant after the study. Observers were unaware of the participant's assigned condition and were only able to see the infant's face, not the video stimuli. For reliability we measured whether the observers agreed about the endpoint of the trial; coders agreed on 92% of test trials. The live and reliability coders' looking times were highly correlated (r=.95). All data presented is done using the data from the original live coder. If infants' expectations about the actors' social relationship vary based on whether the actors used the same or different ritualistic action, then we would expect infants to show different patterns of attention to the test trials based on their assigned condition.

As a secondary question we were also interested in infants' own actions, and whether their likelihood of imitating the novel actions varied based on whether they saw people engage in the same or different actions. So, infants were also given time before watching the videos (initial exploration phase) and after watching the videos (final exploration phase) in which they could explore the push light themselves. In each of these exploration phases, an experimenter brought out the push light, placed it in front of the infant on the table and said, "Look! Here is a new toy! You can play with it however you like." After the instruction, the infant was given 30 seconds to play with the toy. Parents were told not to interfere and not to instruct their children on how to play with the toy. Thus, children explored on their own, unless they dropped the toy, in which case the experimenter picked it up and placed it back on the table. Phases where infants played freely with the toy (initial exploration phase and final exploration phase) were later coded from video for the amount of time spent playing with the light, whether the infant turned on (or clearly attempted to turn on) the light, and the method(s) that each infant used to turn on the light.

2.2. Results

2.2.1 Looking time measures—We first evaluated our primary hypothesis that infants' attention to test trials, a measure of their expectation of the actors' likely social relationship, would vary based on whether the actors had performed the same or different actions during familiarization. Preliminary analyses revealed no effects of sex or test trial order on test trial looking times, so analyses collapsed across these factors. A repeated measures ANOVA on infants' test trial looking times with condition (Same vs. Different Actions) as a between subjects factor and test trial pair number (1st, 2nd, or 3rd) and test trial type (Affiliation vs. Disengagement) as within subjects factors revealed a main effect of test trial pair ($F_{2,29}$=10.80, p=.003; partial eta squared =0.265), reflecting decreasing attention across the session, a significant test trial type by test trial pair interaction ($F_{2,29}$=12.29, p<.001; partial eta squared =0.291), and importantly, the predicted significant test trial type by condition interaction ($F_{1,30}$=13.32, p<.001; partial eta squared =0.307). This interaction suggests the pattern of looking to each test trial type was different based on whether the actors had used the same action or different actions during familiarization. In particular, infants in the Different Actions Condition looked longer at Affiliation (M=9.4 seconds) than Disengagement trials (M=7.0 seconds; Figure 2), suggesting they found it less expected for the actors to affiliate after using different actions. Indeed, this difference was significant parametrically ($F_{1,15}$=22.25, p<.001 partial eta squared =0.597), and non-parametrically (n=15 of 16 infants looked longer at affiliation trials, binomial p<.001, two-tailed). On the other hand, infants in the Same Action Condition did not show this response, and if

anything, looked slightly longer on Disengagement (M=10.6 seconds) than Affiliation trials (M=9.7 seconds; Figure 2). This difference was not significant parametrically ($F_{1,15}$=1.83, p=.196 partial eta squared =0.109), but a greater number of infants looked longer at disengagement trials (n=13 of 16, binomial p=.021, two-tailed), suggesting infants may find it unexpected for actors who engage in the same ritualistic action to socially disengage. The pattern of non-parametric results was significantly different between the Different Actions and Same Actions conditions (Fisher's exact test p<.001). No other main effects or interactions in the overall ANOVA reached significance (ps>.20). Importantly, these effects were not due to differences in attention during familiarization: attention was high throughout the familiarization trials (infants attended to 98% of each familiarization trial on average), and a repeated-measures ANOVA on familiarization looking times[1] with condition (same vs. different actions) as a between subjects variable and trial number (1st, 2nd, 3rd, 4th) as a within subjects factor revealed no significant effect of condition ($F_{1,25}$=0.76, p=.392 partial eta squared =0.029), or trial number ($F_{3,75}$=2.47, p=.069 partial eta squared =0.090), and no significant interaction between the two factors ($F_{3,75}$=1.68, p=.179 partial eta squared =0.063).

2.2.2. Infants' exploration of the push-light—Infants' exploration of the light did not differ based on the condition that the infants were assigned to. Specifically, both before and after the looking time portion of the study a similar number of infants from each condition turned on the light (Same Action: n=6 of 16 during initial exploration, n =10 of 16 during final exploration; Different Actions: n =5 of 16 during initial exploration, n =6 of 16 during final exploration; Fisher's exact tests all ps>.28). Infants also spent similar amounts of time interacting with the light in each condition (Same Action: M=11.7 seconds during initial exploration, M=14.1 seconds during final exploration; Different Actions: M=11.1 seconds during initial exploration, M=12.6 seconds during final exploration). Turning on the light using a method other than a hand touch was rare: no infants turned on the light using a body part other than their hand during initial exploration, and during the final exploration phase 3 infants in the Same Action condition and one infant in the Different Action condition turned on the light using their head, which was not significantly different (Fisher's exact test p=.600). There are a few possible reasons why infants' imitation was so low: (1) the models were presented on video, which may have lead to a video deficit effect (e.g., Anderson & Pempek, 2005; Barr & Hayne, 1999), (2) the toy had multiple affordances (e.g., bells that rang when the toy was shaken), which could have led infants to explore the toy in multiple ways, making it less interesting to focus on turning on the light, and (3) we included a baseline period (the initial exploration phase), which gave infants an opportunity to learn that the toy can be activated without using the novel action, and has been shown to lead to lower levels of imitation (e.g., Pinkham & Jaswal, 2011).

2.3 Discussion

Infants made different inferences about the actors' likely relationship based on how the actors interacted with the light. When the actors intentionally used different actions, infants

[1]Looking to familiarization trials could not be coded for 5 infants based on an error with the picture-in-picture video, which was necessary for determining the start of the trials.

looked significantly longer at subsequent affiliation, suggesting they found affiliation unexpected. On the other hand, infants who saw the actors use the same action did not show this pattern of results: if anything looked longer at disengagement events. Although we predicted that infants who saw the actors engage in the same ritualistic action would potentially look significantly longer at disengagement events, their overall looking times did not differ parametrically from chance. In line with past data (e.g., Liberman, Woodward & Kinzler, 2017), it may be more difficult to find effects that require infants to look less at affiliative events, since these events are positive and therefore may be particularly visually or socially engaging. However, the fact that the patterns of looking differed significantly between the conditions (both parametrically, as reveled by the condition by test trial types interaction in the ANOVA, and non-parametrically, as revealed by the Fisher's exact test), indicates that infants' expectations about social relationships vary based on whether the actors engage in the same versus different ritualistic actions: infants are *more likely* to expect affiliation between people who use the same causally-irrelevant actions than between people who use different causally-irrelevant actions. These results suggest that infants may understand the social significance of engaging in the same versus different rituals.

However, it is also possible that the results of this study were due to lower level perceptual differences between the Same Actions condition and Different Actions condition. Specifically, the actors in the Same Action condition performed perceptually identical actions, whereas actors in the Different Action condition did distinct actions. Infants may merely find affiliation unexpected between actors who do perceptually different actions, regardless of whether those different actions imply anything significant about rituals. To ask whether infants' expectations were based on perceptual similarity or on seeing the actions as potentially ritualistic and socially significant, we created new stimuli. In Study 2, all infants saw the actors engage in perceptually distinct actions, but the perceptual differences were portrayed as either intentional (and perhaps marking different rituals) or as due to a situational constraint (and therefore unrelated to rituals). Specifically, all infants saw one actor turn on the light using her head, and the other turn on the light using her hand. The conditions differed only in terms of whether the actor who used her head did so (1) intentionally, when she could have easily used her hand (No Blanket Condition) or (2) because she faced a situational constraint (she was holding a blanket, making her hands were inaccessible: Blanket condition).

In No Blanket condition, the head-touch action retains ritualistic properties (as in Study 1): the action is causally-irrelevant as the actor could have easily used her hand to turn on the light, but chose not to, and the action is goal-demoted because there was no obvious motivation behind her choice to turn the light on and off with her head. Therefore, in the No Blanket condition, although both actors cause the same outcome, they may seem to have different motivations: the actor who uses her hand wants to turn on the light, and the actor who uses her head is motivated not only to turn on the light, but to turn it on in a specific (ritualistic) way. Although it is unknown why exactly she turns it on with her head, it is clear that the head-touch part of the action is meaningful and intended. In the Blanket condition the same head touch action does not have same ritualistic properties: the actor uses her head *because* she cannot use her hands, making the motivation for her action clear. Thus, in the Blanket condition, both actors have the same goal-oriented motivation: they want to turn on

the light. The perceptual differences in how they do so are merely based on constraints, not on differences in underlying goals or motivations. If infants are merely sensitive to whether the actors' actions are perceptually similar or dissimilar, then they might find affiliation between actors unexpected in both the Blanket and No Blanket conditions. Alternatively, if infants' inferences are based on reasoning about the social significance of ritual, they may only find affiliation unexpected in the No Blanket condition (when the perceptual difference is also a potential signal of differential ritual engagement), but not in in the Blanket condition (when the perceptually difference is due to each actor merely activating the light by the means she has available).

3. Study 2

3.1 Method

3.1.1 Participants—32 sixteen-month-olds (17 female; M_{age} = 16;16, range = 15;18 to 17;19) participated. Two additional infants were tested but excluded due to inattention (n=1) and experimenter error (n=1). Infants were randomly assigned to the Blanket condition (n=16) or the No Blanket condition (n=16). According to parental report, participants came from the following racial backgrounds: 44% White, 28% Black, 9% Asian, and 19% Multiracial.

3.1.2 Procedure—The procedure was similar to Study 1: on each familiarization trial each actor turned the light on and then turned it off (using the same method she used to turn it on). The actor who was not currently interacting with the light watched the other actor's actions (See Videos S5 and S6). In both conditions the actors used different methods to activate the light: one actor turned on the light with her hand, and the other actor turned on the light with her head. The only difference between the Blanket condition and the No Blanket condition was that in the Blanket condition the actor using her head to activate the light was wrapped in a blanket, meaning her hands were inaccessible and it was not possible for her to use them to turn on the light. In the No Blanket condition, the actor who used her head could have used her hands, but instead intentionally placed her hands on the sides of the toy and used her head (Figure 3). The order of the actions (hand first vs. head first) as well as which actor used her head was counterbalanced across subjects. One difference between these familiarization videos and those used in Study 1 is that in this study, the light did not move: it remained centered between the two actors throughout the entire video. This change was made because the actor wearing the blanket in the Blanket condition did not have her hands accessible, and therefore could not have moved the light from the center of the table to a position in front of her body. The familiarization movie repeated four times. Infants then viewed the same exact test trials used in Study 1. Live looking time coding and reliability coding were measured as in Study 1, with coders agreeing on the endpoints of 93% of the test trials. Looking times between the coders were highly correlated (r=.96), and all data analysis is done using the looking times recorded by the original live coder. Additionally, infants were given initial exploration and final exploration periods with the toy for 30 seconds both before and after watching the videos.

3.2 Results

3.2.1 Looking time measures—We again first evaluated our primary hypothesis that infants' attention to test trials, a measure of their expectation of the actors' likely social relationship, would vary based on the actions the actors performed during familiarization. Preliminary analyses revealed no effects of sex or test trial order, so analyses collapsed across these factors. A repeated measures ANOVA evaluating infants' looking times to test trials with condition (Blanket vs. No Blanket) as a between subjects factor and test trial pair (1st, 2nd, or 3rd) and test trial type (Affiliation vs. Disengagement) as within subjects factors revealed the predicted significant test trial type by condition interaction ($F_{1,30}$=29.54, p<.001; partial eta squared =0.496). This interaction suggests the pattern of looking times to each test trial type was different based on whether the actor using her head did so intentionally, or did so due to situational constraints. In particular, infants in the No Blanket looked longer at Affiliation (M=11.0 seconds) than Disengagement trials (M=7.7 seconds; Figure 2), suggesting they found it less expected for the actors to affiliate after intentionally using different actions. Indeed, this difference was significant both parametrically ($F_{1,15}$=20.30, p<.001; partial eta squared =0.575), and non-parametrically (n=15 of 16 infants looked longer at affiliation trials, binomial p<.001, two-tailed). On the other hand, infants in the Blanket did not show this pattern of response, and instead looked longer on Disengagement trials (M=11.2 seconds) than Affiliation trials (M=8.5 seconds; Figure 2), which was significant both parametrically ($F_{1,15}$=10.73, p=.005; partial eta squared =0.417), and non-parametrically (n=13 of 16 infants looked longer at disengagement trials, binomial p=.021, two-tailed), suggesting infants found it unexpected for actors who complete the same goal, using whatever means they have available, to socially disengage. The pattern of non-parametric results was significantly different between the No Blanket condition and the Blanket condition (Fisher's exact test p<.001). No other main effects or interactions in the overall ANOVA reached significance (ps>.06[2]). Importantly, these effects were not due to differences in attention during familiarization: attention was high throughout familiarization (infants attended to 93% of each familiarization trial on average), and a repeated-measures ANOVA on looking times to familiarization with condition (Blanket vs. No Blanket) as a between subjects variable and trial number (1st, 2nd, 3rd, 4th) as a within subjects factor revealed no significant effect of condition ($F_{1,30}$=1.70, p=.202 partial eta squared =0.054), or trial number ($F_{3,90}$=2.18, p=.096 partial eta squared =0.068), and no significant interaction between the two factors ($F_{3,90}$=0.63, p=.596 partial eta squared =0.021).

3.2.2 Infants' exploration of the push-light—As in Study 1, infants' exploration of the light did not differ based on the condition that the infants were assigned to. Both before and after the looking time portion of the study a similar number of infants from each condition turned on the light (Blanket: n=5 of 16 during initial exploration, n =8 of 16 during final exploration; No Blanket: n =6 of 16 during initial exploration, n =6 of 16 during final exploration; Fisher's exact all ps>.47). Infants also spent similar amounts of time interacting with the light in each condition (Blanket: M=15.1 seconds during initial exploration, M=12.0 seconds during final exploration; Different Actions: M=15.6 seconds during initial

[2]The largest F-value was from a non-significant effect of test pair ($F_{2,29}$=3.06, p=.062; partial eta squared =0.152). This marginal effect is likely due to infants attending less as trials repeat. All other main effects and interactions were non-significant (ps>.20).

exploration, M=9.0 seconds during final exploration; all ps>.36). Only one infant (from the Blanket Condition, in the final exploration phase) turned on the light using a head touch.

3.3 Discussion

Infants' inferences about affiliation varied systematically based on whether the difference in the actors' actions appeared to be intentional or to be due to situational constraints. When the difference in the actors' actions appeared intentional (No Blanket condition), infants looked significantly longer at subsequent affiliation. That is, replicating Study 1, infants found it unexpected for actors who intentionally performed different actions to reach the same goal to affiliate. However, when the differences in the actors' actions were due to the actors using whatever means they had available to accomplish the same goal (Blanket condition) infants did not find affiliation unexpected. In fact, infants expected affiliation between actors who attempted to reach the same goal but had to use different actions to do so.

Although we predicted this first result (that the No Blanket Condition would replicate the pattern of results seen in the Different Actions condition of Study 1), the second result (that there would be a significant effect in the opposite direction for the Blanket condition) was surprising. However, there are a couple of differences between the two studies that could explain why infants' inferences in the Blanket Condition of this Study were somewhat clearer than their inferences in the Same Actions Condition of Study 1. For example, in Study 2, rather than moving from the center of the table to a position in front of each actor, the light remained in one position between the actors at all time. This slight methodological difference could (1) make the actors' actions easier to track (as there was less movement and the videos were shorter overall), and (2) have highlighted that both actors were acting on a shared object. Thus, it may have been easier for infants to infer a positive relationship between the actors.

Another difference between the studies is that in the Blanket condition none of the actions need to be seen as rituals (they are not causally opaque, causally irrelevant, or goal-demoted): both actions feature actors reaching their shared goal (of turning on the light) using whatever means necessary. It may be easier to process instrumental actions than it is to process actions that require reasoning about ritual relevant properties (like goal-demotion), leading infants to have a stronger prediction about people who perform (different) instrumental actions to reach the same goal. Building on this idea, it is also possible that including clearly instrumental goals in Study 2 (turning on the light with a hand touch) actually *highlights* the importance of thinking about the motivations of the second actor. If she could use her hand to turn on the light, why didn't she? This extra attention to the goal-demoted vs. non-goal demoted nature of the head-touch action could lead infants to make stronger predictions about the ritualistic significance of the head-touch action in Study 2 than they did in Study 1. Finally, it is important to note that although the parametric looking time data for the Same Action condition of Study 1 did not differ from chance, significantly more infants in that condition looked longer at disengagement, paralleling the results from the Blanket Condition of Study 2. Overall, infants' inferences about social relations did not rely merely on whether the people's actions were perceptually similar or dissimilar; rather,

infants are sensitive to the goals and motivations underlying people's actions, and whether these actions provided information about the actor's engaging in the same versus different rituals.

4. General Discussion

Taken together, these studies indicate that infants expect people's engagement in shared versus dissimilar ritualistic actions to carry social meaning. Specifically, infants expected actors who use the same ritualistic action to be more likely to affiliate than actors who intentionally use different ritualistic actions (Study 1). This finding was not based merely on the physical features of the actors' actions: infants differentiated whether the same action, a head touch, was completed intentionally (and therefore was goal-demoted), or was completed because it was the most efficient means to reach the goal (and therefore not goal-demoted). When differences in the actor's actions did not provide information that the actors were engaging in different rituals, infants did not find it unexpected for the actors to affiliate (Study 2). Overall, infants evidence an early developing understanding of the social significance of engaging in shared versus dissimilar ritualistic actions: they infer patterns of third-party social relationships based on whether people complete the same rituals.

We focused here on the head (and elbow) touch action in particular, because this type of action may have an especially important social, cultural, and ritualistic status. Specifically, this part of the action was not required for reaching a desired outcome (it was causally-irrelevant), and the motivations for engaging in it were unknown (it was goal-demoted). Unlike intentional goal-relevant (instrumental) actions, rituals can serve as reliable signals to social group membership, such that when two people intentionally choose to perform the same ritual they may be demonstrating shared cultural knowledge of a group norm (e.g., Legare & Nielsen, 2015). More generally, whereas people perform actions that are causally necessary *because* they want to reach a desired outcome, people may perform rituals in order to signal knowledge of a social group's practices and therefore belonging to that group. Interesting open questions concern the range of features of actions that guide infants' expectations of social group affiliation (e.g., do infants think that actions with more steps are more likely to serve as rituals and signal group membership?; Legare & Souza, 2012).

Another area ripe for future investigation concerns whether infants' expectations that shared ritualistic action indicate affiliation arise due to (1) expectations that the two actors have shared cultural knowledge or (2) the fact that the second actor copies the first actor's action. Because the actors in these studies sat together and watched each other complete the ritualistic actions, infants may have encoded the events as the second actor chose whether to imitate the first actor or not. Infants understand that imitation can signal that the imitator likes the target of his imitation (Powell & Spelke, in press), so infants may have expected affiliation in cases that looked like imitation. On the other hand, if infants understand that performing the particular action marks the group membership of each actor (e.g., Legare & Nielsen, 2015), then they may expect people who use the same ritualistic action to affiliate regardless of whether there are any signals of imitation. For instance, if two people know the same ritualistic rain dance, then we may expect them to affiliate or be from the same social group regardless of whether they perform the dance separately or together because it is the

knowledge of the dance itself that indicates group membership. Future work can ask this question by investigating infants' expectations of people who engage in the same versus different causally irrelevant actions in non-imitative contexts, such as when the two actors are presented separately.

4.1. Conclusion

To conclude, this work opens novel questions about the kinds of features that infants expect to indicate engagement in a ritualistic action (e.g., causal-irrelevance, and goal demotion) and the kinds of shared features they expect to mark social relationships and cultural groups. Recent evidence suggests infants can reason in sophisticated ways about the social world, for example by forming expectations about patterns of affiliation (e.g., Kuhlmeier, Wynn, & Bloom; Powell & Spelke, 2013; Rhodes, Heatherington, Brink, & Wellman, 2015). Interestingly, infants' inferences about affiliation are influenced by similarities that are fundamentally social, such as shared food preferences or shared language (Liberman et al., 2014; 2016 Liberman et al., 2017). Our results suggest that shared knowledge of ritualistic actions may be another cue that infants expect to mark social relationships and cultural group membership: they infer that people who engage in the same ritualistic action will be more likely to affiliate. Overall, the current findings suggest that in addition being able to learn novel causally-irrelevant actions through imitation (e.g., Gergely et al., 2002; Meltzoff, 1995) and to selectively imitating these types of actions when they are performed by ingroup members (e.g., Buttelmann et al., 2013; Howard et al., 2015), infants expect ritualistic actions to carry social meaning and to indicate likely patterns of social relationships.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was supported by NICHD R01HD070890 awarded to K.D.K., and by a National Science Foundation Graduation Research Fellowship (DGE-1144082) awarded to Z.L. We thank Amanda Favata, Emily Gerdin, Lefeba Gougis, and Nick Furci for their help with data collection and reliability coding.

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Highlights

- We present evidence that infants understand the social significance of rituals
- Infants are sensitive to whether actions are instrumental or have ritual properties
- Infants expect people who engage in the same rituals to be more likely to affiliate

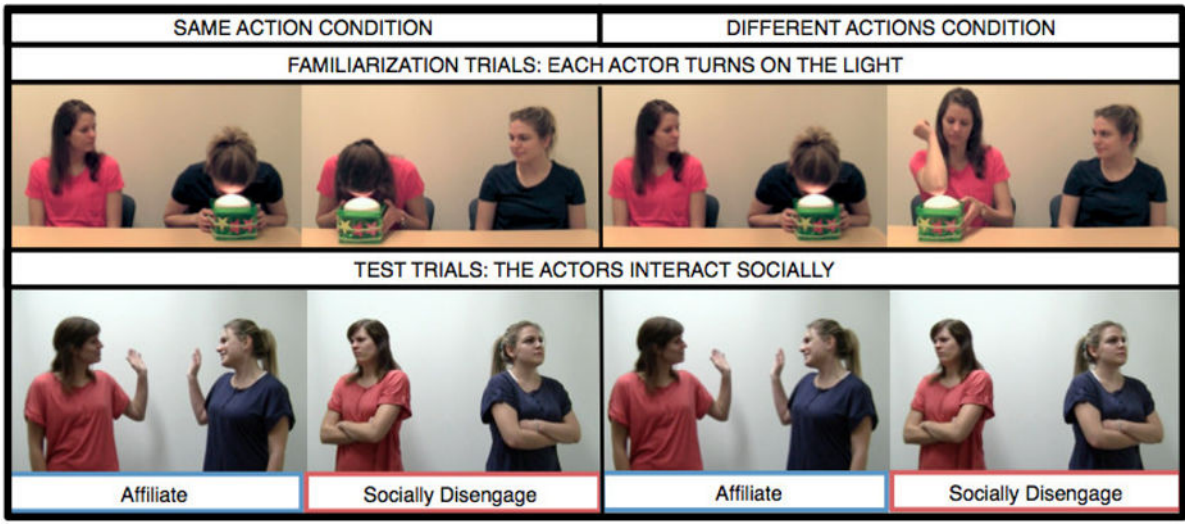

Figure 1.

Study 1 Design. Infants were randomly assigned to the Same Action condition (left) or the Different Actions condition (right). In both conditions infants first saw familiarization trials where actors turned on the light using novel actions (4 trials), and then saw alternating test trials where the actors interacted by affiliating and socially disengaging (6 trials). See Videos S1 & S2 for more details.

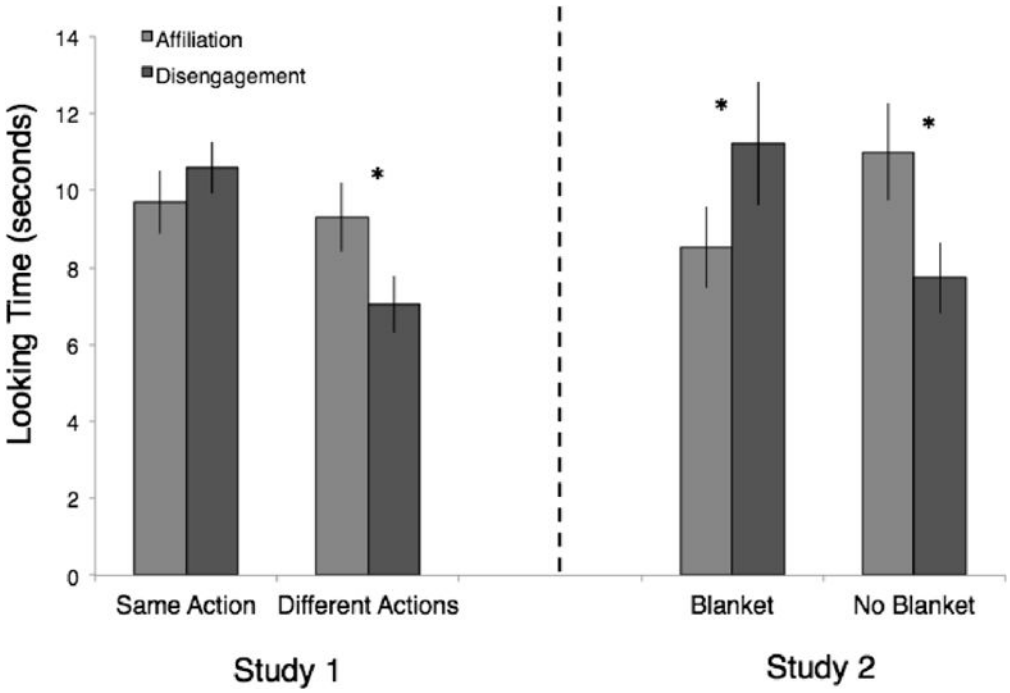

Figure 2.

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

Figure 3.

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