Supporting Information

Powell and Spelke 10.1073/pnas.1304326110

Text S1

In Experiment 4, we demonstrated that 8-month-old infants use social information—proximity and synchrony—to identify social groups, even when there are no visual cues to group membership, and that they subsequently base evaluations of individuals' actions on what those individuals' group members have done in the past. When social groups were not delineated by visual cues, however, infants responded by looking longer to behaviors that were consistent with an individual's group rather than those that were inconsistent, in contrast with earlier experiments where group members looked alike. This reversal in looking time was not a spurious finding, as we replicated it with a group of 7-month-old infants using a habituation paradigm in Experiment 5.

One explanation for these looking-time reversals is that they were driven by greater complexity or extra processing demands introduced by the heterogeneous stimuli (1–3). Groups composed of heterogeneous members may be globally more difficult to process, because the unique features of each individual draw infants' attention away from each group's actions, making it more difficult to extract generalizations about the groups' actions and apply them to the test trials. If this were the case, however, one might have expected the increased exposure to each group's characteristic action, afforded by the habituation paradigm in Experiment 5, to shift looking time back in the direction of longer looking to the inconsistent trials, contrary to our findings.

Alternatively, the greater difficulty of processing the events in the heterogeneous condition may stem specifically from the difficulty of maintaining a representation of which characters are socially related. The added habituation trials in Experiment 5 would not have eased this problem, because those trials contained no information about the social relationships between the figures. Throughout the familiarization phase of the experiment, the figures were spread out on the sides of the screen, displaying neither the synchrony nor proximity that were our selected cues to group membership. On this view, instead of providing more information about how individual group members act, manipulations intended to affect the direction of the looking-time preference should be designed to help infants continue to track the social relationships among the figures. We conducted two additional experiments to test this possibility.

In Experiment S1, we tested older infants. On a given task, increasing age predicts a greater preference for novel events, a principle in line with an enhancing of abilities to process complex stimuli as cognitive capacities develop (1). We reasoned that, as working memory capacity improves throughout infancy (4), infants several months older than the participants in Experiment 4 might be better able to track social relationships among figures with diverse appearances. Sixteen 10-month-old infants (6 females; mean age, 10 months 4 d; range, 9:15–10:15; 1 additional infant excluded for experimenter error and 1 for fussiness) participated in an exact replication of Experiment 4. Infants were introduced to two social groups each composed of three figures, delineated via proximity and synchrony among the members. Following this introductory phase, infants saw two rounds of familiarization trials, in which two individuals from each group circled and landed on group-specific boxes, and test trials, in which the single, remaining figures from each group both landed on the same box, constituting a consistent and an inconsistent trial. The rounds were separated by a group reminder scene; for full methodological details, see the main text. An ANOVA comparing looking times to consistent and inconsistent trials in Experiment S1 to those generated by 8-month-old infants in Experiment 4, and including test order and familiarization distance as additional between-subjects factors, found a significant trial type by experiment interaction [$F_{(1,24)} = 4.074$, $P = 0.05$]. Whereas 8-month-old infants had looked longer to the consistent trials, the older infants did not show this pattern. Their looks trended in the direction of longer looking to inconsistent trials (52.6%) rather than consistent trials (47.4%), although this difference was not significant [$t_{(15)} = 0.76$, $P > 0.4$].

In Experiment S2, we returned to our original age range of 8-month-old infants and asked whether keeping proximity as a cue to social group membership not just during the introduction but throughout the familiarization and test trials might allow infants to better track social group membership. Sixteen 8-month-old infants (9 females; mean age, 7 months 27 d; range, 7:17–8:12; 1 additional infant excluded for experimenter error and 1 for fussiness) viewed a presentation similar to that used in Experiments 4 and S1, with the exception that, instead of spreading out along the side of the screen following the introductory scene, the figures stayed clustered together according to social group membership. During the familiarization trials, the groups remained in the top two corners of the screen, where they were located during the introductory sequence, but before each pair of test trials the groups synchronously moved to the bottom two corners of the screen, so that the test trial motion was initiated from the same locations as in the previous experiments. An ANOVA comparing looking times to consistent and inconsistent trials in Experiment S2 to those generated by infants in Experiment 4, and including test order and familiarization distance as additional between-subjects factors, found a significant trial type by experiment interaction [$F_{(1,24)} = 5.805$, $P < 0.05$]. As in Experiment S1, infants here no longer showed the pattern of looking longer to the consistent test trials, as they had in Experiment 4. Once again, their looks trended in the direction of longer looking to inconsistent trials (54.9%) rather than consistent trials (45.1%), although this difference was not significant [$t_{(15)} = 1.29$, $P > 0.2$].

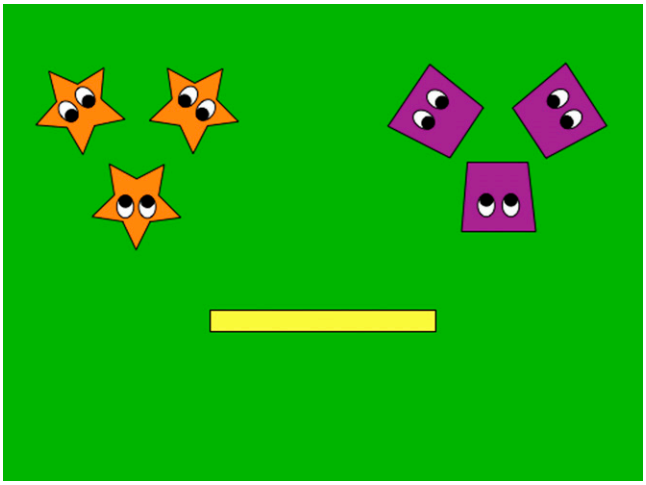
These two supplementary experiments provide evidence for the hypothesis that longer looking times toward group-consistent behaviors in the context of heterogeneous groups are the product of the difficulty of tracking individuals' group membership without the aid of appearance-based cues. Both of our manipulations designed to ameliorate this difficulty—increasing the age of the participants (Experiment S1) and providing additional proximity cues to individuals' social affiliation (Experiment S2)—independently affected the pattern of infants' looking times, leading to significantly increased looking toward inconsistent relative to consistent events compared with to the results of Experiment 4. Nevertheless, looking times to inconsistent trials were not significantly greater than looking to consistent trials within either of the individual experiments, likely because of the continuing difficulty of processing the social groups with heterogeneous members. The effectiveness of these manipulations in increasing looking to inconsistent relative to consistent trials bolsters the interpretation that infants were, indeed, using proximity to form social group representations that informed their behavioral expectations, even when group members lacked any physical resemblance.

1. Hunter MA, Ames EW (1988) A multifactor model of infant preferences for novel and familiar stimuli. *Adv Infancy Res* 5:69–95.

2. Roder J, Bushnell EW, Sasseville AM (2000) Infants' preferences for familiarity and novelty during the course of visual processing. *Infancy* 1(4):491–507.

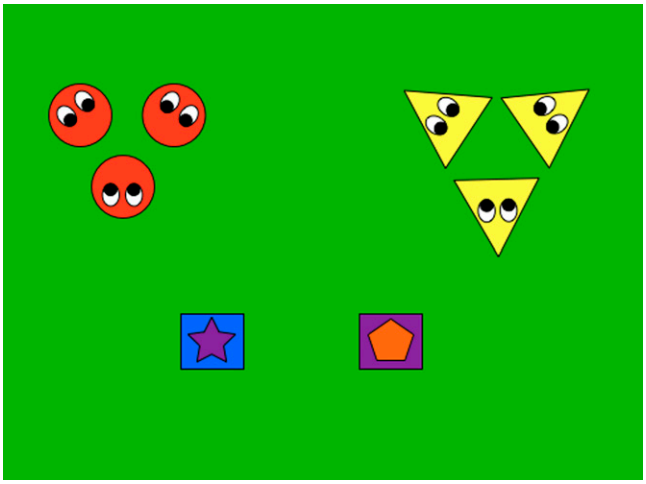
3. Kidd C, Piantadosi ST, Aslin RN (2012) The Goldilocks effect: Human infants allocate attention to visual sequences that are neither too simple nor too complex. *PLoS One* 7(5):e36399.

4. Nelson CA (1995) The ontogeny of human memory: A cognitive neuroscience perspective. *Dev Psychol* 31(5):723–738.



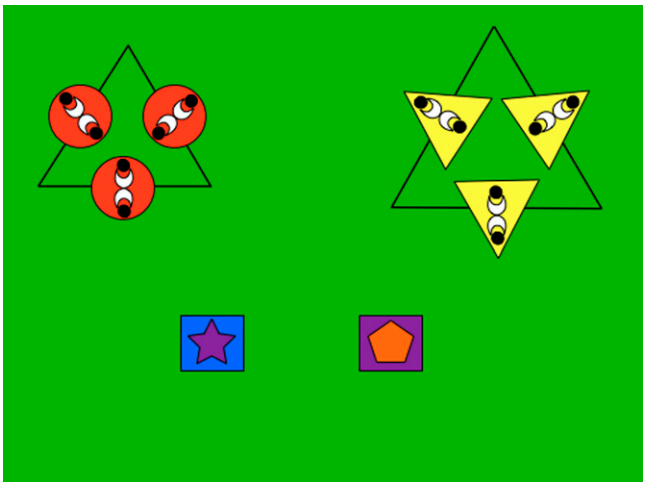
Movie S1. Example display from Experiment 1. The movie must be clicked to continue at points where the display was infant directed.

Movie S1



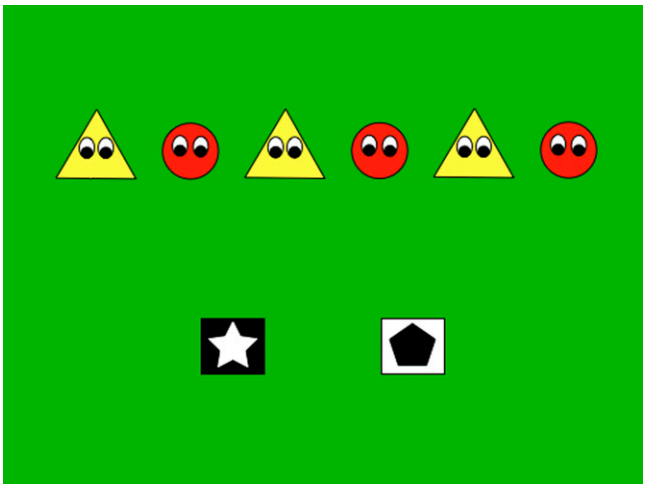
Movie S2. Example display from the animate condition of Experiment 2. The movie must be clicked to continue at points where the display was infant directed.

Movie S2



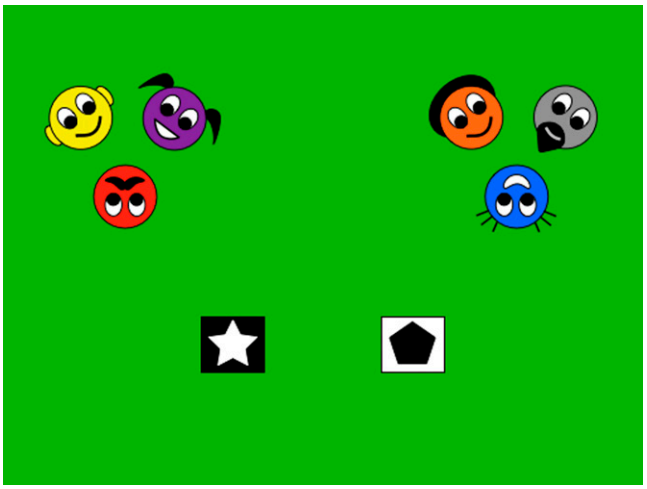
Movie S3. Example display from the inanimate condition of Experiment 2. The movie must be clicked to continue at points where the display was infant directed.

Movie S3



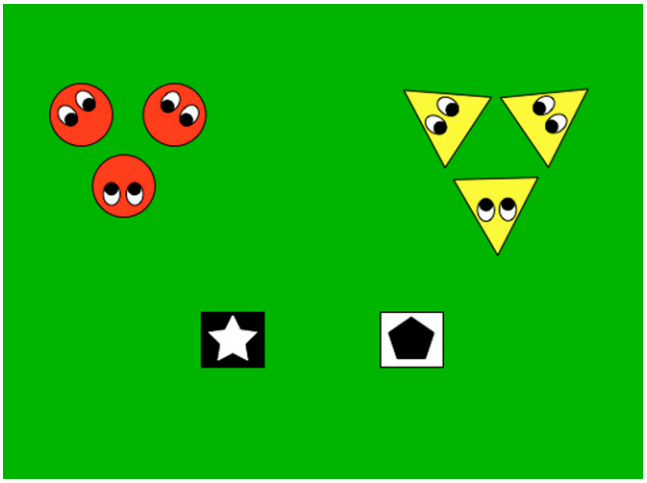
Movie S4. Example display from Experiment 3. The movie must be clicked to continue at points where the display was infant directed.

Movie S4



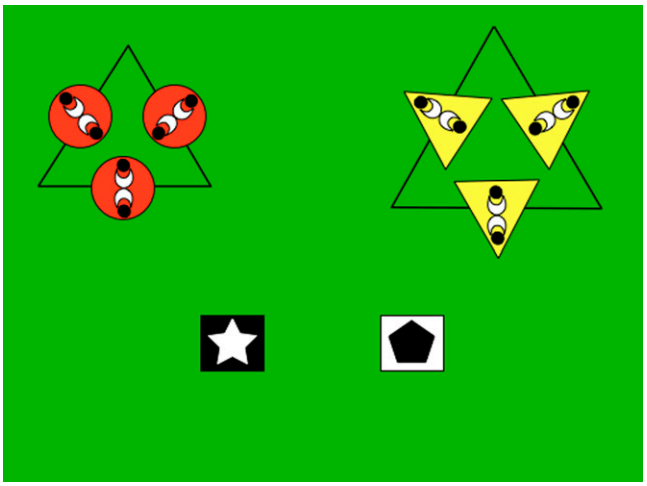
Movie S5. Example display from Experiment 4. The movie must be clicked to continue at points where the display was infant directed.

Movie S5



Movie S6. Example display from the homogeneous-groups condition of Experiment 5. The movie must be clicked to continue at points where the display was infant directed.

Movie S6



Movie S7. Example display from the inanimate condition of Experiment 5. The movie must be clicked to continue at points where the display was infant directed.

Movie S7