

Supplementary Information for

Infants learn who is part of their social world by observing the social interactions of their parents with unknown others Ashley J. Thomas^{1,2,3,4}, Rebecca Saxe^{1,4}, Elizabeth S. Spelke^{3,4}

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Other supplementary materials for this manuscript include the following:

Data, example stimuli, etc. can be found: https://osf.io/z8r7t/

Study 1

Number of prompts

Infants were prompted to choose a puppet between 1 and 10 times (for all participants, M_{prompts} = 2.7 prompts). However, infants who were prompted more than twice never engaged in selective reaching and therefore were not included in the analysis (for included participants, M_{prompts} =1.167).

Extra Analyses and Results

Infants were more likely to choose the imitated puppet in the own parent condition than in the yoked control condition. To compare these two proportions, we used a likelihood ratio test to compare a model that included or did not include the condition (parent versus yoked control) as a factor, with the subject number as a random factor in both models. We found that the model that included the condition was a significantly better fit than the one that did not (p=.02). We used the DHARMa package (1) in R (2) and R studio (3) to check the residuals, and no significant deviations were reported. Note that this analysis was not pre-registered, but we include it here because the main analysis that we pre-registered and reported in the main text (a Bayesian contingency table in JASP) (4) does not account for the data collected within subjects. As reported in the main text, using this Bayesian contingency table, we found strong evidence that the two proportions differed (BF10=10.95 in favor of the alternative hypothesis that the proportions in the two conditions were not the same).

Reliability Coding

Reaching preferences were coded at the time of the study and then re-coded by a second experimenter who did not know the condition or the hypothesis of the study. When the two coders disagreed, the reaching preference that was coded by the person watching the videos was used as the final decision.

Order/Side Effects

To test for order effects, we compared a model that included an interaction between order (own parent or yoked control first) and condition and a null model that did not include this interaction. We found that there was not a significant difference between these two models (p=.34849). In the own parent test condition, of the infants who saw this condition first own parent first, 6/8 of them chose the imitated puppet; of the infants who saw the yoked control condition first, 5/6 of them chose the imitated puppet; in the other parent yoked control condition, of the infants who saw their own parent first, 2/4 of them reached for the imitated puppet; and of the infants who saw their own parent second, 2/8 of them reached for the imitated puppet.

Age Effects

We tested whether the age of the infants predicted their choices using logistic regression, we did not find evidence that age predicted either their choice in either the own parent condition (p=.42) or in the other parent condition (p=.663).

Study 2

Reliability Coding

A second coder, who again did not know the identity of the imitator or condition (own parent or yoked control), coded all videos a second time. We found 95.5% agreement between the two coders.

Order/Side Effects

To test whether the order that children saw the two conditions affected their looking behavior in own parent speaking trial, we ran an ANOVA that asked whether infants seeing the condition

with their own parent as well as which side the imitated puppet appeared. We found positive evidence that these conditions did not ($BF_{01}=2.00$; $BF_{01}=2.887$)

Age Effects

We tested whether there was a correlation between the age of the infant and their looking behavior using Bayesian Pearson correlations. We found strong evidence that older infants spent more time looking at the imitated puppet in the own parent condition during the speaking trial (BF_{10=36.40}). Infant age was not correlated with looking in the other parent condition (BF₀₁=2.94).

Study 3

Reliability Coding

A second coder, who again did not know the identity of the imitator or condition (own parent or yoked control), coded N=4 of the videos a second time. We found 96.81% agreement between the two coders.

Order/Side Effects

To test whether the order that children saw the two conditions affected their looking behavior in the own parent, speaking trial, we ran an ANOVA that asked whether infants seeing the condition with their own parent first as well as the side the imitated puppet appeared predicted their looking time. We found inconclusive evidence as to whether these conditions predicted their looking behavior ($BF_{01}=1.29$; $BF_{01}=1.31$)

Results including infants who were older than the pre-registered age range

In addition to the 24 babies included in the main analysis, we inadvertently collected data from 4 babies who were older than the pre-registered age range. When we tested the hypotheses and included the data from these infants, all the results were the same. Infants looked longer at the imitated puppet in the own parent condition during the speaking trial (M=.604, SD=.134; BF₁₀=137.195) but not the visual preference trial (M=.477, SD=.101; BF₀₁=9.74). We found strong evidence that these two proportions differed (BF₁₀=82.024). In the yoked control condition, infants spent equal amounts of time looking at the puppets in the speaking trial (M=.505 SD=.113; BF₀₁=3.911).

Additional control condition

In this study, the control condition featured another infant's parent who appeared to be imitated by one puppet and not the other (as opposed to in Study 2 during which both the own parent and yoked control condition featured the central adult imitating one puppet and not the other). Previous experiments have found that 12-month-old infants reach for imitators over nonimitators after watching interactions between two unfamiliar characters (15). These results have been interpreted as evidence that infants interpret being an imitator (regardless of the target) as evidence of a preferred social trait (e.g., social responsiveness). In contrast, our studies tested whether infants inferred a specific relationship rather than a preferred social trait. Thus, the imitator control condition tested whether infants would look toward a puppet that imitated a stranger when seeking the source of a voice calling their own name, and we predicted that they would not. In the imitator control condition (not reported in the main text), infants spent equal amounts of time looking at the two puppets in the speaking trial (M=.539, SD=.169; BF₀₁=2.647) and in the visual preference trial (M=.507 SD=.113; BF₀₁=4.23).

Age Effects

We again tested for age effects as outlined under Study 2. Here we found inconclusive evidence as to whether older infants looked longer at the imitated puppet in the own parent condition during the speaking trial (BF₁₀₌1.05). We found positive evidence that infant age was not correlated with looking duration in the other parent condition (BF₀₁=2.91).

Study 4

Reliability Coding

A second coder, who again did not know the puppet that had spoken, coded videos of N=5 babies a second time. There was 94.6% agreement when comparing the coding of how long infants looked at either puppet and 100% agreement about which puppet the infants looked at first after the adult expressed distress.

Order Effects

To test whether the order that children saw the two conditions affected their looking behavior in the conditions, we ran an ANOVA that asked whether infants seeing the condition with their own parent as well as whether they saw the speaking forward test trial first affected their looking behavior. We found positive evidence that it did not ($BF_{01}=2.43$; $BF_{01}=2.52$; $BF_{01}=1.53$)

Age Effects

Infant age was not correlated with the amount of time an infant spent looking at an imitated puppet in the own parent, own name trial ($BF_{01}=3.147$) nor in the other parent, own name trial ($BF_{01}=2.98$).

Study 5

Reliability Coding

A second coder, who again did not know the puppet that had spoken, coded videos of N=4 babies a second time. There was 92.14% agreement when comparing the coding of how long infants looked at either puppet during the 6 second pause and 100% agreement about which puppet the infants looked at first after the adult expressed distress.

Order Effects

To test whether the order that children saw the two conditions, as well as which puppet was the speaking puppet, affected their looking behavior in own parent condition, we ran an ANOVA that asked whether infants seeing the condition with their own parent as well as whether they saw

the speaking forward test trial first affected their looking behavior. We found positive evidence that it did not ($BF_{01}=2.82$; $BF_{01}=3.75$).

Age Effects

Infant age was not correlated with the amount of time infants spent looking at the speaking puppet after their parent expressed distress (BF_{01} =4.21), but we found weak evidence that infant age was negatively correlated with how much time infants spent looking at the speaking puppet when an unfamiliar adult expressed distress (BF_{01} =2.85): older babies were less likely to look at the imitated puppet during this trial.

Interpreting the null findings in the visual preference trial

A priori, it was possible that in Study 1, infants might have shown both a looking preference and a reaching preference for the target of their parent's imitation. However, in our pilot study and in related studies from our lab, we found that 12-month-old infants show a reaching preference but not a looking preference. We pre-registered this prediction (see below), and indeed, in every experiment, we found clear evidence: infants do not look preferentially to the target of their parent's imitation when the two puppets are presented in silence, dancing to music, or calling another infant's name. It is in light of these results that we conclude that 12-month-old infants are not generally more interested in, or curious about, the target of their parent's imitation.

From our pre-registration of Study 1 (https://osf.io/t5mhp):

"We anticipate that we will find reaching preferences, but not looking preferences. This is based on the previous study we did with novel individuals. However, we will report all findings in the final manuscript. We don't predict that these two measures will disagree, but if they do (i.e., if they reach more for one puppet but look more at another puppet), it could suggest an 'interest' in one puppet, but a willingness to interact with the other. Thus, a reaching preference will be interpreted as a stronger indicator of preference than the preferential looking measure."

These results are consistent with the broader literature. While preferential looking can reveal infants' social preferences, most such studies are with younger infants than the population we test here. Indeed, in several domains, younger infants' looking preferences converge with older infants' reaching preferences. For example, in the original helper/hinder studies 3-month-olds look at helpers, while older infants reach for (but do not look preferentially toward) helpers. In a new meta-analysis of the 22 most recent studies of infant or toddler social evaluations, looking preferences are reported in infants up to 8 months old, but studies with older infants use reaching preferences (5) In the work about preferences for people who speak the same language as the infant's caregiver, 4- to 5-month-old infants look more toward a native speaker, and 10-month-olds take a toy from a native speaker. In the imitation literature, 4-month-olds look at an imitator, and 12-month-olds reach for an imitator.

However, very few prior studies have directly compared preferential looking and preferential reaching in the same experimental paradigm and age group, let alone within the same experiments as we do here. Thus, it is hard to estimate from the previous literature, whether a dissociation between looking and reaching as measures of preference is robust, and at what age it emerges. This is a fundamental methodological question for studies in infant social cognitive development, but beyond the scope of the current paper. The key result for the crucial question in our study is that infants did systematically expect the puppet whom their parent imitated to be more likely to socially engage with them.

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