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Learning to reason about desires: An infant training study

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Abstract
A key aspect of theory of mind is the ability to reason about other people's desires. As adults, we know that desires and preferences are subjective and specific to the individual. However, research in cognitive development suggests that a significant conceptual shift occurs in desire-based reasoning between 14 and 18 months of age, allowing 18-month-olds to understand that different people can have different desires. We examined this ability in a lab (characterized as a mixed model) where infants are trained to infer others' preferences (Gopnik & Wellman, 1994).

Introduction
As social creatures, we are constantly trying to figure out what other people are thinking. The ability to infer others' mental states, such as their desires and beliefs, serves a number of important functions. It allows us to please or irritate others, to consider the consequences of distinct preferences. The suggestion is that during this training, children must observe or participate in many desire-based interactions where people make choices or produce other signals that suggest that their preferences are congruent with another or with the infants themselves.

Keywords: Theory of mind; Desire-based reasoning; Infant learning; Social cognition; Preferences.

Experiment 1: Methods
Participants
Infants in both experiments were recruited by phone and email from the California East Bay Area and Southwestern Ontario. In Experiment 1, 55 infants were tested. We used the strict criterion that only infants who did not share the correct item on an initial pre-test (described below) continued to training, increasing the likelihood that participants completing training did not already know that preferences are diverse. Twenty infants per condition were tested in the full design (DDT), 14 infants (henceforth, DDT) where they observed multiple training trials with two experimenters demonstrating different preferences from one another. The other half completed a “Non-Diverse Desires” Training condition (henceforth, N-DDT), where they observed multiple training trials with two experimenters demonstrating the same preferences. Following training, infants were tested again on two unmatched test trials, one directly after training and the other approximately 24 hours later. The second test trial occurred 1 day later to examine how enduring the effects of training might be – would the effect still be evident following a delay? We predict that only infants in the DDT condition should show improved performance in attributing preferences on the test trials.

Material
Food. Four sets of food pairs were used in the experiment. The pairs were broccoli and Goldfish crackers, celery and rice puffs, cucumbers and Cheerios, and green peppers and wheel-shaped infant crackers.

Results
While this is an important distinction we will not discuss it further, because both processes result in identical behavior in our task. Understanding of preferences by testing them in a modified version of Repacholi & Gopnik's (1997) Goldfish/broccoli task. All infants were tested in the critical unmatched trial type, wherein the experimenter’s preference conflict with the infant’s previous expectations. Older infants were considerably more likely to be able to infer the other experimenter the food she liked continued to a training condition. The critical manipulation is that half of the infants completed a “Diverse Desires Training” condition (henceforth, DDT) whereas they observed multiple training trials with two experimenters demonstrating different preferences from one another. The other half completed a “Non-Diverse Desires” Training condition (henceforth, N-DDT), where they observed multiple training trials with two experimenters demonstrating the same preferences. Following training, infants were tested again on two unmatched test trials, one directly after training and the other approximately 24 hours later. The second test trial occurred 1 day later to examine how enduring the effects of training might be – would the effect still be evident following a delay? We predict that only infants in the DDT condition should show improved performance in attributing preferences on the test trials.
ensure that they could share with the experimenters. The warm up consisted of each experimenter passing a toy (e.g., a ball or toy keys) to the infant and asking her to pass it back by placing it in the experimenters’ hands.

Prior to testing, we had infants’ preferences for vegetables, fruit, and crackers tested to ensure that both foods were liked and disliked by the infant in the DDT condition (e.g., liked dogs and disliked ducks) and green peppers and wheel-shaped crackers).

Design. The foods used on each trial were randomized (some infants saw broccoli and Goldfish on the pre-test, some on training trial 2, some on post-training test 1 and some on post-training test 2), so that each food item appeared on the opposite side of the pre-test and post-training tests. For training trials, Infants and disliked vegetables in the pre-training test, she would continue to like animals and dislike vegetables in subsequent training trials. For half the participants, Experimenter 1 liked animals and for the other half, Experimenter 1 liked vegetables. This was crossed with half of the infants seeing disliked expressed first and half seeing liked expressed first. None of these counterbalancing factors led to any systematic differences in the data (when entered into ANOVAs, all p’s > .05 for these factors).

Predictions. We predicted that infants in the DDT condition would be more likely to offer the experimenter the correct food on the post-tests than infants in the N-DDT condition even though both conditions provided infants with practice in considering other people’s preferences and desires. In the N-DDT condition, infants saw two experimenters liking the same foods – this does not provide the infants with any information that allows them to learn that different people can have different mental states. In the DDT condition, infants saw two experimenters display different preferences from each other, which would provide a great deal of evidence to suggest that different people can have different preferences.

Experiment 1: Results

Of the initial 55 infants who participated in the experiment, 15 passed the pre-test by giving the correct food (p < .01, binomially, significantly fewer than chance), 34 infants shared the incorrect food, and 6 infants shared nothing, replicating that infants this age perform below chance on this task (Repacholi & Gopnik, 1997). This confirms that, in general, infants below 18 months are not able to attribute desires to others.

For the first 10 infants in both conditions, the food on the post-test was identical to the food on the post-training test 2 (which the infant used with Experimenter 1 on Day 1 but did not share). We switched this to a new food type to ensure that any improvement in infants’ performance on Day 2 in DDT could not be explained by already being familiar with these foods.

Experiment 1: Discussion

Our results suggest that the type of information provided during training was crucial to learning about others’ desires. When infants were provided with a large number of instances indicating that two different people can like different things, they appeared to learn the desires that they disliked but the experimenter preferred. However, infants’ performance did not improve when they saw preferences that were not diverse: infants in the N-DDT condition did not share the correct food with the experimenter on any post-training tests. This suggests that training with appropriate evidence can result in significant changes to children’s explicit Theory of Mind.

But what did infants in the DDT condition only demonstrate advances in understanding on Day 2 of the experiment, during the second post-training test? We see at least two possible explanations. One possibility is that post-training test 1 served as a final training trial, giving infants the minimum number of examples required to change their model of how preferences work (i.e., to learn that they apply to the individual). A second possibility is that a night of sleep resulted in improved learning of this general knowledge about other’s minds, allowing infants to pass the test on Day 2 but not on Day 1. We will address these possibilities more fully in the General Discussion.

Before we can speculate as to why children appeared to learn something new about preferences in the DDT condition, we must first investigate an alternative interpretation of the Experiment 1 data. It is possible that the infants in the DDT condition did not learn that preferences are diverse, but instead learned something less conceptually powerful like, “In this game I’m playing, people always get opposite things they should give to another person the thing that I didn’t take.” If this is the case, then the participants did not learn that preferences are specific to the individual; they play a game of opposites that ran a second experiment to tease apart these explanations.

Experiment 2

Experiment 2 explored the alternative interpretation that infants in the DDT condition of Experiment 1 only learned to give the experimenter the opposite of what they liked. Infants completed the same training as in the DDT condition of Experiment 1 but with a “matched” trial on post-training test 2. In a matched trial type, the experimenter demonstrates the same preference as the infant, instead of demonstrating opposite preferences. In this case, if infants in Experiment 1 DDT condition learned that preferences are specific to the individual, and is that why they tend to share the correct the food with the experimenter on post-training test 2, then they should learn to offer the food the she likes even though this is also the food that the infant herself likes. Conversely, if infants in the DDT condition of Experiment 1 learned through the course of the session that people should simply always be given opposite things to their partner, then they will give the experimenter the food that they themselves do not like on post-training
Experiment 2: Methods

Participants

Participants were 29 infants and, as in Experiment 1, only children who failed to give the correct food on the initial pre-test continued to training with 20 infants tested in the full training procedure (mean age = 15.5 months; Range 14-17 months). An additional 10 infants were tested but not included in all analyses due to failing to complete the study because of fussiness (1), parental interference (1) or refusing to share anything with the experimenters on all test trials (8).

Materials

Food. The food was the same as in Experiment 1 except that the wheel-shaped crackers were replaced with Animal Crackers. This was done because we could no longer find the wheel-shaped crackers.

Toys. The set of toys were 4 hippo and 4 trucks, and 4 cats and 4 planes. Again, all of the toys within an individual type were slightly different in shape and/or color.

Procedure and Design

The experimental procedure, counterbalancing and randomization were identical to Experiment 1 DDT.

Predictions

We predicted that infants would perform at chance on post-training test 1, as they did in Experiment 1. If infants give the experimenter the correct food on post-test 2 (the food that both the therapist and the infant have), then this will suggest that infants in Experiment 1 did not simply learn to play a game of opposites but instead learned that preferences are diverse.

Experiment 2: Results

Again we replicated the findings from Repacholi & Gopnik (1997), although 9/29 infants passed the pre-test (p = .06, binomial, marginally significantly fewer than chance), 18 infants shared the incorrect food and 2 infants shared nothing.

Six out of 20 infants were correct on post-training test 1 and 13 out of 20 were correct on post-training test 2, both not significantly different from chance (p = .32 and p = .26, respectively).

The critical comparison is between infants’ performance on post-training test 2 in the Experiment 1 DDT condition and in Experiment 2. This comparison addresses whether infants in Experiment 1 simply learned to play a game of opposites and would have shared the opposite food type to their own preference regardless of what the experimenter demonstrated on post-test 2. For this analysis, we coded infants’ performance in terms of whether they gave the experimenter the opposite food to what the infant preferred (which is correct in Exp 1 DDT but incorrect in Exp 2). We gave infants a score of 1 for sharing the opposite food and a score of zero for sharing the same (non-opposite) food. This resulted in a score of 7/20 for Experiment 1 and 15/20 on post-training test 2 in the DDT condition of Experiment 1. Using a Fisher’s Exact test, we found that performance on these trials was significantly different from one another: X²(1) = 6.46, p = .01, suggesting that infants in Experiment 1 were more likely to share the opposite food than infants in Experiment 2, where they would have been incorrect in doing so.

Experiment 2: Discussion

Overall, most infants gave the experimenter the food that they preferred (and the food they also preferred) on post-training test 2 (this was not significantly different from chance using a binomial test). Though we would have expected infants to share the correct food at higher than chance levels in this “matched” trial, we suspect that the non-significant result is due to a lack of statistical power caused by having relatively few participants for binomial statistics. In general, the percentage of infants offering the correct, “matched” food on this trial is very similar to the percentage of younger infants who did so in Repacholi & Gopnik (1997) (65% vs. 72%, respectively).

The purpose of Experiment 2 was to eliminate the possible explanation that participants in the Experiment 1 DDT condition only learned to give the experimenter the opposite food of what they themselves wanted. Comparison of Experiments 1 and 2 suggest that this was not the case, as infants shared the food that they preferred in Experiment 2 and not reflexively gave the experimenter the opposite food following training.

General Discussion

Together, these findings show that infants younger than 18 months can learn about the subjectivity of preferences when provided with diverse preferences during training, infants were able to reason correctly about another person’s preferences, providing the experimenter with the food that she liked. In contrast, the infants who only saw congruent expressions of liking and disliking options did not learn to reason correctly about another person’s preferences, and continued to give the experimenter the food that they themselves preferred, regardless of the experimenter’s preference.

Experiment 2 helped to clarify these findings, providing evidence that infants did not simply learn to always give the experimenter the same food as the infant preferred (and the infant liked), we can be confident that infants in Experiment 1 learned that preferences are diverse. Taken together, these findings resulted in infants learning through training about the diversity of desires, moving from a less to a more sophisticated understanding of other’s preferences.

One broader level, these findings suggest that young children can learn from experience to make an important advance in explicit reasoning about Theory of Mind.

One concern regarding these data is the relatively low statistical power that results from our experimental design and the small sample size for each experiment. Although the results in the Experiment 1 DDT condition were significant, it will be prudent to replicate these findings. This replication experiment is currently underway in the lab.

An interesting finding in these experiments is that the participants performed identically during the pre-test and post-training test 1, but performed significantly above chance on post-training test 2 in Experiment 1. Both tests occurred after training and we had not predicted this pattern of results, so we now return to the question of why we only saw improvement on post-training test 2.

One possible explanation for this improved performance on post-training test 2 is that post-training test 1 might act as another piece of evidence to train the infants to better understand diverse preferences. That is, post-training test 1 gives infants yet another trial in which the experimenter demonstrates that she likes the opposite food to the infant. It is possible that this extra trial is what allows the infants to learn that preferences are subjective. This possibility can be examined by manipulating the number of training trials, to include an additional trial before post-training test 1 on Day 1. Related to this, we can also examine what type of evidence is most informative – evidence that involves first-person experience such as training trial 2 and post-training test 1, or training trials that involve observing two actors displaying diverse preferences. By manipulating the number and type of training trials across various conditions in future experiments, we can answer these questions.

Another possible explanation for the improved performance only on Day 2 is the role of memory consolidation in sleep. Post-training test 2 occurs the following day, whereas post-training test 1 occurs on the same day as the training trials. Therefore, a potentially critical difference between the two tests is sleep. Research has shown that sleep is important for the consolidation of memories, and improvements in children’s and infants’ learning is correlated with longer and more intense sleep (Wilhelm, Prehn-Kristensen & Born, 2012). For example, Hupbach, Gomez, Buitzin, and Nadel (2009) found that when 5-month-old infants napped after they were exposed to an artificial language, they were more likely to remember the general grammatical pattern of that language 24 hours later, compared to infants who did not nap. It is possible that the infants in our experiment performed better on post-training test 2 because they had slept. To address the sleep hypothesis, one could conduct an experiment similar to those here, except with the entire procedure occurring on the same day. After infants complete post-training test 1, half of the infants would take a nap and half would experience a similar delay without taking a nap. Follow-up that infants who napped performed better than those who did not, this would suggest that sleep consolidation is a crucial aspect of their improved performance.

Conclusion

Research on children’s desire-based reasoning has persisted for decades. Here we examined a prediction from a particular model of how children attribute preferences to others, namely that appropriate training regarding the diversity of desires could result in infants undergoing a significant shift in conceptual development (Lucas et al., 2014). We found that following exposure to different people demonstrating divergent desires, infants were able to move from a model of universal preferences to a model that allows for the individualization of preferences. The success of this training procedure more broadly suggests that early advances in Theory of Mind could be due to experience.

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