

Theory of mind selectively predicts preschoolers' knowledge-based selective word learning

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Abstract

Children can selectively attend to various attributes of a model, such as past accuracy or physical strength, to guide their social learning. There is a debate regarding whether a relation exists between theory-of-mind skills and selective learning. We hypothesized that high performance on theory-of-mind tasks would predict preference for learning new words from accurate informants (an epistemic attribute), but not from physically strong informants (a non-epistemic attribute). Three- and 4-year-olds ($N = 65$) completed two selective learning tasks, and their theory of mind abilities were assessed. As expected, performance on a theory-of-mind battery predicted children's preference to learn from more accurate informants but not from physically stronger informants. Results thus suggest that preschoolers with more advanced theory of mind have a better understanding of knowledge and apply that understanding to guide their selection of informants. This work has important implications for research on children's developing social cognition and early learning.

Keywords: Selective learning; Word learning; Trust; Knowledge; Accuracy; Strength; Theory of mind

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Human children, like the young of many other species, rely heavily on information provided by other individuals when learning about their world (Rendell, Fogarty, Hoppitt, Morgan, Webster & Laland, 2011). However, not every individual is a good source for learning new information. Young children can often appear gullible, taking everything an adult says at face value (Fusaro, Corriveau, & Harris, 2011); in fact, children will sometimes forgo their own assumptions when presented with a conflicting claim made by an adult informant (e.g., Jaswal, 2010; Lyons, Young, & Keil, 2007; Ma & Ganea, 2010). Fortunately, children are not completely indiscriminate in their choices of social sources of information: even young children can be selective in whom they prefer to learn from (see Mills, 2013, for a review).

Although still a relatively young area of research, there is an extensive body of literature looking at children's selective learning. Researchers have identified several cues that children can use to guide their learning. Some of these cues can be considered "epistemic" cues, or indicators of an informant's knowledge. For example, Sabbagh and Baldwin (2001) demonstrated that children are more likely to learn novel words from a puppet who claims to be knowledgeable about the words' referents. Children prefer to learn from adults (live or videotaped) who display confidence rather than uncertainty (Birch, Akmal & Frampton, 2010; Brosseau-Liard & Poulin-Dubois, 2014; Jaswal & Malone, 2007), and prefer to acquire information from individuals with appropriate information access (for instance, learning about an object's visible properties from puppet who has seen the object; e.g., Brosseau-Liard & Birch, 2011; Nurmsoo & Robinson, 2009a). Multiple studies have demonstrated over several experimental variations that preschool-age children are more likely to learn from individuals with a history of making accurate claims over individuals who have been inaccurate or ignorant (e.g., Birch, Vauthier & Bloom, 2008; Corriveau, Meints & Harris, 2009; Fitneva & Dunfield, 2010; Jaswal & Neely, 2006; Koenig, Clément & Harris, 2004; Koenig & Harris, 2005a; Scofield & Behrend, 2008).

Children can also use non-epistemic cues (i.e., cues that distinguish individuals but are not indicative of differences in *knowledge*) to guide their selective social learning. For example, children prefer to learn new labels from more attractive individuals (Bascandziev & Harris, 2014), and preferentially trust nice puppets as opposed to mean ones (Mascaro & Sperber, 2009). Kinzler, Corriveau and Harris (2011) found that after watching videos of native and foreign-accented speakers of English, English-speaking children were more likely to selectively endorse novel object functions provided by the native-accented speaker during a silent video demonstration. Similarly, when witnessing physically stronger and weaker informants, preschoolers explicitly assess stronger informants as more competent at labeling novel objects, and judge them as smarter (Fusaro, Corriveau & Harris, 2011).

Recent research has started investigating possible individual differences in selective learning (e.g., Jaswal, Pérez-Edgar, Kondrad, Palmquist, Cole & Cole, in press; DiYanni, Nini, Rheel, & Livelli, 2012). Some researchers speculate that individual differences in social cognitive abilities, particularly theory of mind, might explain some of the differences in source evaluation that children demonstrate (DiYanni et al., 2012; Fusaro & Harris, 2008; Mills & Elashi, in press). Here, we investigated the contribution of theory of mind on children's selective word learning. Theory of mind refers to the ability to reason about other people's mental states, including desires, intentions, knowledge, and beliefs. Preschoolers famously show some important weaknesses in their mental state reasoning abilities, especially when they have to explicitly evaluate or justify individuals' knowledge and beliefs. For instance, younger preschoolers routinely fail tasks that involve attributing false beliefs to other individuals (Wellman, Cross & Watson, 2001). They also have difficulty identifying and correctly selecting knowledge sources (e.g., Fitneva, Lam & Dunfield, 2013; O'Neill & Chong, 2001; Robinson, Butterfill & Nurmsoo, 2011; Robinson, Haigh & Nurmsoo, 2008).

There is some debate on whether preschoolers' preference for learning from some individuals over others is supported by advancements in their theory of mind development. This question has been

brought up in the context of children's preferential learning from verbally accurate individuals. Some researchers have stated that children's selective learning likely depends at some level on mental state understanding (e.g., Koenig & Harris, 2005b). Children with a better understanding of the mental state of knowledge should, according to this perspective, show greater selectivity in their learning because they are able to interpret individual differences in verbal accuracy as reflecting differences in individuals' knowledge about language and use these attributions to decide from whom it is best to learn. Others, however, believe that children can succeed at accuracy-based selective learning tasks using relatively shallow strategies that do not require mental state understanding (e.g., Nurmsoo & Robinson, 2009b; Lucas & Lewis, 2010).

A few studies have attempted to uncover a link between theory of mind and selective learning. Some early studies failed to show a clear link between success on some theory of mind tasks and selective learning performance. For instance, 3- and 4-year-olds who score poorly on false belief tasks can still reliably track informant accuracy (Pasquini, Corriveau, Koenig, & Harris, 2007). However, several studies have now found associations between success on theory of mind tasks and the propensity to endorse claims from a more accurate informant, especially when multiple false-belief trials (DiYanni & Kelemen, 2008; DiYanni et al., 2012; Lucas, Lewis, Pala, Wong & Berridge, 2013) or a variety of theory-of-mind tasks (Fusaro & Harris, 2008) are used to assess the construct of theory of mind instead of a single false-belief task. These associations hold even after controlling for children's age, which is associated with both increased theory of mind and selection of accurate informants in the preschool period (e.g., DiYanni & Kelemen, 2008; DiYanni et al., 2012). Additionally, children's understanding of the reasons underlying inaccuracy appears to be associated with their theory of mind (Robinson & Nurmsoo, 2009).

The number of such findings in the recent literature suggests that there exists some link between mental state understanding and performance on at least *some* selective learning tasks. So far, however,

no study has attempted to specifically contrast the predictive value of theory of mind for selective learning based on different attributes. We sought to provide such a test. More specifically, we hypothesize that, if theory of mind is involved in children's selective learning, it should specifically predict the use of cues that are *relevant* to the domain of learning and *epistemic* in nature. For instance, in a novel word learning situation, children with advanced theory of mind should be superior at using an individual's past labelling accuracy to moderate their learning, because these children would be able to attribute greater *verbal knowledge* to a more accurate individual. However, we would not expect theory of mind to be related to children's use of attributes that are not related to epistemic knowledge of words.

We thus tested whether preschoolers' performance on theory-of-mind tasks equally predicts a preference for selective learning based on a domain-relevant epistemic attribute, specifically informant accuracy at labelling, and a domain-unrelated non-epistemic attribute, specifically an informant's physical strength. Physical strength is an attribute that can distinguish individuals in terms of a certain type of competence, but is not intrinsically related to differences in knowledge. Children have been shown in recent work to use demonstrated individual differences in strength to answer knowledge-related questions, but less so than strength-related questions, suggesting that they differentiate the two domains (Hermes, Bich, Thielert, Behne & Rakoczy, 2015). Even if children overall prefer to learn from a stronger individual over a weaker one, children's propensity to use this cue should not be related to their skills at mental state understanding since responding to someone's physical strength (or other physical traits like attractiveness or size) does not require one to reason about that individual's knowledge or other mental states. Therefore, we predicted that individual differences in theory of mind would predict a greater use of informant accuracy to moderate learning but not of physical strength.

Method

Participants

Participants were 65 typically-developing children (M age = 50 months, range 43 – 58 months; 38 males) recruited from a university database. Four additional participants were not included in the final sample because of experimenter error. The majority of participants (62%) were identified solely as Caucasian of North American or European origin, with the remaining participants identified with one or several other ethnic origins (2 participants did not report ethnic origin). Our sample represented a wide range of parental income, educational and occupational categories. The sample size was decided a priori based on power calculations examining the sample size required to have a 80% chance of detecting a correlation of .30 (a number based on prior studies showing a relationship between ToM and selective learning; e.g., DiYanni & Kelemen, 2008).

Materials

Materials are illustrated in Figure 1. The two selective learning tasks required four child-like hand puppets and six unfamiliar objects, three familiar objects for the accuracy task (a toy car, spoon and cat), and three colourful cardboard boxes for the strength task. The theory of mind battery required a figurine of a man and pictures of cookies and carrots (Diverse Desires task), a woman figurine and pictures of a bush and a garage (Diverse Beliefs task), a girl figurine and a box containing a toy dog (Knowledge Access task), and a boy figurine and a Band-Aid box containing a toy horse (Contents False Belief task).

Procedure

Participants were seated in front of a puppet theatre. All participants first saw one of the two selective learning tasks (either Accuracy or Strength – counterbalanced between participants), followed by the theory of mind battery and finally the remaining selective learning task. The procedure took approximately 15 minutes. Below is a description of all tasks.

Selective learning: Accuracy.

Participants were first introduced to two child-like female hand puppets. During the familiarization phase, three familiar objects (toy car, spoon, toy cat) were presented one at a time. Following the presentation of the first object, each puppet provided a label, one which was accurate and the other inaccurate. This was repeated for the other two objects, with one puppet labeling all three familiar objects accurately and the other labeling the same objects inaccurately. The identity of the accurate and inaccurate puppets was counterbalanced across participants. Then, on each of the three test trials, the puppets were presented with a novel object, and gave conflicting novel labels (e.g., one puppet would call the object a “mirp” and the other would call it a “preek”). Participants were then asked to endorse one of the labels, and were prompted to point to one of the puppets if they did not answer immediately. They were given one point for each trial on which they endorsed the label provided by the previously accurate puppet, for a possible score between 0 and 3. After all three test trials, participants were asked to recall which puppet labelled the familiar objects accurately and inaccurately during the familiarization phase.

Selective learning: Strength.

This task was modelled after Fusaro et al. (2011). Participants were introduced to two new female puppets. During the familiarization phase, one box was presented and each puppet in turn attempted to lift the box, one successfully lifting it and the other visibly struggling and failing. This was repeated for two more boxes; one of the puppets (identity counterbalanced) successfully lifted all three boxes and the other puppet failed to lift all three. The three test trials were similar to those in the Accuracy task, with different novel objects and labels. Participants scored one point on each trial where they selected the same label as the stronger puppet, for a total score ranging between 0 and 3. After the test trials, participants were shown one of the boxes from the familiarization phase and prompted to recall which puppet successfully lifted and failed to lift the box.

Theory of mind scale.

We used the four easiest tasks from the battery by Wellman and Liu (2004): Diverse Desires, Diverse Beliefs, Knowledge Access, and Contents False Belief. Tasks were presented in a fixed order of increasing difficulty. In the Diverse Desires task, the experimenter presented a male figurine (Mr. Jones) and a picture of a carrot and a cookie. Participants were told that Mr. Jones was hungry and would like a snack. The participant was then asked to decide which snack they would prefer, and based on their response, they were then told that Mr. Jones prefers the opposite snack. The experimenter stated that Mr. Jones could only choose one snack, and the participant was asked which snack Mr. Jones would choose. One point was given if participants claimed that Mr. Jones would choose the snack that they themselves did not prefer.

In the Diverse Beliefs task, the experimenter presented a female figurine (Linda), a picture of some bushes, and a picture of a garage. The participant was told that Linda was trying to find her cat. The participant was then prompted to indicate where they thought the cat was hiding (in the bushes or in the garage), and then based on their response they were told that Linda thought her cat was hiding in the opposite location. The participant was then asked where Linda would look for her cat. The participant scored one point if they stated that Linda would look for her cat in the location opposite to their own belief.

In the Knowledge Access task, participants saw a box and were asked to guess the contents. They were then shown that there was a toy dog in the box. The experimenter then introduced the participant to a female figurine (“Polly”) and told them that Polly had never seen inside the box. Participants were asked whether Polly knew the contents of the box and whether she had seen inside the box. To score one point, the participant must have indicated *both* that Polly did not know what was inside the box *and* had never seen inside the box.

In the Contents False Belief task, the experimenter showed participants a Band-Aid box and asked them to guess what was inside the box. The experimenter then showed the participant that there

was really a horse inside the Band-Aid box. The experimenter then introduced the participant to a figurine (“Peter”), and told them that Peter had never seen inside the Band-Aid box. The participant was asked what Peter thought was in the box (Band-Aids or a horse) and whether Peter had seen inside the box. To score one point, participants had to conclude that Peter thought there were Band-Aids in the box *and* to correctly state that Peter had not seen inside the box. Finally, the scale score (out of four points) was calculated by summing points across all four tasks¹.

Results

Means and standard deviations for both selective learning tasks and the theory of mind scale are included in Table 1. One-sample t-tests showed that participants performed above chance on the Accuracy task, $t(64)=6.41$, $p<.001$, but not on the Strength task, $t(64)=-1.48$, $p=.145$, *ns*. On theory of mind trials, preschoolers performed above chance on Diverse Desires (85%; binomial $p<.001$) and Diverse Beliefs (69%; binomial $p=.003$), but were at chance on Knowledge Access (57%; binomial $p=.32$, *ns*) and below chance on Contents False Belief (35%; binomial $p=.025$).

We conducted two multiple linear regression analyses predicting performance on each selective learning task based on children’s age in months and the theory of mind scale (ToM). We included age as a predictor because older preschoolers tend to perform better than younger ones on theory of mind tasks (e.g., Wellman, Cross & Watson, 2001; Wellman & Liu, 2004; Wimmer & Perner, 1983) and many types of selective learning tasks (e.g., Brosseau-Liard & Birch, 2011; Fusaro et al., 2011; Koenig & Harris, 2005a). Including age as a predictor thus controls for any association between theory of mind and selective learning that is simply due to increasing age. Results of the regression analyses are

¹ Note that, to ensure the same approximate delay between the two selective learning tasks, all four theory of mind trials were administered instead of interrupting after the failure of a task as in Wellman and Liu (2004). We thus have a sum score out of 4 for all children. We also calculated the score as in Wellman and Liu (2004), giving points for all tasks that a child passed before the first failed task; this alternative score and the sum score were highly correlated ($r(65)=.867$), and repeating analyses using the alternative scale score (treated as an ordinal variable in an ANCOVA) instead of the sum score in multiple regression yielded the same pattern of results.

reported in Table 2. For Accuracy, the combination of predictors significantly predicted children's performance and accounted for 11.2% of the variance in selective learning. Both age in months ($\beta=.289$, $p=.017$) and ToM ($\beta=.243$, $p=.043$) were significant predictors. For Strength, the model and individual predictors were non-significant (age: $\beta=-.054$, $p=.67$, *ns*; ToM: $\beta=-.005$, $p=.97$, *ns*).

On the Accuracy task, 7 children failed either one or both memory questions (2 additional children were not asked one or both memory questions because of experimenter error). Theory of mind performance remains a significant predictor of performance on the accuracy task even if these 9 children are removed from the sample. Similarly, on the Strength task, 11 children failed one or both memory questions and 2 children were mistakenly not asked the memory question; neither variable significantly predicts performance on the Strength measure after removing these 13 children.

Furthermore, preliminary analyses did not find any effect of the identity of the informants or of the child's gender on performance on selective learning tasks, but there was a significant order effect on the Strength task: children were more likely to side with the stronger individual if the Strength task came at the beginning ($M=1.72$ trials) rather than at the end ($M=.85$ trials), $t(63)=3.06$, $p=.003$ (there was no order effect on performance on the Accuracy task, $t(63)=.29$, *ns*)². Because of the strong order effect on the Strength task, we additionally performed the regression for this task separately by order. Predictors remained non-significant in both orders: More specifically, theory of mind did not predict a greater propensity to learn from the stronger puppet in either the Strength First order, $\beta=.086$, $p=.64$, *ns*, or the Accuracy First order, $\beta=.106$, $p=.55$, *ns*. Power is of course lower when splitting the sample in two

² The weaker selection of the strong informant for those in the Accuracy First order appears to be due to a tendency for those who sided consistently with the accurate informant to then systematically side with the *weak* one – note that, in the experimental design, if the accurate puppet spoke first in the Accuracy task the weak puppet spoke first in the Strength task (and vice versa). This carry-over effect was not found in the reverse order, and likely explains why children did not significantly side with the strong puppet overall; if we remove the subset of children who show this pattern, the remaining children in the Accuracy First order side with the strong puppet at a rate comparable to those in the Strength First order ($M=1.65$ trials vs. $M=1.72$ trials), and similar to that found in past studies (e.g., Fusaro et al., 2011).

halves, but, as the observed effect sizes were small for both orders, it seems unlikely that the non-significance of the predictor is due to low power.

Finally, since we administered four different ToM tasks, we conducted exploratory analyses to evaluate which of these tasks best predicted children's selective word learning. Note that the four tasks differ not only in the type of mental state understanding they assess but also in their difficulty level, and that children's success was correlated across the different tasks. These analyses are thus not meant to definitely indicate which aspect of mental state understanding is responsible for individual differences in selective learning but rather to provide a preliminary exploration of this question. We conducted four ANCOVAs, each using children's selective learning on the Accuracy task as a dependent variable and success (pass/fail) on one of the four ToM tasks as a predictor, with age in months as a covariate. Controlling for age, only performance on the Diverse Beliefs task significantly predicted greater selective learning from the previously accurate informant, $F(1,62)=9.48, p=.003$ (all other $ps > .40$).

Discussion

The goal of the present study was to assess whether the development of social-cognitive abilities specifically relates to selective social learning based on relevant epistemic cues in a word-learning situation. We hypothesized that children with more advanced theory of mind would demonstrate a preference to use a domain-relevant epistemic cue, namely an informant's prior labelling accuracy, to decide from whom to learn new labels, but that theory of mind would not be related to the use of an irrelevant non-epistemic cue, namely physical strength, in selective word learning.

In line with our hypothesis, our results indicated that preschoolers with more advanced theory of mind were more likely to endorse novel word labels from a previously accurate informant over an inaccurate one. This finding is consistent with some prior research that found positive correlations between selective learning and theory of mind performance (e.g., DiYanni et al., 2012; Fusaro & Harris, 2008). Also following our prediction, results suggested that preschoolers' higher performance on theory-

of-mind tasks does not predict a preference for selective learning from physically stronger informants. Given that physical strength is inherently unrelated to an informant's word knowledge, it makes sense that preschoolers' ability to reason about mental states such as knowledge would not affect their use of this specific cue for source selection decisions. Our study is, to our knowledge, the first to simultaneously investigate and predict individual differences on several selective learning tasks. The fact that theory of mind predicts selective word learning based on prior labelling accuracy but not strength suggests that the relationship between mental state understanding and selective learning has to do with the interpretation of the specific cue differentiating the individuals, and not, for instance, a general tendency for children with better theory of mind to be more selective or more attentive to all possible attributes of individuals. We also specifically ensured that the predictive association between theory of mind and epistemic selective learning held even when controlling for age, thus ensuring that the association was not merely due to older children performing better on both tasks.

Contrary to some past work that assessed theory of mind strictly based on the ability to pass false-belief tasks, we included several behavioral tasks with different difficulty levels. We thus hoped to get a more comprehensive measure of theory of mind and better chart individual differences, especially since false belief tasks are notoriously difficult for younger preschoolers (Wellman et al., 2001) and might thus fail to uncover individual differences in theory of mind in the youngest children in our sample. Note that, though theory of mind significantly predicted children's performance on accuracy-based selective learning, the effect size of this predictor was quite small ($\beta=.243$). In fact, theory of mind and age together only accounted for slightly more than 10% of the variance on this selective learning task. Therefore, even though theory of mind does predict children's propensity to selectively learn from more accurate individuals, it clearly does not *completely* explain this ability, and there are likely many other variables influencing this selective learning propensity. Of course, some of these influences may not be of great theoretical interest (e.g., a child's idiosyncratic preference for one or the other puppet),

but much of the variance may be due to important social and cognitive attributes. Research on individual differences in selective learning is still very new, yet already interesting associations have been found with, for instance, inhibitory control (Jaswal et al., in press), categorical knowledge (Danovitch, 2013), attachment style (Corriveau et al., 2009) and parenting style (Tagar, Federico, Lyons, Ludeke & Koenig, 2014). The relative importance of these many variables, as well as the causal direction and mechanisms underlying these various associations, remain to be determined. Future research could administer various tasks examining individual differences in cognitive skills such as IQ, verbal ability, or executive functions in order to better determine the relative contribution of these different cognitive skills to selective learning.

Participants were significantly above chance on the selective learning task for labelling accuracy, but not on the selective learning task for strength. Note that preschoolers' preferential word learning from accurate labellers has been replicated in multiple studies with many methodological variations, but to our knowledge the use of strength in a selective word learning situation has only been investigated by Fusaro et al. (2011), and the effect in that study was only marginally significant. Note that in Fusaro et al. (2011), children did use puppets' past physical strength to guess who had performed an ambiguous lifting action; this, however, does not involve the learning of new information, but rather attributing an action to an individual. In the present research, in contrast, we specifically focused on cues used by children in a selective word *learning* situation. Our results are thus consistent with the non-significant findings of Fusaro et al. (2011). Still, future research could aim to replicate the present results with other attributes, perhaps other non-epistemic cues that children would use to a significant extent to moderate their word learning. For example, preschoolers have demonstrated a preference to learn from both attractive (Bascandziev & Harris, 2014) and familiar informants (Corriveau & Harris, 2009; Corriveau et al., 2009); if theory of mind similarly failed to predict the use of these non-epistemic cues in selective

learning, this would further support the position that mental state understanding contributes specifically to the use of *epistemic* cues in social learning preferences.

In conclusion, past work yielded mixed results in terms of the link between selective word learning and theory of mind. In addition to being consistent with prior research, our results additionally show that this relationship is specific to the use of verbal accuracy (a domain-relevant epistemic cue) and does not generalize to the use of physical strength (an unrelated non-epistemic cue). The present study thus lends support to the position that more advanced mental reasoning plays a significant role in selective social learning from individuals showing knowledge-related attributes.

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Table 1. Descriptive statistics for study variables.

Task	Range	<i>M</i>	<i>SD</i>
Accuracy	0-3	2.28	.98
Strength	0-3	1.28	1.22
Theory of mind scale	0-4	2.46	1.06

Table 2. Results of multiple linear regression models predicting total score on selective learning tasks.

Selective Learning Task	<i>F</i>	<i>P</i>	Adjusted <i>R</i> ²	Predictor	Unstandardized <i>B</i>	β	<i>p</i>
Accuracy	5.02	.010*	.112	ToM Scale	.224	.243	.043*
				Age in Months	.066	.289	.017*
Strength	.09	.914	-.029	ToM Scale	-.006	-.005	.969
				Age in Months	-.015	-.054	.674

Figure 1. Materials.

Selective Learning - Accuracy



Selective Learning - Strength



ToM Scale

