That'll Teach 'em: How Expectations about Teaching Styles may Constrain Inferences

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Abstract

How do learners' expectations about teachers' informativeness shape subsequent learning? Here, we suggest that expectations about teaching style may constrain learning through inferences over (1) the amount of information to be learned, and (2) the importance of the demonstrated information. Adult behavioral data from two experiments conform with our predictions: Given a single pedagogical demonstration, as teachers were expected to share less information, adults inferred that there should be more additional information to be learned, and greater importance of the demonstrated information. Modeling of these results sheds insight into how adults may be making these inferences, and provides a framework with which we may predict future results of children's exploration following pedagogical demonstrations from different teachers.

Keywords: pedagogy, guided play, learning, modeling

Introduction

Children learn a lot in an incredibly short period of time. Before entering formal schooling, they have impressive knowledge of the names of objects, causal relationships, and language, just to name a few. While this feat of learning may seem impossible, young learners have an exceptional resource at their disposal: The existing knowledge of other people. Indeed, young children are highly adept at seeking out and learning from others (Harris, 2002; Clément, Koenig, & Harris, 2004; Csibra & Gergely, 2009). One robust finding from this epistemic trust literature is that young children prefer to learn from teachers who are fully informative over those who omit information (Bass, Bonawitz, & Gweon, 2017; Gweon, Pelton, Konopka, & Schulz, 2014; Gweon & Asaba, 2017). Consider, for instance, the findings from Gweon et al. (2014): Six-year-olds rated teachers who provided true but under-informative evidence as worse than teachers who provided complete evidence. Furthermore, after seeing an informant pedagogically demonstrate one function on a novel toy, children explored that toy more if that teacher had previously omitted information (as opposed to providing complete information), presumably because children did not trust that informant to be fully informative. These results highlight children's sensitivity to how others teach, and their flexibility in learning from different kinds of teachers.

Taken together, however, these two sets of findings from Gweon et al. (2014) represent something of a conundrum. On the one hand, children prefer to learn from fully informative teachers; on the other hand, if a child *expects* a teacher to omit information, she may actually explore and learn *more* than a child who assumes her teacher will be fully informative. This raises the question, how and when might learners leverage information about different teachers to draw inferences from new pedagogical demonstrations? Here, we will make two main claims. First, we will suggest that learners' *expectations* about their informant's teaching style critically influence how learners interpret the meaning of subsequent demonstrations for new events. Second, extending past computational work, we will propose that learners use informants' demonstrations to make inferences both about the *amount* of information that remains to be discovered, as well as the relative *importance* of the demonstrated information.

The Sampling Assumption

Past computational work on the development of pedagogical reasoning (namely, Shafto & Goodman, 2008) has conceptualized pedagogy as a set of mutually dependent inferences: The teacher, or "informant", pedagogically samples evidence that maximizes the learner's belief in the target hypothesis, and the learner rationally updates her belief in that hypothesis with the assumption that the evidence has been sampled pedagogically. This *sampling assumption* leads to a strong expectation that the teacher has provided necessary and sufficient evidence for the learner to infer the correct hypothesis — if there were more evidence to be seen, a good teacher would have shown it.

This expectation for teachers to be fully informative is so strong that pedagogy may actually *constrain* exploration in some contexts. For example, in Bonawitz et al. (2011), a teacher showed children just one function on a novel toy with several non-obvious functions; this demonstration was framed either as pedagogical (e.g., "That's how my toy works!"), or accidental (e.g., "Oops! Did you see that?"). In the pedagogical context, children were more likely to restrict their exploration to the demonstrated function, reflecting their inference that the toy only had as many functions as the teacher showed them. This is the pedagogical model's sampling assumption at work.

Without any other available information, then, children likely *assume* that most teachers will be fully informative — and rationally so. But ideal learners should also take into consideration how an informant tends to teach and then use this information to interpret the implication of new demonstrations, as in Gweon et al. (2014). In particular, an implicit potential implication of the pedagogical sampling assumption is that as a teacher provides less complete information, the weaker the pedagogical bias should be, and thus the weaker the constraints on the inferred number of functions from novel demonstrations. That is, ideal learners shouldn't let demonstrations from "bad" teachers constrain their beliefs; rather, they should use their prior knowledge about how an informant *tends* to teach in order to guide the inferences made from that informant's demonstrations. However, this idea has yet to be directly tested empirically.

What is Inferred?

While learners' expectations about teachers' informativeness may modulate the amount of information they believe remains to be discovered, there are likely also other inferences that learners make during pedagogical demonstrations. For example, past work typically looks at children's total play time, the number of unique actions performed, and the proportion of time spent fixating on the demonstrated function as an implicit quantification of a learner's expectations about the number of functions (Bonawitz et al., 2011). However, informants' demonstrations may also provide some information about the *importance* of knowing about some functions over others. For instance, if a learner is shown that a toy can squeak and is then allowed to explore the toy, she might initially fixate on the squeaker because she thinks it is one of the only things that the toy can do, *but also* because she thinks the squeaker is somehow especially important to know about.

Critically, whether a learner interprets a demonstration as conveying importance or exhaustive evidence should depend on how they expect the informant to teach (i.e., their teaching style). Interestingly, both highly informative and underinformative teachers may result in play that focuses on just the demonstrated function, albeit for different reasons. A demonstration from a teacher who always provides complete information would convey strong evidence about the number of functions on the toy, thus constraining exploration of other aspects of the toy. However, the same demonstration from an informant who is expected to show nothing should be particularly surprising (*"Why suddenly show me something now?"*). Such a demonstration may convey a high degree of importance on the demonstrated function, and thus potentially encourage this learner to focus on just that function during play. However, because exploratory learning problems in past work have been captured by indirect measures (such as variability of action and time spent on demonstrated functions), we cannot currently disambiguate functional or importance inferences, which are confounded with these measures.

This interpretation of exploration reflecting a trade-off between inferences over amount and importance provides one plausible factor that improves learning from the expectation of partially informative instruction: It strikes a "sweet spot" between fully informative instruction, which curbs exploration through learners' inferences about the amount of information, and fully uninformative instruction, which may do so through the implied importance of the demonstration. This would also be consistent with prior educational research on teaching styles suggesting that children's learning outcomes may be superior in *Guided Play* formats, as compared with *Direct Instruction* and *Free Play* (Honomichl & Chen, 2012; Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013). While there are numerous components that factor into "ideal guidance" in Guided Play, such as the timing and content of information, one important characterization is the idea that Guided Play teachers provide scaffolding for learners, but let much of the choice for exploration remain child-led (Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Guided Play thus necessarily results in teachers who provide incomplete information, as children are encouraged to discover on their own. This is in contrast to Direct Instruction, which is on the "fully informative" end of the teaching-style spectrum, wherein the teacher imparts complete information to a largely passive learner; and Free Play, which is on the "fully uninformative" end, wherein children play independently and self-direct their learning.

Current Work

Although past work on epistemic trust has explored how past experience with *misleading* informants affect inferences, to our knowledge, no formal account has captured how past experience with teaching *styles* informs assumptions about features given novel demonstrations. A critical difference is that although teachers may not always provide complete information, in the current studies, learners are always capable of discovering truth, and are not actively misled by teachers. Thus, the first goal of this paper is to empirically investigate how expectations about informants' teaching styles may affect inferences about the amount of information to be learned and the importance of the demonstrated information. Second, we will aim to explore how these inferences could be captured computationally. This modeling aspect will be key for understanding the underlying processes that allow learners to make these inferences, and will aid us in making specific predictions in future work with children.

Experiment 1

In Experiment 1 we ask whether, given identical pedagogical demonstrations, adults differentially infer the amount of information to be learned (here operationalized as the number of functions on a novel toy) based on what they know about their informant's teaching style. We tested three teaching styles: Free Play, Guided Play, and Direct Instruction. Among other factors described below, these teaching styles were characterized by the degree to which the teacher was fully informative. We predict that the number of inferred functions should be highest following a demonstration from a teacher who is expected to utilize Free Play, and lowest when learning from a Direct Instruction teacher, with Guided Play falling in between. We also collected data from a separate group of participants who received no information about teachers or toys, in order to assess people's prior beliefs about how many functions children's toys typically have.

Method

Participants Adult participants were recruited from Amazon Mechanical Turk. Our final sample consisted of 200 participants (Age: $M = 34.4, SD = 10.5$, range: 19-76 yrs; 88 female), with 50 in each of three experimental conditions (paid $0.60 for completing the five-minute study), and 50 participants in one additional shorter "priors" condition (paid $0.25). An additional 76 participants were run, but dropped for failure to pass memory and attention checks.[1]

Procedure In the experimental conditions, participants were first familiarized with a simple children's toy, which had four buttons that made small animals pop out of it, and one non-functional slider. After answering check questions to ensure they understood how the toy worked, participants watched three videos of different adult actors teaching child actors (aged 4- to 6-years-old) about this toy. In the *Direct Instruction* video, the teacher shows the child everything about the toy. In the *Guided Play* video, the teacher shows the child one thing about the toy, and then encourages the child to explore ("What else can it do?"), while also providing some structure in the form of feedback and pedagogical questions (Yu, Bonawitz, & Shafto, 2017). In the *Free Play* video, the teacher does not show the child anything about the toy, and the child explores completely unaided. The order of the actors in these three videos was always the same, while teaching style was fully counterbalanced across the videos. The third teacher that participants saw was the *Test Teacher*; thus, whatever teaching style the Test Teacher used determined the experimental condition (*Direct Instruction, Guided Play*, or *Free Play*). Importantly, the child actors proceeded to learn about (or self-discover) all possible functions of the toy in all three conditions. Thus, teachers were not better or worse as judged by the child actors' learning outcomes, but simply varied on the style with which information was imparted.

After watching all three videos, and answering check questions to ensure they remembered each informant's teaching style, participants were told that the last informant that they had seen (the Test Teacher, whose teaching style varied by experimental condition) had a new toy that she wanted to teach them about. Participants were asked to imagine that the teacher showed them one thing that this toy could do.[2] Thus, the "pedagogical demonstration" was equivalent across all three conditions — all that varied was participants' expectations about the Test Teacher's teaching style. Finally, participants were asked the critical question: Without knowing anything else about this new toy, given what they knew about this informant's teaching style, and that she had just shown them one thing that the toy could do, how many functions did they think were on this new toy? Participants typed their numerical estimates into a text box.

In the priors condition, participants were not shown any videos of teachers. Instead, they were simply asked to input

[1]These exclusion rates are typical for mTurk workers performing specialized tasks with technical demands, such as watching videos.

[2]In the developmental literature, children are typically shown novel toys with an ambiguous number of functions. However, because adults have strong expectations about functional affordances, we instead asked them to imagine a toy, in order to achieve a similar level of ambiguity.

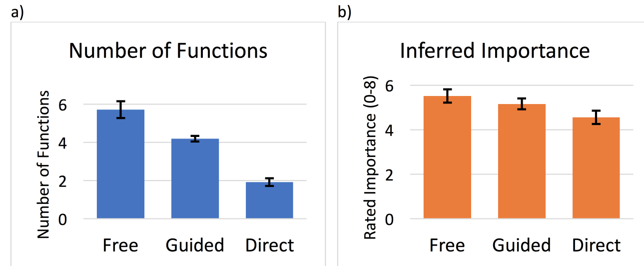

Figure 1: a) The number of functions (Experiment 1), and b) the importance of the demonstrated function (Experiment 2) inferred by participants across teaching styles. Error bars represent standard errors.

the number of functions they thought would be on a typical children's toy. These results are reported in the Modeling section below.

Results

We first examined the qualitative findings from the experimental conditions: Would participants infer different numbers of functions on a toy given identical pedagogical demonstrations from informants with different teaching styles? A one-way ANOVA revealed significant group differences, $F(2,147) = 41.3, p < .001, \eta^2 = .36$. Post-hoc Tukey pairwise comparisons revealed significant differences between all three conditions: Participants in the Free Play condition ($M = 5.72, SD = 3.17$) inferred significantly more functions than those in the Guided Play condition ($M = 4.2, SD = 1.03$), who in turn inferred more functions than those in the Direct Instruction condition ($M = 1.92, SD = 1.48$), all $ps \leq .001$. We additionally found a significant linear trend across conditions, $p < .001$. See Figure 1a.

Given identical pedagogical demonstrations, then, participants differentially inferred how many functions they thought were on the toy, based on how they expected that particular informant to teach. In line with our predictions, the less information an informant was expected to provide, the more functions participants thought there might be to discover.

Experiment 2

In Experiment 2, we ask whether participants' inferences about the importance of demonstrated information is affected by expectations about the informant's teaching style. Participants should judge information shown by a Free Play teacher to be most important, since this teacher is not *expected* to explicitly demonstrate anything.

Method

Participants Adult participants were recruited from Amazon Mechanical Turk, and were paid $0.60 as compensation for their participation. Eighty-nine participants were dropped and replaced for failure to pass memory and attention checks; our final sample consisted of 150 participants, with 50 in each of three experimental conditions (Age: $M = 37.5, SD = 11.6$, range: 19-72 yrs; 72 female).

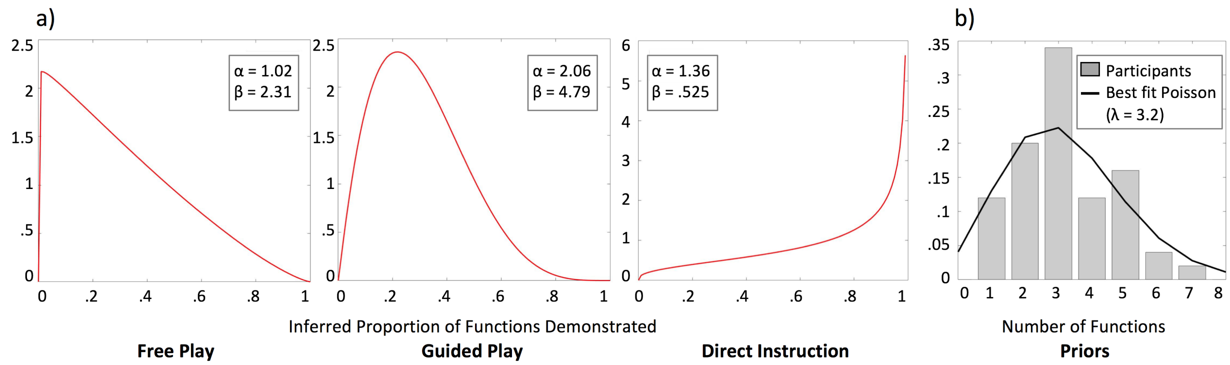

Figure 2: a) PDFs for Beta distributions with the best fit parameters recovered from the behavioral data in Experiment 1. b) Participants' prior beliefs about the number of functions on toys, along with the best-fit Poisson distribution.

Procedure The procedure was identical to Experiment 1, except for the final question. Instead of being asked about the number of functions on an imaginary toy, participants were asked how *important* they thought the demonstrated function was to know about, given what they knew about the Test Teacher's teaching style. Participants provided their responses on a Likert scale (0-8).

Results

We wanted to know whether expected teaching style influenced participants' importance ratings. A one-way ANOVA revealed marginally significant group differences, $F(2,147) = 2.89, p = .059, \eta^2 = .04$. Post-hoc Tukey pairwise comparisons revealed significant differences between the Free Play ($M = 5.52, SD = 2.14$) and the Direct Instruction conditions ($M = 4.56, SD = 2.15$), $p = .048$. Thus, participants believed the demonstration to be more important when it was provided by a teacher who was expected to provide no information whatsoever as compared with an informant who was expected to share everything. No significant differences were found between the Guided Play condition ($M = 5.16, SD = 1.75$) and either of the other two conditions, $ps \geq .30$. However, there was a significant linear trend across conditions, $p = .019$. See Figure 1b.

While the effects are more subtle than those from Experiment 1, results suggest that participants are using their expectations about an informant's teaching style to inform their inferences about the importance of that informant's demonstrations. In particular, Free Play and Direct Instruction appear to be on opposite ends of a spectrum, such that learners believe demonstrations are more important the less they expect their teacher to share.

Modeling

Number of Functions

To formalize our intuitions and gain insight into the how individuals may have inferred the number of functions on the toy, we wish to infer people's beliefs about the proportion of functions demonstrated from their judgments about the total number of functions. We formalize individuals' judgments within each condition as samples from a common prior. Because proportions range from zero to one, a Beta distribution is a natural choice for these beliefs. We computed the maximum likelihood estimates (MLEs) of Beta distribution parameters α and β from participants' responses in each of the three conditions in Experiment 1. To map to the Beta distributions, which must range from 0 to 1, we transformed participants' responses from a raw number of functions into the *proportion* of functions they thought the teacher had shown with their single pedagogical demonstration — e.g., if a participant thought the toy had 2 functions, their response was recoded as 0.5, because having seen a single demonstration given an inference of 2 functions implies the teacher presented half of the information.[3] The resulting maximum likelihood α and β parameter values from the test results across conditions reflect our intuitions about the initial teaching demonstrations: Participants in the Free Play condition ($\alpha = 1.02, \beta = 2.31$) were best fit by a Beta distribution with a higher probability of showing a low proportion of functions, while the distribution for the Direct Instruction condition ($\alpha = 1.36, \beta = .525$) peaked much closer to 1, and Guided Play fell in the middle ($\alpha = 2.06, \beta = 4.79$; see Figure 2a).

How well do these Beta distributions capture our behavioral data? To answer this question, we must incorporate information about participants' *prior* beliefs about the number of functions toys have in general. Following past work (Bonawitz et al., 2011), we fit a Poisson distribution to participants' responses in the priors condition; MLE for $\lambda = 3.2$ (see Figure 2b). These prior beliefs, together with the estimated likelihoods, allow us to compute the predicted posterior distribution on the number of functions participants entered. We correlated the estimated posterior of each possible ratio estimate to the proportion of participants who provided responses consistent with those ratios. These correlations between estimated posteriors and participants' actual responses were significant in all three conditions (all $r(18) \geq .44$, all $p \leq .05$; see Figure 3). This model thus effectively cap-

[3] We added a small $\varepsilon = -.05$ noise to scores of 1 to ensure that the Beta likelihood function is not unbounded at these points, and thus standard MLE is possible.

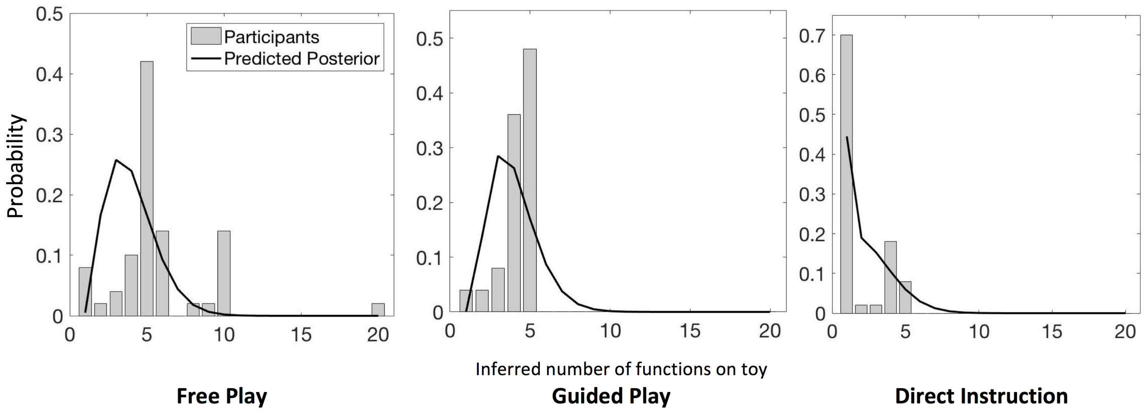

Figure 3: Estimated posteriors, with histograms of responses for the estimated number of functions in Experiment 1.

tures participants' inferences about the amount of information there is to be learned, given an informant's demonstrations and their expected teaching style. This suggests that human behavior approximates rational solutions that integrate information about teaching ratios with prior beliefs about functions to compute updated posteriors given new observations.

Importance

What exactly does it mean from a modeling perspective for information to be "important"? While there are a variety of factors that may be relevant (including the cost of demonstration; see Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016), here we designate *surprise* as a proxy for importance. This is because we assume that importance is inferred in order to *explain away* surprising evidence (at least in this learning context with a novel toy). When a learner is faced with a sudden shift in distributions (as when a prior belief holds that a toy has relatively few functions, but a new observation suggests there are instead many functions), she may either radically update her beliefs, or attempt to explain away the observation in order to maintain her beliefs. Importance provides a mechanism by which a sudden increase in the expected number of functions can be explained away. Thus, we quantify surprise (and thus importance) as the shift from the prior distribution (as given by the Poisson fit to our empirical data from the Priors condition) to the updated likelihood (given by the demonstration and the inferred teaching style). To quantify this shift, we computed the mean squared error (MSE) between these pairs of distributions for each condition. The MSE was highest in the Free Play condition (.073), lowest in the Direct Instruction condition (.053), with Guided Play falling in between (.062). Inferred importance of the demonstration as captured by this formalization is therefore predicted to be highest in Free Play, mirroring behavioral results from Experiment 2.

Discussion

From early childhood through adulthood, humans rely on others for information — and, as many of us have likely experienced, there is a great deal of variability in how other people may choose to present that information. An extensive literature on epistemic trust has investigated how learners flexibly integrate diverse information about others and the evidence they've provided to draw inferences that go far beyond the face value of that evidence. Here, we demonstrate one role of learners' expectations in this complex inference process, and reveal adult learners' ability to use these expectations to guide inferences about unobserved features of problems, and titrating inferences about the importance of what has been demonstrated. In line with our predictions, participants inferred that there was more information to be learned from teachers who shared less information in prior contexts. Participants also inferred greater importance of the demonstrated information from teachers who shared less information previously. Our computational modeling approached this problem directly, by attempting to characterize what people might expect based on past experience with an informant, and how that would affect interpretation of behaviors that were surprising. In line with past work, these findings provide yet another piece of corroborating evidence that people are highly skilled at making subtle social inferences, informed by past experience, based on what is done, not done, and expected to be done.

The models presented are informative from a cognitive perspective, in that they suggest that adults are approximating rational solutions to these complex social inference problems. These models may be used to make quantitative predictions for the inferences we might expect learners to make in yet untested conditions. This is an exciting prospect, given that this is the first formal account to our knowledge that captures how past experience with teaching styles may simultaneously inform inferences about importance and the number of additional features. Future work will ultimately aim to develop a comprehensive computational model, which captures additional relevant factors that may constrain learners' interpretations of pedagogical demonstrations across learning contexts. It will also be important to think carefully through the intricate dependencies that are likely at play here — for instance, how the importance of observed features is dependent on the number of unobserved features will be critical to identify in order to formulate a comprehensive model that captures expectations about teaching styles.

The current findings have clear developmental implications. Given children's reliance on others, it will be critical to understand young learners' expectations about different kinds of informants (e.g., caregivers, peers, teachers, etc.), and how these expectations manifest in pedagogical demonstrations across contexts. For example, even with such brief exposure, adults in the current work readily used their experience with the test teacher to guide their inferences. However, adults have likely experienced many types of teaching. If constrained by limited experiences with teachers (such as in early childhood, when children primarily encounter only their own parents as informants), children's assumptions about how teachers act in general could be strongly constrained, shaping expectations in new learning environments from new informants. Particularly relevant to this point is a recent finding identifying a multitude of individual difference factors that predict the kinds of teaching styles parents tend to use with their children (Yu et al., 2017). Given the results presented here, one could imagine that children in formal schooling environments might interpret the information provided by their teachers differently, depending on what kinds of teaching styles they expect (i.e., the teaching style they are accustomed to at home). Our findings may thus inform debates about "one size fits all" education systems, suggesting another point of nuance that should be considered in these arguments. It will likely be important for future work seeking to answer these deep questions about education and learning to also draw from computational literatures, in order to better understand the various factors that are trading off to influence individual children's learning outcomes.

These findings predict an exploratory "sweet spot" for learners who expect to be provided with partially informative evidence. This is because learners may infer that non-demonstrated functions are likely to exist while not putting too much weight on the importance of demonstrated functions. In contrast, learners who are used to fully informative teachers may believe a newly demonstrated function is not important (and thus not worth time to explore), but will also have strong beliefs that there are few other functions to be discovered, thus squelching exploration altogether. In contrast (but with similar consequences), learners who are used to non-informing teachers may believe that there are myriad possible other functions to discover, but may forgo exploration given strong assumptions about the importance of learning about a demonstrated function. This "pedagogical Goldilocks" effect between these extremes may help to explain one factor that could contribute to the recent success of Guided Play approaches. To the degree to which Guided Play is characterized by a balance between adult demonstrations and encouraged child-led discovery, learners may make inferences predicted by this interaction captured by our account. Future work should explore these predictions.

We set out to address how expected informativeness might affect learning outcomes, but many questions remain: How might guided play approaches such as pedagogical questions enhance learning (Yu et al., 2017)? How can feedback be optimally structured to encourage further exploration (Honomichl & Chen, 2012)? Why do children learn better when they take an active role in directing their own learning experience (Sim, Tanner, Alpert, & Xu, 2015)? We hope that the results from the current analysis may help to inform future work in these exciting domains, and highlight how modeling can be used as a tool with which to tackle these deep questions about how children learn.

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References

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology*, *103*(1), 1–18.

Bass, I., Bonawitz, E., & Gweon, H. (2017). Didn't know, or didn't show? Preschoolers consider epistemic state and degree of omission when evaluating teachers. *Proceedings, 39th Conference of the CogSci Soc*.

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition*, *120*(3), 322–330.

Clément, F., Koenig, M., & Harris, P. (2004). The ontogenesis of trust. *Mind and Language*, *19*(4), 360-379.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *TiCS*, *13*(4), 148–153.

Fisher, K. R., Hirsh-Pasek, K., Newcombe, N., & Golinkoff, R. M. (2013). Taking shape: Supporting preschoolers' acquisition of geometric knowledge through guided play. *Child Development*, *84*(6), 1872–1878.

Gweon, H., & Asaba, M. (2017). Order matters: Children's evaluation of under-informative teachers depends on context. *Child Development*.

Gweon, H., Pelton, H., Konopka, J. A., & Schulz, L. E. (2014). Sins of omission: Children selectively explore when teachers are under-informative. *Cognition*, *132*(3), 335–341.

Harris, P. (2002). What do children learn from testimony? In P. Carruthers, S. Stich, & M. Siegal (Eds.), *The cognitive basis of science.* Cambridge University Press.

Honomichl, R. D., & Chen, Z. (2012). The role of guidance in children's discovery learning. *Wiley Interdisciplinary Reviews: Cognitive Science*, *3*(6), 615–622.

Jara-Ettinger, J., Gweon, H., Schulz, L. E., & Tenenbaum, J. B. (2016). The naïve utility calculus: Computational principles underlying commonsense psychology. *TiCS*, *20*(8), 589-604.

Shafto, P., & Goodman, N. (2008). Teaching games: Statistical sampling assumptions for learning in pedagogical situations. *Proceedings, 30th Conference of the CogSci Soc*.

Sim, Z. L., Tanner, M., Alpert, N. Y., & Xu, F. (2015). Children learn better when they select their own data. *Proceedings, 37th Conference of the CogSci Soc*.

Weisberg, D. S., Hirsh-Pasek, K., & Golinkoff, R. M. (2013). Guided play: Where curricular goals meet a playful pedagogy. *Mind, Brain, and Education*, *7*(2), 104–112.

Yu, Y., Bonawitz, E., & Shafto, P. (2017). Pedagogical questions in parent–child conversations. *Child Development*. doi: 10.1111/cdev.12850