# Children's social learning is active learning: social contexts shape learners' choices

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# Abstract

Children's rapid conceptual development is one of the more remarkable features of human cognition. How do they learn so much so quickly? Social learning theories argue for the importance of learning from more knowledgeable others. In contrast, active learning accounts focus on children's learning via exploration and the testing of hypotheses. In this paper, I argue that an important step towards a complete theory of human learning is to understand how active learning behaviors unfold within fundamentally social learning contexts. To integrate the two accounts, I use a framework of rational decision making that emphasizes the role of utility (i.e., costs and benefits of an action) for explaining choice behavior. The key insight is that social learning is not separate from active learning, and the costs/benefits of children' decisions about what to learn are shaped by interactions with other people.


*Keywords:* human learning, active learning, social learning, decision making, theory

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## Introduction

Human learning is remarkable. Consider that children, despite striking limitations in their general processing capabilities, are able to acquire new concepts at a high rate eventually reaching an adult vocabulary ranging between 50,000 to 100,000 words (P. Bloom, 2002). And they do this while also developing motor skills, learning social norms, and building causal knowledge. What sorts of processes can account for children's prodigious learning abilities?

Social learning theories offer a solution by pointing out that children do not solve these problems on their own. And although children learn a great deal from observation, they are typically surrounded by parents, other knowledgeable adults, or older peers – all of whom likely know more than they do. These *social* contexts can bootstrap learning via several mechanisms. For example, work on early language acquisition shows that social partners provide input that is tuned to children's cognitive abilities (Eaves Jr, Feldman, Griffiths, & Shafto, 2016; Fernald & Kuhl, 1987), that guides children's attention to important features in the world (Yu & Ballard, 2007), and that increases levels of arousal and sustained attention, which lead to better learning (P. K. Kuhl, 2007; Yu & Smith, 2016).

Social contexts can also change the computations that support children' learning from evidence. Recent work on both concept learning and causal learning suggests that the presence of another person leads the learner to reason about *why* people perform certain actions. The key insight is that knowledge of the underlying process that generates information allows learners to make more appropriate inferences to facilitate learning (Bonawitz & Shafto, 2016; Frank, Goodman, & Tenenbaum, 2009; Shafto, Goodman, & Griffiths, 2014). For example, people will draw different inferences from the same observations depending on whether they think that the behavior was accidental or intentional. Moreover, adults and children will make even stronger inferences if they think an action was selected with the goal to help them learn (i.e., teaching) (Shafto, Goodman, & Frank, 2012).

However, children are not passive recipients of information – from people or from the world. Instead, children actively select behaviors (e.g., ask questions, choose where to allocate attention) that modulate the content, pacing, and sequence of information they receive. In fact, recent theorizing and empirical work in cognitive development conceptualizes early learning as an active process of exploration and hypothesis testing similar to the scientific method (Gopnik, Meltzoff, & Kuhl, 1999; Schulz, 2012). Moreover, recent empirical work across a variety of domains (education, machine learning, and cognitive science) has begun to explore the benefits of self-directed choice for speeding learning outcomes via an increase in attention/arousal (CITE) during learning or by providing better information that is more tightly linked to the learners' cognitive state and interests (Castro et al., 2009; Markant & Gureckis, 2014; Settles, 2012).

Thus, both social and active contexts can facilitate learning by engaging distinct learning processes and by providing the learner with better information. But real-world learning involves a complex mixture of these processes that unfolds over multiple timescales. One important challenge for understanding human learning is to precisely characterize the mutual influence of social learning contexts and children's developing ability to exert control over their environment. In this paper, I argue that learning from social contexts can be productively construed as providing opportunities for *constrained* *active learning.* The key insight is that the presence of other people can qualitatively change the cost-benefit calculus of learners' choices, which in turn shapes children's input and the subsequent social context.

The plan for the paper is as follows. I first review evidence of the effects of social learning across a variety of learning domains. I also present three different mechanisms through which social contexts facilitate learning: attentional, informational, and inferential. In part II, I discuss work on active learning that explores the influence of giving people control over the learning environment. In part III, I integrate the social and active learning accounts using ideas from formal models of decision making that emphasize the utility structure of different actions available to the learner. I conclude by presenting a conceptual analysis that explores the utility of a variety of choice behaviors available to young learners in real-world social learning contexts.

## Part I: The power of learning from other people

Children's conceptual development is faster and more flexible compared to any other species. Why is this the case? Social learning theories argue that a key factor is humans' unique capacity to transmit and acquire information from other people.[1] One of the primary benefits of this cultural learning process is that learners gain access to knowledge that has accumulated over many generations: information that would be far too complex for any individual to figure out on their own (Boyd, Richerson, & Henrich, 2011). Moreover, social contexts can facilitate learning because more knowledgable others can select input to best support children's learning (Kline, 2015; Shafto et al.,

[1] In this paper, I define "social" contexts as learning environments where another agent is present. This definition includes a broad range of social learning behaviors: e.g., observation, imitation, and learning from direct pedagogy.

2012), providing learning opportunities filled with generalizable information (Csibra & Gergely, 2009).

A large body of empirical work on children's learning shows the effect of social contexts on a variety of learning domains – emotional, cognitive, and linguistic. However, these effects manifest through different pathways, such as guiding attention, increasing arousal, selecting better information, and changing the strength of children's inferences. In this section, I present a brief, high-level overview of the evidence supporting the role of each of these social learning processes, with the goal of synthesizing different explanations for the benefits of social learning.

**Social interactions enhance attention.** From infancy, humans are preferentially attend to input that comes from other people. For example, in the visual domain, newborn infants prefer to attend to face-like patterns compared to other configurations (Johnson, Dziurawiec, Ellis, & Morton, 1991) and will even show a preference for faces that make direct eye contact compared to faces with averted gaze (Farroni, Csibra, Simion, & Johnson, 2002). In the language domain, newborns prefer to listen to speech over non-speech stimuli (Vouloumanos & Werker, 2007), their mother's voice over other voices (DeCasper, Fifer, Oates, & Sheldon, 1987), and infant-directed speech over adult-directed speech (Cooper & Aslin, 1990; Fernald & Kuhl, 1987; Pegg, Werker, & McLeod, 1992). Moreover, recent work by Yu & Smith (2016) using head-mounted eye tracking found that one-year-olds sustained visual attention to an object longer when their parents' had looked at that object.

These attentional biases lead to different outcomes in social learning contexts. For example, 4-month-olds' show better memory for faces if that face gazed directly at them as compared to a less-social, averted-gaze condition (Farroni, Massaccesi, Menon, & Johnson, 2007). Moreover, 4-month-olds' memory for objects is enhanced if an adult gazed at that object during learning (Cleveland, Schug, & Striano, 2007; Reid & Striano, 2005). And 7-month-olds more easily segment words from infant-directed speech compared to adult-directed speech (Thiessen, Hill, & Saffran, 2005).

P. K. Kuhl (2007) refer to these sorts of effects as "social gating" phenomena since the presence of another person activates children's computational learning mechanisms. One striking piece of evidence of the social gating hypothesis comes from a study of infants' foreign-language phonetic learning. In this experiment, P. K. Kuhl, Tsao, & Liu (2003) exposed 9-10 month-old English-learning infants to Mandarin speakers either via live interactions or via audiovisual recordings and measured their ability to discriminate Mandarin-specific phonemes two months later. Only the infants who were exposed to Mandarin within the social interactions were able to succeed on the disrimnation task; whereas, infants in the audiovisual recording condition showed no evidence of learning. P. K. Kuhl et al. (2003) also showed that infants in the social interaction condition exhibited higher rates of visual attention to the speaker, suggesting that the social contexts enhanced learning by increasing children's attention to the input.

The common thread across these findings is that the presence of another person is a particularly good way of increasing attention. In this model, social input is more salient and therefore more likely to come into contact with children's general learning mechanisms. However, increases in arousal, attention, and memory are only one way that social contexts can influence early learning. In fact, one of the defining features of early learning environments is the presence of other people who know more than the child. This creates an opportunity for more knowledgable others to select learning experiences that are particularly beneficial – either because the information is tuned to children's current cognitive abilities or because the information is likely to be generalizable. ### Social interactions provide "good" information

The notion that children's input might be shaped to facilitate their learning is a key tenet of several influential theories of cognitive development (e.g., Vygotsky's *Zone of Proximal Development* (Vygotsky, 1987), Rogoff's *Guided Participation* (Rogoff et al., 1993), and Csibra & Gergely's *Natural Pedagogy* (Csibra & Gergely, 2009)). But how do social interactions provide particularly useful information for children's learning?

A particularly compelling set of evidence comes from studies of how caregivers alter the way they communicate with young children, which in turn helps children solve a variety of language learning problems. That is, adults do not speak to children in the same way as they speak to other adults; instead, they exaggerate prosody, reduce speed, shorten utterances, and elevate both pitch and affect (see (Fernald & Simon, 1984) for a review). And subsequent empirical work has shown that these features of "infant-directed speech" facilitate vowel learning (Adriaans & Swingley, 2017; De Boer & Kuhl, 2003), word segmentation (Fernald & Mazzie, 1991; Thiessen et al., 2005), word recognition (Singh, Nestor, Parikh, & Yull, 2009), and word learning (Graf Estes & Hurley, 2013).

In addition to the findings on infant-directed speech, work on infants' early vocal production provides evidence for the importance of *contingency* of social feedback. For example, Goldstein & Schwade (2008) measured whether infants modified their babbling to produce more speechlike sounds after interacting with caregivers who either provided contingent or non-contingent responses to infants' babbling. They found that only infants in the contingent feedback condition changed their vocalization behavior to produce more adult-like language forms. Goldstein & Schwade (2008) hypothesized that the contingency effect was driven by infants' receiving input that was paricularly useful for solving this learning problem since the feedback was close in time to infants' vocalizations, making it easier for them to compare discrepancies between the two.

A third piece of evidence comes from research on children's early word learning. Social-pragmatic theories of language acquisition have emphasized the importance of social cues for reducing the (in principle) unlimited amount of referential uncertainty present when children are trying to acquire novel words (P. Bloom, 2002; Clark, 2009; Hollich et al., 2000). Empirical work by Yu & Smith (2012) shows that young learners tend to retain words that are accompanied by clear referential cues, which serve to make a single object dominant in the visual field (see also (Yu & Smith, 2013; Yu, Ballard, & Aslin, 2005). Moreover, correlational studies show positive links between early vocabulary development and parents' tendency to refer to objects that children are already attending to (i.e., "follow-in" labeling) (Tomasello & Farrar, 1986).

Taken together, these findings suggest that the features of social input are particularly well-suited to helping children learn. In addition, social partners often communicate information that will generalize beyond the current learning context. Csibra & Gergely (2009) argue that this assumption of *generalizability* is a fundamental component of "Natural Pedagogy" – a uniquely human communication system that allows adults to quickly and efficiently pass along cultural knowledge to children. Experiental work shows that children are biased to think that information presented in a communicative context is generalizable (Butler & Markman, 2012; Yoon, Johnson, & Csibra, 2008), and corpus analyses provides evidence that generic language (e.g., "birds fly") is common in everyday adult-child conversations (Gelman, Goetz, Sarnecka, & Flukes, 2008).

Thus far, I have reviewed evidence showing that social information can benefit learning because it (a) enhances attention, (b) it is especially learnable, and/ (c) it is likely to be useful beyond the current learning context. However, learning from other people also engages distinct social reasoning processes that can change how learners interpret and learn from evidence.

**Social interactions change inferential learning.** One of the defining features of human social learning is that teachers and learners' actions are not random. Instead, people select behaviors with respect to some goal (e.g., to communicate a concept), and learners reason about *why* someone chose to perform a particular action. The key point is that this reciprocal process of reasoning about others' goal-directed actions can change how people interpret superficially similar behaviors, altering the learning process.

In recent empirical and modeling, Shafto et al. (2012) formalized this social reasoning process within the framework of Bayesian models of cognition. In these models, learning is described as a process of belief updating that depends on two factors: what the learner believed before seeing the data and what the learner thinks about the sampling process that generated the data. The key insight is that if the learner assumes that the information is generated with the intention to communicate/teach, then they can make qualitatively different inferences.

For example, in a causal learning task, Goodman, Baker, & Tenenbaum (2009) showed adult participants a person pressing two buttons (A and B) on a box while a light turned on. The participant's task was to explain how the device worked (i.e., how to turn on the light?). Results showed that when participants thought the person knew how the device worked and had decided to turn it on, they inferred that pressing *both* buttons was necessary to turn on the light. In contrast, when the person did not turn on the light via goal-directed action, participants made a different inference and were less sure about the causal structure.

In addition to causal learning, similar effects of social reasoning have been found in the domains of word learning (Frank & Goodman, 2014; Xu & Tenenbaum, 2007), selective trust in testimony (Shafto, Eaves, Navarro, & Perfors, 2012), tool use (Sage &

Baldwin, 2011), and concept learning (Shafto et al., 2014). Moreover, there is evidence that even very young learners are sensitive to the presence of goal-directed behaviors and will change their learning accordingly. For example, Yoon et al. (2008) showed that 8-month-olds will encode an object's identity if their attention was directed by a communicative point, but they will encode an object's spatial location if their attention was directed by non-communicative reach. And Senju & Csibra (2008) found that infants will follow another person's gaze only if the gaze event was preceded by the person providing a relevant, communicative cue (e.g., infant-directed speech or direct eye contact).

Across all of these studies, learners interpretated similar information in different ways depending on their assumptions about other people's goals. These social reasoning effects are different from the attentional and informational explanations reviewed above in that the inferences based on social information are placed as part of the underlying computations that support learning. This account also fits well with evolutionary models that emphasize the importance of pedagogy for the accumulation of human cultural knowledge (Boyd et al., 2011; Kline, 2015) and theories of cognitive development that emphasize adults' role in providing children with generalizable information (Csibra & Gergely, 2009).

## Part II: The power of learning on your own

Classic theories of development have shared the intuition that knowledge acquisition is a fundamentally active process with the learner playing an important role in shaping their own learning environment (Berlyne, 1960; Bruner, 1961). Moreover, the potential benefits of active learning have been the focus of a great deal of recent empirical work on a broad set of research areas, including education (Grabinger &

Dunlap, 1995), machine learning (Settles, 2012), and cognitive science (Castro et al., 2009).[2]

Recent theoretical and empirical work has formalized these ideas by characterizing development as a process of active hypothesis testing and theory revision that can be described by principles of Bayesian reasoning (Gopnik et al., 1999; Schulz, 2012). And work in cognitive science has also modeled active learning as a process of Bayesian updating with a "hypothesis-dependent sampling bias" (Markant & Gureckis, 2014). In the present section, I review these frameworks with the goal of outlining the variety of mechanisms through which self-directed control of behavior can enhance/change learning.

**Active learning enhances attention and memory.** Markant et al. (2016) describe the benefits as "enhanced memory may be a common outcome of active learning that can arise from a number of distinct mechanisms, depending on the kinds of control afforded by an instructional activity"

Examples:

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* Encoding of Distinctive Sensorimotor Associations
* Elaborative Encoding Through Goal-Directed Search and Planning
* Co-ordination of Selective Attention and Memory Encoding
* Adaptive Selection of Material
* Enhanced Memory Due to Metacognitive Monitoring
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[2] Across these different literatures, the term "active learning" has been used to mean a variety of behaviors such as question asking, increased physical activity, or active memory retrieval. In this paper, I focus on a specific subset of these behaviors: the *decisions* that people make, or could make, during learning. That is, the capacity to exert control over the learning experience, including the selection, sequencing, or pacing of new information.

**Active learning provides "good" information.** Markant and Gureckis (2014). Machine learning work

Focusing on *choices* is useful since there is a rich literature that has formalized decision-making process, which can be used to describe behaviors made by both more knowledgeable others and by learners. The interesting question is how costs/benefits of active learning behaviors are altered by the social context and how reasoning about learners as active might change the social context.

**What is missing from the active learning account?.** Active learning in social contexts. The presence of another agent can change the cost/benefit structure of choices made for learning and therefore we must include this information in our models of self-directed learning, which often view the learner as moving back and forth between active exploration and passive reception. This type of active learning account does not leave room for social reasoning processes (i.e., native utility calculus, goal reasoning) to change the utility of active learning behaviors.

## Part III: Integrating social and active learning

There are two points to make here. Active social learning - seek information from social targets. Models of seeking information from social targets:

- `Baldwin & Moses (1998): The Ontogeny of Social Information gathering`
- `Chouinard (2007): Children's questions as learning mechanism`
- `Hyo's and Liz Bonawitz's work`

Active learning takes into account a utility structure that can include both the costs of data acquisition and the rewards of choosing an example (e.g., in terms of information acquisition/uncertainty reduction relative to some longer term learning goal).

Process:

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- analyze costs and benefits of behavior
- planning models that take into account long-term value
- decisions in the brain and in non-human primates
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## Conclusion

Models of self-directed learning should include information the social-communicative context in which learning often occurs. Reasoning about other people modulate the choices that learners make: whether it's who to talk to, what to look at, or what questions to ask.

Models of social learning should take into account the choice behaviors available to the learner. i.e., think about teaching as reasoning about another person's active learning or setting up a social learning context where the learner selects actions

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