Active Learning in Language Development

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Recent evidence suggests that children play an active role in their own learning in many domains, yet the study of language development has typically cast children as passive recipients of adult guidance. We argue that this approach overlooks language learning as a fruitful domain in which to explore children's active, self-directed learning — specifically, instances where children *seize language learning opportunities and/or select the linguistic information they want to receive, thereby enhancing their own learning*. We suggest that reframing the child as an active language learner introduces novel explanations for key phenomena in language development, and offers researchers complex, ecologically valid tests of rational learning accounts.

Introduction

Children are famously scrappy learners. And yet within the study of how children learn language — a complex social system that they are highly motivated to master — research often casts children as passive recipients of adult language 'input' and guidance. The idea that children learn language passively might be intuitive, given that adults often appear to be *teaching* children to talk by engaging them with simplified, exaggerated speech (Soderstrom, 2007). Moreover, the public sphere is rife with media promoting child-directed language, including messages that liken talking to children to feeding them ("language nutrition;" Zauche et al., 2017). We argue that this emphasis on children's 'receipt' of adult language overlooks language development as a fruitful domain in which to explore children's self-directed learning. Below, we show how adopting a view of children as active language learners can yield new insights and research directions.[1]

We define an active or self-directed language learner as a learner who seizes language learning opportunities, and who selects the linguistic information they want to receive, in order to enhance their own learning[2] (*cf.* Gureckis & Markant, 2012). Prior research shows that chil-

dren demonstrate active learning in diverse ways from early in life. Infants attend to things in the world on the basis of their novelty, complexity, and learnability (*e.g.*, Gerken et al., 2011; Kidd et al., 2012). Toddlers explore to reduce uncertainty (*e.g.*, Sim & Xu, 2017a). Preschoolers conduct impromptu experimental tests of their hypotheses (Cook et al., 2011; Sim & Xu, 2017b), and school-age children ask increasingly strategic questions as they mature (Ruggeri & Lombrozo, 2015). Yet this active child learner — so central to research programs in causal and ecological learning — has remained largely absent from research in language development. How might children's apparent prowess at directing their own learning in non-linguistic domains translate to language?
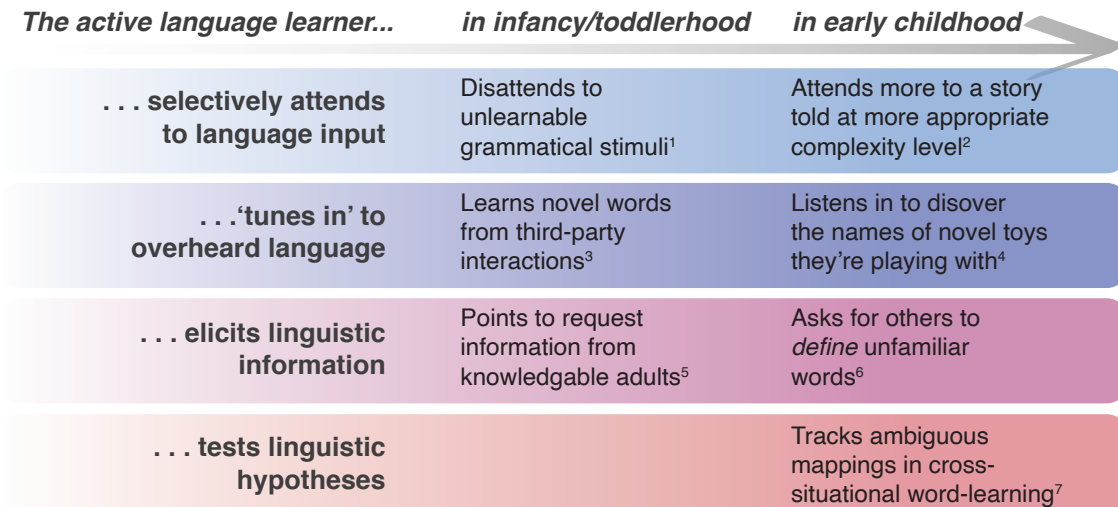
The social nature of language knowledge makes it an especially interesting target of self-directed learning. In experimental demonstrations of children's self-directed *causal* learning capabilities, often what is noteworthy is that children generate evidence (*e.g.*, of how a novel toy works) without input from others, and independently test their hypotheses (Cook et al., 2011; Sim & Xu, 2017b). Language learning, by contrast, does not lend itself to such solitary discovery and validation. That is, children cannot "teach themselves" language: a child cannot independently generate their language's label for dogs by spending enough time alone with the family pet. And to confirm that they have discovered the *right* words, children must attend to how others use and respond to them. Thus, because languages are culturally-transmitted systems of communication, there are limits on what children can independently learn of them.

Nevertheless, recognizing that language can only be learned via exposure to others' usage still leaves a role for the child in selecting among different potential sources of learning. After all, children are exposed not only to language directed to and customized for them, but also to language between familiar adults, strangers, language to and from other children, and language on the television, radio, or over the phone. Children cannot attend continuously to all of these potential language sources, all of the time, raising the question of how they distribute their attention across them.

Zooming out, then, language development might actually be a natural place to look for naturalistic evidence of self-directed learning. Even infants grasp the utility of linguistic communication (Martin et al., 2012), suggesting that children are intrinsically motivated to learn language to communicate from early in life. What's more, language development is resilient: children learn their native language(s) across diverse contexts, from environments where the majority of the language around them is simplified and child-directed, to envi-

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[1]It is worth noting that 'nativist' perspectives on language development have also historically de-emphasized the role of adult teachers, and of linguistic input more generally, in children learning language. However, such theories suggest the child learner advances language development by virtue of language-specific machinery and expectations, rather than domain-general learning expertise.

[2]While we acknowledge that this framing connotes conscious intentionality, we do not mean to make any claims about the learner's conscious awareness of their own learning, nor their explicit choices to advance it.

The active language learner... | in infancy/toddlerhood | in early childhood

The active language learner...	in infancy/toddlerhood	in early childhood
. . . selectively attends to language input	Disattends to unlearnable grammatical stimuli[1]	Attends more to a story told at more appropriate complexity level[2]
. . . 'tunes in' to overheard language	Learns novel words from third-party interactions[3]	Listens in to disover the names of novel toys they're playing with[4]
. . . elicits linguistic information	Points to request information from knowledgable adults[5]	Asks for others to *define* unfamiliar words[6]
. . . tests linguistic hypotheses		Tracks ambiguous mappings in cross-situational word-learning[7]

[1] Gerken et al., 2011; [2] Foushee et al., 2022; [3] Floor & Akhtar, 2006 ; [4] Foushee et al., 2021; [5] Begus & Southgate, 2012; [6] Chouinard et al., 2007; Jimenez et al., 2018; [7] Zettersten & Saffran, 2021

Figure 1. The State of the Evidence for Self-Directed Language Learning from Infancy through Early Childhood.

ronments where language between others dominates instead (Hoff, 2006; Schieffelin & Ochs, 1987). One reason that children successfully learn across these different contexts may be *because* they play a driving role in the learning process, adapting their strategies to leverage available sources of language input, and seeking out further relevant linguistic information as needed (Bloom, 2000).

As children's exposure to child-directed language is highly variable across contexts, it cannot be relied on as their exclusive source of linguistic information. That children learn by 'tuning in' to the language that surrounds them suggests that children *seize available language learning opportunities*. That children also preferentially *attend* to some sources of language over others illustrates one way in which children *select the linguistic information they want to receive, in order to enhance their own learning*. Finally, because children are surrounded by competent language users, they can also use others to elicit new language data, and to selectively test their linguistic hypotheses. In the present paper, we review emerging evidence for these signatures of active language learning, and illustrate how adopting a view of the child as an *active language learner* can provide insight into basic questions about how language development unfolds, and what language input is most effective for learning. We focus on the child's developing lexicon to illustrate active learning in language development for two reasons: first, word forms are largely arbitrary conventions (they must be learned); second, although some of the words that children know — think "boo-boo" — likely come from language directed to them by caregivers, others — think profanity — are likely picked up from language directed to others (words can trace learning environments). In what follows, we review how children actively learn language by (1) rationally deploying their attention to sources of linguistic information, (2) tuning in to ambient language to reduce uncertainty, (3) eliciting language input from knowledgeable interactants, and (4) evaluating evidence to bear on linguistic hypotheses.

Children efficiently allocate attention among potential sources of language input

Take a scenario that might be familiar: having just finished reading the same story aloud for the $12th$ time, your three-year-old listener cries, "Again! Again!" Research linking children's attention to stimulus 'learnability' raises the possibility that a child's asking to hear the same story again and again might be a sign that there is still something in it for them to learn.

Do self-directed language learners select the language data they receive so that their learning will be the most efficient? In support of this idea, Gerken and colleagues (2011) showed that the amount of attention infants paid to artificial language stimuli in the lab depended on the learnability of the grammar. *Unlearnable* stimuli were either indescribable via any set of grammatical rules or pattern, or lacked sufficient cues for learners to infer the relevant rules. In contrast, *learnable* stimuli all conformed to an evidently discoverable grammatical pattern. Interestingly, 17-month-old infants looked away more quickly when listening to the unlearnable grammar, and stayed looking longest when the grammar they heard was *subjectively learnable* — inferred to be such because a previous sample of same-aged infants was able to learn the critical rule, given a similar period of familiarization.

More recently, we directly tested the link between preschoolers' learning from spoken language input, and the amount of attention they directed to it (Foushee et al., 2021).
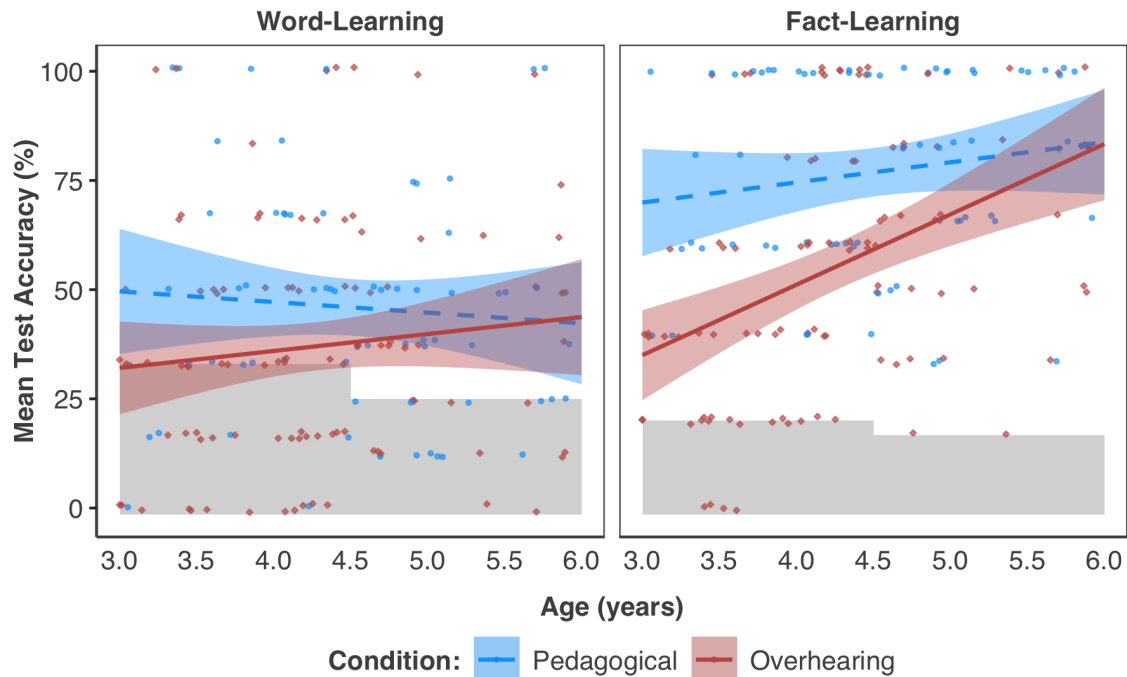
Figure 2. Age Effect in *Foushee, Srinivasan, & Xu, 2021*. Mean test accuracy for two types of novel linguistic information corresponding to a set of unfamiliar toys: words (*e.g.*, *pimwit*; left panel) and facts (*e.g.*, *the one my sister loves*; right panel). Shaded region indicates accuracy at or below chance. *Note.* Children were tested in two age bins: 3–4.5-year-olds heard 3 novel words ($chance = 33\%$; $M_{\text{Overhearing}} = 30\% - 39\%$), and 5 facts ($chance = 20\%$, $M_{\text{Overhearing}} = 46\% - 57\%$), while 4.5–6-year-olds heard 4 novel words ($chance = 25\%$; $M_{\text{Overhearing}} = 41\%$), and 6 facts ($chance = 17\%$; $M_{\text{Overhearing}} = 64\%$).

Children (4–6 years) listened to a story narrated at either a Simple (using age-appropriate words) or Complex (using later-acquired words) level, while an eyetracker captured their visual attention across a storybook display. The looping audio narration for each page automatically advanced to the next page if the child lost interest in the story and instead attended to an on-screen distractor (a continuously jump-roping penguin). Hypothesizing that a child's attention to spoken language reflects its subjective complexity — *i.e.*, how understandable or learnable the language is for the child — we expected that a given objective degree of complexity should be experienced differently by children of different ages, due to their different levels of linguistic competence. Indeed, children's age predicted the degree to which the Complex versus Simple speech maintained their attention. When listening to the Complex speech, older children were more likely to continue listening to the page narrations. The opposite was true in the Simple condition, where *younger* children — for whom the speech was likely at a 'just right' level of complexity — were more likely to continue listening. This is the pattern of results we would expect if a child's attention to spoken language is responsive to how much they can learn from it. And indeed, individual children's story comprehension and novel word learning, tested after the story, were positively correlated with their attention to the speech.

This study provides suggestive evidence that children at-

tend to linguistic information in order to enhance their own learning. A strong interpretation of the results is that children deliberately switch their attention from spoken language input when their learning rate falls below some threshold. Alternatively, children's attention to spoken language may merely reflect whether they comprehend it, such that they can be lured away by a distractor when the it 'goes over their heads.'

Children learn from ambient language in the absence of adult guidance

The internet is awash with vivid displays of children's self-directed language learning: the query "where did my toddler learn to swear?" returns billions of search results, and clips of young children surprising us with their perfect mimicry of adult verbal behavior — the choreography of a domestic quarrel[3], a grown-up's 'phone voice'...regularly go viral. In such instances, children are evincing knowledge of language that is unlikely to have been directed to them, but rather learned via *overhearing*.

In a recent study, we assessed whether preschoolers spontaneously 'tune in' to naturalistic overheard speech. Children (3–6 years) had the opportunity to learn about a set of objects as they played with them, across experimental conditions that differed in how much self-directed information

[3]*e.g.*, "Listen, Linda:" https://youtu.be/aFYsJYPye94

gathering they required of learners (Foushee et al., 2021). In the Pedagogical (read: *passive learning*) conditions, an experimenter *taught* the child a label and fact associated with each object, explicitly cueing their attention to the object and its properties as she discussed it. Though the experimenter used the same script in the Overhearing (read: *active learning*) conditions, she delivered it while talking on the phone at a distance from the child, looking at neither them nor the objects (Fig. 3A).[4] Our results indicate that, with age, children's ability to coordinate their attention between the overheard speech and the objects improved, resulting in significantly better learning of both words and facts from overhearing at older ages (Fig. 2). Strikingly, by ages 4.5–6, children learned *four* novel object labels equivalently from overheard speech as they did from pedagogical, child-directed speech.

Together, the studies reviewed to this point may help resolve an apparent paradox in the language development literature: although even toddlers are able to learn new words from overheard speech in experimental studies under simplified conditions (*e.g.*, Floor & Akhtar, 2006), there is surprisingly little evidence that children learn words from overheard speech in their natural language environments (*e.g.*, Shneidman & Goldin-Meadow, 2012). As active learners "in the wild," children may monitor all potential sources of language in order to learn most efficiently. In contexts where simplified child-directed speech is available, children may be less likely to attend to and learn from overheard speech that is relatively complex. However, in contexts where child-directed speech is rare, children may adapt by attending to and learning more from overheard speech (*e.g.*, Tsethlikai & Rogoff, 2013). This hypothesis may help explain how children appear to reach linguistic milestones on similar timetables across environments that vary in their composition of child-directed and overheard speech (Casillas et al., 2019; Foushee & Srinivasan, 2022).

Children elicit labels from adults

A toddler waddles over carrying an unfamiliar object (as in Fig. 3B) and produces some variant of "What's this?" The caregiver replies with a label. As conventions, words only have value to the extent that they are agreed upon by others: thus, a child who wants to be able to talk about *these-things-I-just-found* will need help to find the right words.

Both experimental and observational evidence illustrate how children expand their vocabularies by eliciting linguistic information from those around them. Laboratory studies show that infants use pointing to request information from knowledgeable adults (Begus & Southgate, 2012; Lucca & Wilbourn, 2019), and that preschoolers know both when they don't know what something is called (Lipowski et al.,

2013), and who to explicitly ask (Koenig & Harris, 2005). Indeed, many of the questions that pepper children's early productions represent requests for linguistic information: in an analysis of four children's spontaneous speech, for example, between 28% and 65% of the questions children asked between their first and second birthdays were requests for labels (Chouinard et al., 2007). Along similar lines, children's active role in language learning may partly explain why the onset of locomotion often coincides with a marked increase in vocabulary growth (He et al., 2015; Walle and Campos, 2014, though see Moore et al., 2019). With a newfound visual perspective, autonomy, and freer hands, walkers encounter new and different things to name, and elicit verbal responses from caregivers by sharing objects with them (Karasik et al., 2014). Note, however, that this connection remains speculative: unlike infants' pointing gestures (Begus & Southgate, 2012; Lucca & Wilbourn, 2019) and children's questions (Chouinard et al., 2007; Jimenez et al., 2018), evidence that walkers intentionally share objects with caregivers to elicit *information* — as opposed to merely attention — remains indecisive.

## Children test and refine their hypotheses about word meanings

Children use other, more capable language users not only to get new words, but also to refine their hypotheses about words' meanings. In 2020, for instance, a four-year-old asks their mother, "is *coronavirus* really popular right now?" Their question seems aimed at triangulating a new word's meaning: what does *coronavirus* refer to, such that all adults are suddenly talking about it?

Children seek linguistic information from the social world in a way that implicitly reflects their relative certainty about how to use or interpret a given word. Children recruit help with how to define or interpret words explicitly (Jimenez et al., 2018), as in the question about coronavirus above. They also engage in subtler information-seeking behaviors: for example, preschool-aged (2–5 years) children scan an adult experimenter's face more when the experimenter makes a referentially ambiguous request, *e.g.*, asking the child for the "modi" when two novel objects are present, relative to when a novel object and familiar object are present (Hembacher et al., 2020). One-year-olds in a similar task even know *whose* face to scan when they are unsure (namely, the experimenter who had previously known what things were called, over one who was previously ignorant; Bazhydai et al., 2020).[5]

Additional evidence for how young children monitor and reduce their uncertainty about word meanings comes from a cross-situational word-learning experiment where children saw both novel and familiar object-word pairings. Some

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[4]This study builds on a previous literature comparing novel word-learning between children exposed to the target word(s) in a third-party verbal interaction, versus when directly addressed (*e.g.*, Floor & Akhtar, 2006). However, in many of these previous studies, the third-party interactions that children 'overheard' involved adult speakers gazing at, pointing to, and/or directly interacting with the referents of the to-be-learned words, minimizing demands on children's self-directed learning capabilities (see Foushee et al., 2021 for a detailed discussion).

[5]We note that our focus here is on evidence that children *actively seek* linguistic information to reduce their own uncertainty, rather than on behaviors that — by providing signals to adults — ultimately lead to the adults' provision of useful information. For example, a child who looks confused, or alternatively who exhibits particular interest (Smith & Trainor, 2008), might well receive relevant linguistic information from an attentive adult.
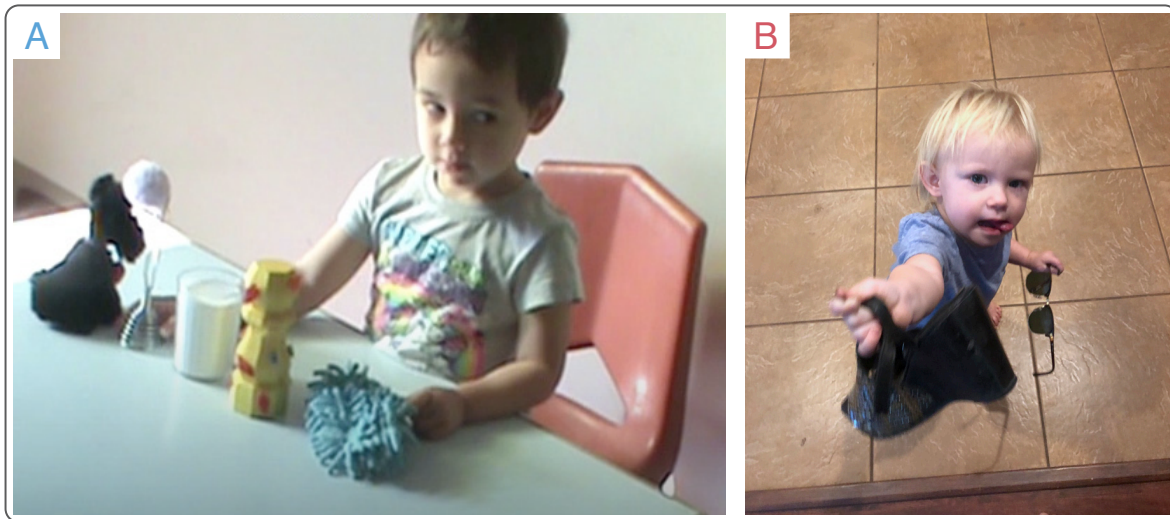
Figure 3. Self-Directed Learning Behaviors in Language Development. **A:** Children *seize language learning opportunities* by 'tuning in' to relevant ambient language nearby. **B:** Children *select the information they want to receive* by eliciting language from caregivers, as when sharing objects.

of the novel object-word pairings were ambiguous (*e.g.*, the same two novel objects always co-occurred with the same two novel words), while others could be disambiguated via an inference (*e.g.*, given the words *leemu* and *dog*, *leemu* must refer to the non-dog object). When later given the opportunity to learn more about specific objects, children (3–8 years) preferentially chose to sample referents whose labels had remained ambiguous, and were more likely to do so with age (Zettersten & Saffran, 2021). Thus, learners track not only their hypotheses about potential word meanings, but also the strength of their evidence, and actively seek additional information to reduce their uncertainty.

Discussion

The preceding sections have reviewed how an active learning framework can be extended to explain children's remarkable success at learning language. Several key questions remain, which we hope will inform future research:

(1) How can we characterize the mechanisms of self-directed learning in language development? What do children track to guide their attention (*e.g.*, how predictable the language is, versus the simplicity of the rules that govern it)? Do children exploit similar signals in other domains?

(2) What is different about how an infant directs their own language learning, and how a preschooler does? What are the relevant developmental processes influencing children's self-directed learning capabilities (*e.g.*, developments in working memory)?

(3) Is children's allocation of attention *rational*? Is it possible to build computational models specifying the optimal allocation of individual children's attention, given the goal of learning language?

(4) Where can we see active learning of other aspects of language knowledge? We have focused on the utility of active learning for acquiring the lexicon, but there are no doubt analogies for grammar-learning. For example, is there some 'just right' level of syntactic complexity to which children at a given stage of language development are most attentive?

(5) How does affect intersect with cognitive motivations for language learning? One promising research area concerns how children's lexical development reflects their *interests* (*e.g.*, dinosaur names; Mani & Ackermann, 2018). On functional accounts of emotions (Barrett & Campos, 1987), children's attention to fruitful learning opportunities may be driven by a positive *affective* experience, rather than some metacognitive insight.

Conclusion

In our view, there is great potential in a research program at the intersection of active learning and language development — especially one with an eye toward ecologically valid demonstrations of children's abilities. Diverse empirical questions lie at this intersection. As this review illustrates, reframing the child as an active language learner introduces novel explanations for phenomena in the development of language. At the same time, using language as a test domain for formal rational learning accounts can provide researchers with complex learning tasks that make sense to children, and are informative of how children navigate the daily complexity of early life. Finally, applying the active learning framework to language development presents an opportunity to make our science more inclusive: the one-on-one pedagogical contexts that research and public policy tend to emphasize represent

only a sliver of the language learning contexts that young children experience over the course of the day, across different households and cultures. That children across diverse milieux become capable adult language-users may reflect children's active role in getting the linguistic information they need.

Recommended Reading

Bloom, L. (2000). (*See References*). A chapter centering the agency and action of the developing child in the process of word-learning.

Gureckis, T. M., & Markant, D. B. (2012). (*See References*). A theoretical review of work in cognitive and computer science regarding cases where learners control the information they experience.

Saylor, M. M. & Ganea, P. A. (Eds.) (2018). (*See References*). An edited volume of research on the role of active learning in cognitive and linguistic development.

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