Jean Piaget Society Dissertation Prize Submission:
Self-directed learning in language development:
Interactions of linguistic complexity, learner attention, & language socialization

First and foremost, this dissertation **carries on the Piagetian legacy by committing to a view of the child as an "active learner"** — one who constructs knowledge by observing and selectively attending to the world around them, assessing and revising their own knowledge, and developing their own ability to learn. My dissertation also follows Piaget in seeking a common narrative for the child's active learning from infancy through early childhood, and in using a multi-method approach, starting always with careful observation of development in the real world. The knowledge I am interested in here is language knowledge.

Notably, while we celebrate children as curious, active, and resourceful learners, when we consider their development of language — a complex social system that children are highly motivated to master — we tend to study them as passive recipients of adult guidance. I argue that this emphasis on the child's 'receipt' of language input and on one-on-one adult verbal engagement (1) handicaps our ability to build generalizable theories, (2) flies in the face of evidence that children drive their own learning in other domains, (3) overlooks language as an ecologically valid domain in which to test predictions of rational learner behavior, and (4) precludes insights that conceptualizing the child as a more "active" or "self-directed" learner might bring to the study of language development.

My research program thus lies at the intersection of active learning and language development, which means that I use language as a test domain for big questions about learning: *What is the learner's role in driving their own learning? How does the learner's current knowledge inform what is appropriate (or possible) to learn next? Are there things it's better to be taught? To what degree do learning strategies represent universal mechanisms, versus environmental adaptations? (Does the learner 'learn to learn'?)* At the same time, I leverage computational and cognitive frameworks for active learning (*e.g.*, Gureckis & Markant, 2012) to shed light on basic questions about language: *In what ways is learning language* like *versus* unlike *constructing other sorts of knowledge? What counts as "effective" linguistic input for language learning?* I define the ***active language learner*** — **in contrast to the *passive* learner — as one who *selects the linguistic information they want to receive, in order to enhance their own learning*** (Foushee et al., 2022).

In my dissertation work, I showed how this novel angle could help resolve gaps in our understanding of what makes different sources of language "effective" for learning, focusing in particular on overheard speech as a cross-cultural source of linguistic input and a naturalistic demonstration of children's active learning (Foushee et al., 2021). Remarkably, relative to what we know about the language that children hear *directly* and its consequences for development, we know almost nothing about the language that children hear *around* them, and how children's own development might interact with it to determine learning. Similarly, relative to what we know about how infants and toddlers learn language when their attention is being directed by an adult, we know little about how children learn when they must manage their own attention across their complex linguistic landscapes.

A puzzle in the existing literature.

As a demonstration of the potential in this program of research, my dissertation leveraged the active learning framework to address an apparent paradox in the language development literature: That is, although even toddlers are able to learn new words from overheard speech in experimental studies, there is surprisingly little evidence that children learn words from overheard speech in their natural language environments.[1] In one particularly influential body of work, researchers use snapshots of individual children's language environments between 18 and 30 months of age to predict those children's language outcomes six months to a year later (Ramírez-Esparza et al., 2014, 2017; Shneidman et al., 2013; Shneidman and Goldin-Meadow, 2012; Weisleder and Fernald, 2013). Surprisingly, only the amount of child-directed — not overheard — speech that children hear correlates with growth in their vocabularies and language processing speed. Although these studies have been taken to indicate that overheard speech is ineffective for word-learning, numerous experimental studies with children during the same period show learning from simplified indirect speech in laboratory settings. I draw on evidence that infants disattend to stimuli that are too complex for their current level of competence (Gerken et al., 2011; Kidd et al., 2012, 2014) to explain these conflicting results. Specifically, I propose that young rational learners in environments where child-directed speech is common may initially learn little from overhearing because the overheard speech that surrounds them is too complex to maintain their attention — especially when compared to the simplified speech that they regularly receive in interactions with caregivers (Foushee et al., 2016). A combination of results derived from methods across developmental science, natural language processing, psycholinguistics, and anthropology (see Table 1) suggest that this proposal holds promise.

Table 1: Dissertation Chapter Foci and Empirical Approach

Chapter	The Active Language Learner ...	Method
1	*& Their Teachers*	computational corpus analysis*†
2	*Versus The Passive Learner*	cross-sectional behavioral experiment‡
3	*Chooses What to Learn*	eyetracking experiment*‡¶
4	*Shapes Their Environment*	qualitative case study‡§
5	*Learns to Learn*	culturally-specific field experiments*‡§

*Linguistics, †NLP, ‡Psychology, §Anthropology, ¶Education

1: Active learners may rationally ignore language not designed for them.[2]

Chapter 1 quantifies the relative learnability of child-directed and simulated overheard speech to understand the landscape in which young learners are directing their attention. To quantify complexity, I use previous psycholinguistic research (e.g., Kuperman et al., 2012) to identify text-based variables associated with slower or more difficult language processing. I compare these empirically-motivated operationalizations of complexity across longitudinal corpora of adults speaking to children (MacWhinney, 2000; VanDam et al., 2016), versus of adults speaking to other adults (Du Bois et al., 2000; Love et al., 2017). These analyses quantify the intuition that adults significantly simplify their speech to young children, and do so responsively: as children mature, the child-directed speech they receive becomes more abstract, less predictable, and includes more diverse, later-acquired words.

[1] The 64,800,000 Google search results for "where did my toddler learn to swear?" may be an exception...

[2] An early version of this work appears in Foushee et al., 2016.

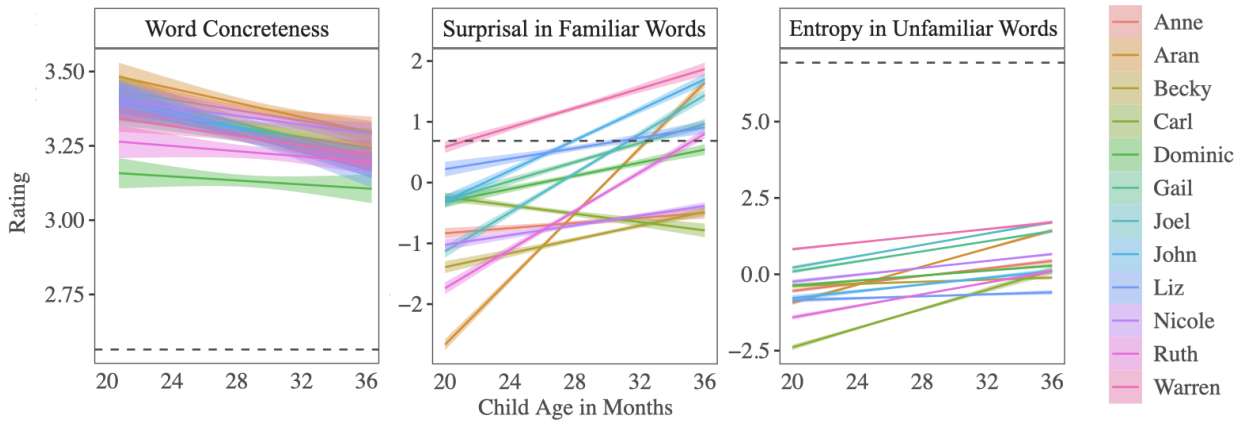

Figure 1: Language Complexity in Child-Directed Speech Increases with Child Age.

Note. Data come from the Manchester corpus (Theakston et al., 2001). Shading indicates standard error; dashed lines mark estimated values for speech between adults.

Critically, if caregivers' child-directed speech offers an accurate estimate of the speech complexity appropriate for a given child, and if children's attention to different sources of spoken language input is at least partly responsive to their complexity, then we might expect overheard speech at or below the level of the child's typical child-directed speech to be eligible as a target of the child's attention and a reliable source of learning. Our results suggest that for most children this may not be until after language development is well underway, and after the period in which previous studies have measured the overheard speech in children's environments (Ramírez-Esparza et al., 2014, 2017; Shneidman et al., 2013; Shneidman and Goldin-Meadow, 2012; Weisleder and Fernald, 2013).

Thus, focusing exclusively — as previous studies have done — on overheard speech in the first two years of life, and without a unifying explanation for the advantage of child-directed speech versus impotence of overheard input, may have led to the premature conclusion that overheard speech is permanently ineffective for learning. This conclusion ignores the growth of the child's own learned capacity *to learn*, which is the subject of Chapter 2.

2: Children 'listen in' to reduce uncertainty in their environments.[3]

Despite substantial interest from the computational, educational, and psychological communities, the majority of research on young learners' ability to direct their own information-gathering has focused on their independent investigation of causal systems (e.g., Cook et al., 2011; Schulz and Bonawitz, 2007; Sim and Xu, 2017), rather than social or linguistic systems, while the majority of laboratory overhearing studies have tested learning from highly simplified, repetitious speech (Akhtar, 2005; Akhtar et al., 2001; Baldwin, 1991; Fitch et al., 2020; Floor and Akhtar, 2006; Gampe et al., 2012; Martínez-Sussmann et al., 2011; Shneidman et al., 2009). Three experiments in Chapter 2 instead compare learning of multiple learning targets in conditions representing two extremes in terms of the demands they impose on self-directed learning: (1) an adult-guided interaction in which children were explicitly taught words and facts about a set of objects (Pedagogical condition), and (2) a situation in which children could overhear an adult's phone conversation about the objects, but in which the adult did not look at the objects or the child (Overhearing condition).

While all children in our sample were able to learn a set of 5–6 novel facts, only older preschoolers

[3]Results appear in Foushee et al., 2021.

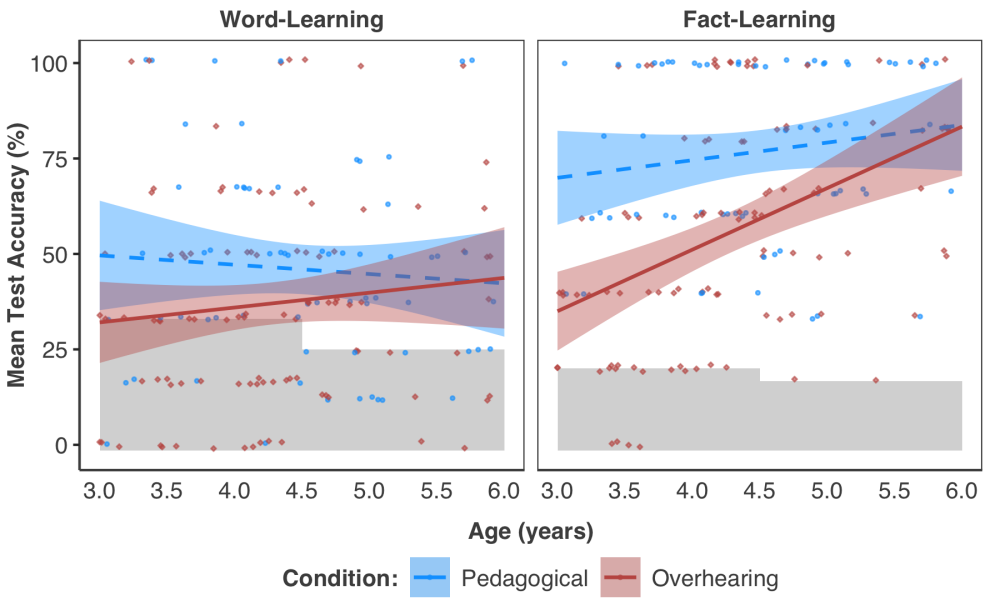

Figure 2: Age Effects across Learning Conditions and Learning Targets in Experiments 1–3. Plot shows mean test accuracy for two types of novel linguistic information corresponding to a set of unfamiliar toys: words (*e.g.*, *pimwit*; left panel) and facts (*e.g.*, *the one my sister loves*; right panel). Shaded region indicates accuracy at or below chance.

(M_{age} = 5.1 years) demonstrated robust learning of novel *words* through overhearing (Figure 2). Analyses of children's play and gaze behavior during the overhearing episode suggest that older children were better able to coordinate their attention between the overheard speech and objects, though even younger children showed evidence of attention to the overheard speech. Together, these results demonstrate that by age 5, children can learn substantial linguistic information via overhearing, while learning by children younger than 5 may especially benefit from contexts in which their attention is directed and maintained by an adult teacher.

3: Children's attention and learning is responsive to complexity.[4]

In Chapter 3, I develop a novel method to test the classic idea that children learn best from information that is of an appropriate level of complexity (Bruner, 1961; Piaget, 1954; Vygotsky et al., 1978) — focusing in particular on the role that children themselves might play in actively selecting and attending to such information. Where previous research manipulated the learnability of highly simplified visual or auditory stimuli (Berlyne, 1960; Gerken et al., 2011; Kidd et al., 2012, 2014), we use naturalistic language stimuli, which both interests children and carries real information for learning.

Preschoolers (M_{age} = 4.6 years) watched a video where the illustration for each page of a children's book was displayed alongside a distracting animation (Figure 3). The audio narration for each page was looped such that the story progressed faster if the child looked at the distractor for an extended period of time, indicating their loss of attention towards the story. The complexity of the storybook narration was manipulated in two between-subjects conditions: the Simple narration contained largely familiar words and had led to robust learning in a previous sample of same-age children, while the Complex narration contained multiple later-acquired words and supported learning

[4]Foushee et al., n.d.

only for children toward the end of our age range. We expected that children's relative familiarity with later-acquired words — and their ability to infer the meanings of entirely *un*familiar words — would track with linguistic experience, such that more complex speech would become an increasingly appropriate source of learning as children matured.

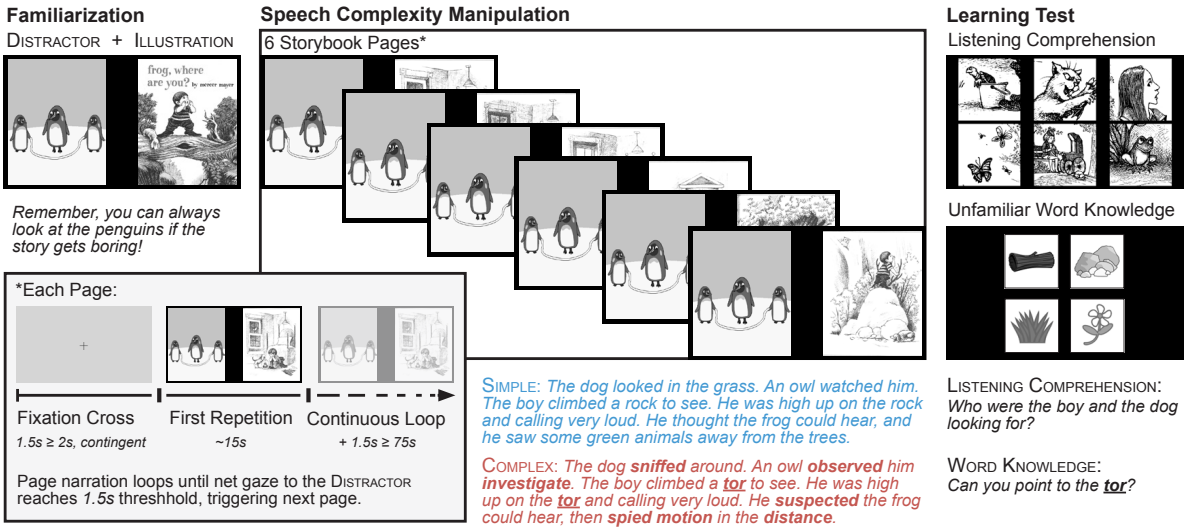

Figure 3: Overview of Naturalistic Storybook Paradigm Used in Chapter 3.

We measured children's listening comprehension and word learning after the story, enabling us to test the prediction that children's attention to a stimulus should reflect their ability to learn from it — which, in turn, should depend on the child's pre-existing level of knowledge and development. If children's attention is truly influenced by such learnability considerations, we expected to see (1) differences in child attention to speech at different levels of complexity, (2) increases in child attention to more complex speech with age, (3) *decreases* in child attention to more simple speech with age, and (4) a positive relation between a child's sustained attention to a speech source, and measures of the amount they learned from it.

Our results conform to these predictions: participants who listened to the Simple narration exhibited greater attention to the story-relevant visual stimulus, lesser visual attention to the distractor stimulus, and longer listening times to the narration itself ($M_{\text{Simple}} = 75.5s$ [40.7, 109.00]; $M_{\text{Complex}} = 47.0s$ [27.50, 68.00]). Importantly, these indices were significantly related to children's overall learning at test, controlling for condition and age ($F(1) = 6.73$, $p = .012$) — suggesting that the learning effects we see are not explained by objective characteristics of the speech, but rather how those characteristics interact with children's own cognitive-linguistic development to drive learning.

Finally, as we would expect if children's sustained attention to the speech were at least partly a reflection of its continued support for their learning, there was a significant interaction between condition and age ($\chi^2(1) = 7.37$, $p = .007$ via a mixed effects logit model; Bates et al., 2015) in predicting whether children continued listening on each page of the story (Figure 4). That is, when listening to the Simple speech, older children were less likely to continue listening than younger children ($OR = 0.56$ [0.32, 0.93]), but the opposite was true when listening to the Complex speech: older children were *more* likely than younger children to continue listening ($OR = 3.40$ [1.42, 9.23]).

Together, these results open the possibility that young children may actively direct their attention toward the linguistic input that is most appropriate for their current level of language knowledge and cognitive development, and to disattend when their learning becomes inefficient.

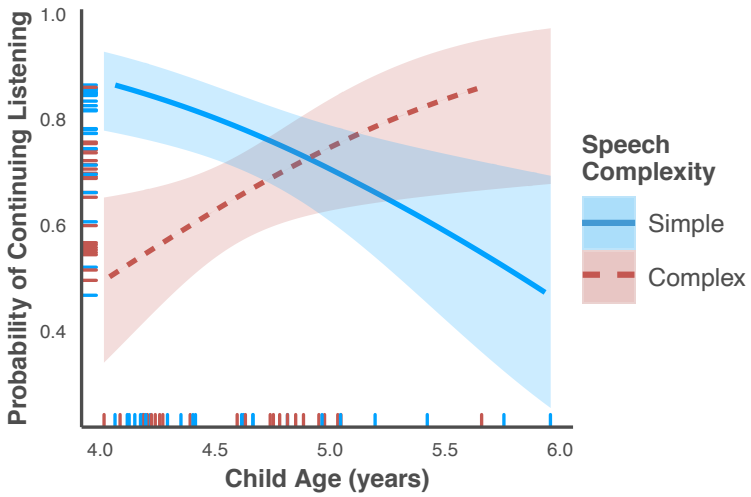

Figure 4: Model-estimated Probabilities of a Child "Continuing Listening" to Further Optional Repetitions of a Storybook Narration.

4: Learners with access to child-directed speech may learn to selectively attend.

Inspired by qualitative studies typically limited to child-directed speech, in Chapter 4, I develop a coding scheme enabling us to characterize the full range of sources of language knowledge accessible to a given child, in terms of their relative utility for word-learning. I homed in on *referential transparency* as a demonstrably important dimension of language learning contexts that could be coded from video, and took a case study approach, capitalizing on longitudinal video recordings documenting the language environment of a single child — Naima, from the Providence corpus (Demuth et al., 2006). I analyzed over six thousand utterances spanning the first two years of Naima's life, when cues to words' meanings are argued to be especially critical for language development (e.g., Cartmill et al., 2013). By applying the same qualitative coding scheme to caregiver utterances coded as 'child-directed' versus 'overheard,' I find that while greater referential transparency characterizes the set of utterances spoken to Naima directly (Figure 5), child-directed and overheard utterances often overlap along learning-relevant dimensions, and shift over time in how well they predict the current focus of Naima's attention.

Given the frequent overlap between child-directed and overheard speech quality, analyses of these new data suggest that caregivers' "sing-song" prosody may play a critical role in marking speech as intended for the child. In one analysis, for example, classification error by a linear discriminant function skyrocketed when information from prosody was removed. Thus, I hypothesize that learners may make use of caregivers' non–adult-like prosody not to decrypt language itself, as has been suggested in previous literatures (e.g., Fernald & Simon, 1984). Instead, I suggest that we understand caregivers' prosodic modification as a learned — and self-reinforcing — cue to highly transparent language data, where infants' attention has a higher probability of being rewarded.

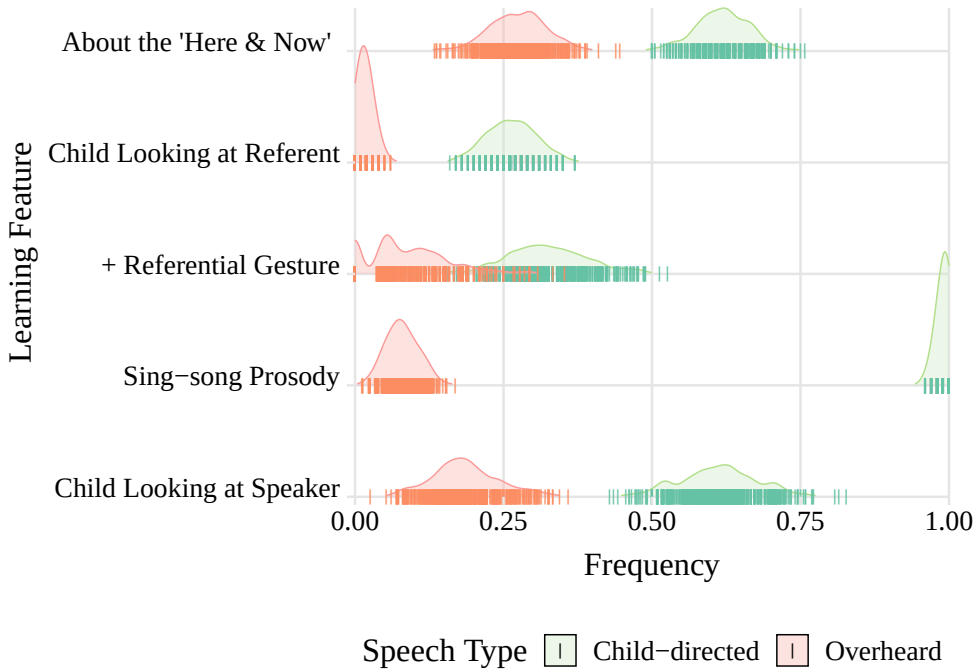

Figure 5: Distributions of Binary Learning Features in Child-Directed and Overheard Utterances.

5: Active infant learners may 'learn to learn.'[5]

Simultaneous with developmentalists' growing emphasis on the primacy of child-directed language, linguistic anthropologists describe widespread variation in child-directed speech customs, which nonetheless result in similar timetables for acquisition (Lieven, 1994). This raises the possibility of adaptation: namely, infants raised in contexts with little child-directed speech might develop distinct patterns of attention and skills at 'listening in.'

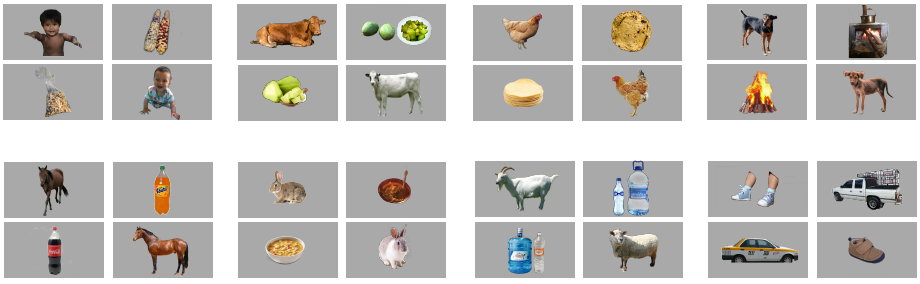

Figure 6: Adapted Stimuli for Testing Early Common Noun Knowledge in Tseltal Maya.

Responsive to this call, in Chapter 5, I designed tests specific to the developmental context of infants in the Tseltal Maya community where I regularly conduct language experiments. Not only are Tseltal infants exposed to very little directed speech, by virtue of being carried on their mothers' backs, but the high-frequency honorifics used to greet adults (and only adults) in the Tseltal language offer the perfect stimuli to test linguistic knowledge that could *only* have been acquired through

[5]Final results of this study were recently presented at the 46th Annual Meeting of the Boston University Conference on Language Development (BUCLD46).

overhearing. Remarkably, when shown two faces (*e.g.*, an old man and a young woman; Figure 7), and hearing an honorific (*e.g.*, *tatik*, to greet an older man), infants (M_{age} = 10.1 months) reliably looked to the face that matched the honorific. In special support for the adaptation hypothesis, Tseltal infants demonstrated implicit knowledge in this task *over a year earlier* than Western infants have been shown to succeed on any analogous task requiring them to discriminate between members of the same semantic category (as in two unfamiliar human faces).

Figure 7: Trial Testing Tseltal Greetings for a Older Man (Target) vs. Younger Woman (Non-Target).

Conclusion: What *we've* learned.

In contrast to the majority of current rhetoric around language development, the dissertation summarized here adopts a view of the language-learning child as an active, or self-directed, language learner. Of the manifold skills and strategies of the self-directed learner (Bruner, 1961; Chi, 2009; Gureckis & Markant, 2012; Piaget, 1954), I focused on children's strategic attention allocation and independent information-gathering in explaining a puzzle in the extant literature. Namely:

(1) Across studies, the amount of child-directed — but not overheard — speech in children's early environments predicts their later vocabularies.

   (a) This remains true even in contexts where infants are rarely spoken to directly, and where overhearing instead predominates.

(2) In lab studies, children as young as 18 months can learn a new label through overhearing.

(3) All children ultimately become competent speakers of their native tongues.

A constellation of experimental and observational studies sought evidence for an intuitive solution, leveraging the idea that children rationally allocate their attention to stimuli based on its complexity or learnability. I hypothesized that overheard speech is likely to be highly linguistically complex, such that young rational learners may initially ignore it. However, with greater language knowledge, the difference between the subjective complexity of the speech that children receive in interactions with adults and the overheard speech that they could 'tune in to' in their environments will shrink, such that older children may be able to benefit from overheard language as a source of new knowledge.

The dissertation's approach to this particular puzzle should be understood more generally as demonstrating the 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. As these studies demonstrate, reframing the child as an "active" language learner can introduce novel explanations for phenomena in the development of language, while using language as a test domain for formal accounts of rational learning can provide researchers with learning tasks that are at once complex and meaningful for children's daily lives.

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