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ARTICLE

Being pragmatic about syntactic bootstrapping

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Abstract

Words have meanings vastly undetermined by the contexts in which they occur. Their acquisition therefore presents formidable problems of induction. Lila Gleitman and colleagues have advocated for one part of a solution: indirect evidence for a word's meaning may come from its syntactic distribution, via SYNTACTIC BOOTSTRAPPING. But while formal theories argue for principled links between meaning and syntax, actual syntactic evidence about meaning is noisy and highly abstract. This paper examines the role that syntactic bootstrapping can play in learning modal and attitude verb meanings, for which the physical context is especially uninformative. I argue that abstract syntactic classifications are useful to the child, but that something further is both necessary and available. I examine how pragmatic and syntactic cues can combine in mutually constraining ways to help learners infer attitude meanings, but need to be supplemented by semantic information from the lexical context in the case of modals.

Keywords: attitude verbs; modality; pragmatics; syntactic bootstrapping

1. Introduction

Imagine a mother and infant sitting at a café, watching a boy run after a pigeon. The mother utters a short sentence, in a language the infant has not yet acquired. What did she say? Perhaps it was somehow related to the boy and the pigeon. But how? Maybe the scene prompted the mother to say that she loves the autumn, that life is cruel, that she misses her own childhood, or that she wants chicken for dinner. What we say is rarely a running commentary on what is unfolding right in front of us. Therefore the immediate context of speech will not determine the topic of our utterances. But suppose that in this case life is easy, and the mother plays the role of sportscaster, narrating what just happened with the boy and the pigeon. Even then, the scene could be described in many different ways: the child chased the pigeon, the pigeon and the child are both running, the child is scaring the pigeon, the pigeon is running away, this boy is a menace, etc. Accordingly, there are countless meanings the mother's words may have, as far as the infant is concerned, even if we know which scene she is describing. As Quine observed (1960), the problem infects even what seem like simple acts of reference or predication. If the mother says "*paloma*"

and points to the pigeon, does she mean 'pigeon'? How can we be certain she does not mean 'animal', 'wing', 'non-dog', 'vermin', 'delicacy', 'pigeon or bus', or something even more remote? One is hard pressed to pin down the meaning of any word based solely on the physical context of its utterance.

Perhaps our shared human psychology can lessen the inferential problem. If infants see the world through much the same lens as the speakers around them, they might carve it into similar chunks, and assume these chunks make better lexical meanings than others (e.g., Carey, 2009; Markman, 1990; Spelke, 1990). But while this may be sufficient to learn the meaning of words that refer to concrete objects, like "*pigeon*" or "*ball*", much of our lexicon consists of words which do not readily occur in ostensive contexts, and whose use doesn't coincide with clear correlates in the physical environment. Verbs, for instance, even those labeling concrete actions, tend not to be used when those actions are unfolding: we typically don't say "*I'm opening the door*" when opening doors (Gleitman, 1990). How then do children figure out the meaning of a word if that meaning is vastly undetermined by the physical context in which the word occurs?

Landau and Gleitman (1985) and Gleitman (1990) proposed that children could rely on indirect evidence about a word's meaning stemming from its syntactic distribution, a process known as SYNTACTIC BOOTSTRAPPING. To illustrate, a novel word "*gorp*" heard in our chasing context above is compatible with very many meanings (*chase, run, menace, scream…*). However, hearing it in a sentence like "*the child is gorping the pigeon*" drastically reduces the space of possibilities: "*gorp*" likely refers to an action that involves at least two participants. Moreover, expecting that subjects name agents, and objects, patients, could further prune out meanings like '*run away from*', in favor of meanings like '*chase*'. Similarly, hearing a verb "*dax*" with a sentential complement, as in "*the child daxes that pigeons are fun*" seems to prune out actions from the set of possible meanings for "*dax*", and to narrow it down to mental states. Thus, a learner equipped with a few noun meanings, some syntactic knowledge, and certain expectations about how meaning and syntax correlate could in principle exploit these correlations to home in on a novel word meaning, particularly in those cases where the physical context is unhelpful.

For such syntactic bootstrapping to work, at least two conditions must be met. First, there need to be systematic correlations between meaning and syntactic distribution, especially in cases where physical cues are sparse. Second, children need to be able to exploit these correlations. As for the first condition, a rich formal syntax and semantic literature has independently argued for principled links between meaning and syntax (e.g., Baker, 1988; Dowty, 1991; Farkas, 1985; Fillmore, 1968, 1970; Grimshaw, 1990; Gruber, 1965; Hooper, 1975; Jackendoff, 1972; Levin, 1993; Levin & Rappaport Hovav, 1995, 2005; McCawley, 1978; Perlmutter, 1978), proposing, for instance, associations between particular syntactic positions and thematic roles, such as agent or patient.

Experimental studies show that correlations between meaning and syntax exist not just in the minds of formal linguists, but also in those of naïve speakers, whose judgements of semantic similarity for various verbs correlate with the verbs' ability to appear in different syntactic frames (Fisher, Gleitman & Gleitman, 1991; White, Hacquard & Lidz, 2018a). Further studies show that syntactic cues are particularly helpful in cases where the physical context fails to be. For one, the original motivation and support for syntactic bootstrapping came from Landau and Gleitman (1985), who showed how similarly blind and seeing children acquire word meanings, including for words like *look*, *see*, and color terms, despite blind children lacking access to the visual context. Gillette, Gleitman, Gleitman and Lederer (1999) further demonstrated the usefulness of syntax in contexts where the visual context is under-informative by testing adult participants' ability to guess

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words uttered by a parent in silenced videos of interactions between the parent and their child, with a beep when the word was used. This was contrasted to participants' ability to guess the same words based solely on the syntactic frame in which the word occurred. Participants were able to guess nouns correctly about 45% of the time based on the visual context alone, but verbs only 15% of the time. However, they were much better at guessing verbs based on syntactic frame alone (~50% accuracy), and in particular attitude verbs (90% accuracy vs. 0% accuracy with visual context). These results suggest that, in principle, syntactic cues to verb meanings are available and reliable in children's input, especially when visual cues aren't.

But do children actually make use of syntactic cues when acquiring word meanings? Many studies argue that they do – with preschoolers, for instance, assigning different interpretations to novel verbs presented in different syntactic contexts (e.g., Arunachalam & Waxman, 2010; Fisher, 1996; Lidz, Gleitman & Gleitman, 2003; Naigles, 1990, 1996; Naigles & Kako, 1993; Papafragou, Cassidy & Gleitman, 2007; Yuan & Fisher, 2009). To illustrate, in a seminal study, Naigles (1990) showed that two-year-olds who heard the transitive sentence "*the duck is gorping the bunny*" looked longer at a scene in which a duck pushed a bunny than at one in which a duck and a bunny each wheeled their arms independently, while those who heard the intransitive "*the duck and the bunny are gorping*" did not – suggesting that, by age two, children are aware of the association between transitive syntax and causal events.[1]

While these studies demonstrate children's sensitivity to syntax when inferring meaning, the knowledge that drives this inference remains elusive, however. What is the nature of the generalizations about meaning and distribution that children make use of? Part of what makes the answer to this question challenging is the variation in how these correlations are instantiated across languages, and the various exceptions that occur even within a language. Because of this variation, actual syntactic evidence about meaning is bound to be noisy and highly abstract.

Most of the literature on syntactic bootstrapping has focused on children's acquisition of verb meanings. However, words from other lexical categories present similar challenges and possible solutions: determiners, adjectives, or prepositions, for instance, tend to have meanings that lack clear reliable correlates in the physical environment, but occur in restricted syntactic contexts, making them good candidates for syntactic bootstrapping. The few studies that examine their acquisition suggest that children can and do rely on syntactic cues to figure out their meanings (see e.g., Fisher, Klingler & Song, 2006 for prepositions; Booth & Waxman, 2009 for adjectives; Wellwood, Gagliardi & Lidz, 2016 for determiners vs. adjectives). For reasons of space, however, I will restrict my discussion to verbal categories.

In this paper, I examine the role that syntactic bootstrapping can play in acquiring meaning given the variation in the syntax/semantics mappings across languages, and within a language. I focus on cases for which the physical context seems particularly uninformative, and thus where children may especially need to rely on linguistic cues: attitude verbs (like "*think*", "*know*", or "*want*", which express internal states of belief, knowledge, or desire); and modals (like "*might*", "*can*", or "*must*"), which express abstract possibilities and necessities, for which the evidence is always indirect. I argue that, in these cases, some highly abstract syntactic classifications are indeed useful, but also that something further is both necessary and available. In section 2, I discuss some regularities

[1]For overviews of the successes of syntactic bootstrapping, see Fisher, Gertner, Scott & Yuan (2010); Lidz (2022).

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between form and meaning, and the limits of these regularities for syntactic bootstrapping. In section 3, I examine the role that pragmatics can play to support syntactic bootstrapping. Reasoning about the speaker's involvement in the conversation about how they mean to contribute can provide useful evidence about the meanings of the words they used. I argue that this pragmatic reasoning can be combined with syntactic bootstrapping in mutually constraining ways, particularly when it comes to the acquisition of attitude verb meanings. In section 4, I argue that syntactic and pragmatic bootstrapping come up short in the case of modals, but can be supplemented by semantic information from the lexical context in which the modals appear. Together these cases show how hard word learning can be, requiring cues stemming from different sources of information, as well as sophisticated conceptual, pragmatic, and linguistic abilities to triangulate word meaning.

2. Syntactic bootstrapping and its limits

The formal literature argues for principled links between meaning and syntactic distribution, which, as we saw, children seem able to exploit to infer some verb meanings. But what exactly is the nature of the knowledge that drives this inference? What precisely are the generalizations that hold within and across languages about meaning and syntax? And how much of these generalizations do children have access to when acquiring different word meanings? In what follows, I consider these questions for action verbs, attitude verbs, and clause types.

2.1. Syntactic bootstrapping and action verbs

A major challenge to formulating precise generalizations about form and meaning independently of acquisition is that the correlations between the two are complex and full of apparent exceptions, both within and across languages. To illustrate briefly with action verbs, there seem to be compelling generalizations between syntactic positions and 'thematic roles' – or ways of being involved in an event.[2] In transitive sentences like those in (1), for instance, the subject tends to name the doer, or 'agent', of the action described by the clause, while the object tends to name its 'patient', the individual to whom the action is done (Baker, 1988; Dowty, 1991; Fillmore, 1970; Jackendoff, 1972). However, the precise underpinnings of this generalization are not entirely clear and agreed upon in the literature. Broad generalizations require highly general thematic relations. But is it plausible to say that (1d) assigns to the key the same relation to the opening that (1c) assigns to Alex? Or that the role of the door in an opening is the same, in some definable way, as that of the kicked thing in a kicking? And what should we make of pairs of verbs that might seem to assign the same thematic roles but to reverse positions, as in (2)? Are there finer-grained distinctions, requiring us to individuate more and more thematic roles?

(1) a. Alex kicked the ball.
b. Alex kicked Frankie.
c. Alex opened the door.
d. The key opened the door.

[2]For an overview of the theoretical literature and its relevance for acquisition, see Williams (2015, 2021).

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(2) a. Alex likes pigeons.
b. Pigeons please Alex.

While these complications might seem to threaten the usefulness of syntactic cues for word learning, Dowty (1991) himself argues that rough thematic-based generalizations need not cover all cases to be useful to learners. Expecting subjects to be associated with more agent-like arguments and objects with more patient-like arguments should help children break into the system, and make rough initial classifications. As Lidz (2022) suggests, children may only expect probabilistic associations between semantic and syntactic features, and learn exceptional cases through different means.

Of which generalizations children actually make use also depends on what syntactic knowledge they can independently rely on, at the time they are acquiring various meanings. For instance, if children lack the ability to identify a syntactic asymmetry between subjects and objects in their language, a semantic correlation stated in terms of this asymmetry will provide no help.[3] Recent evidence shows that, at least by 20 months, English-learning children already rely on thematic role-based generalizations to infer some verb meanings (Perkins, 2019; Perkins, Knowlton, Williams & Lidz, 2022), suggesting an upper-bound for when children distinguish subjects and objects. Without this ability, learners would have to rely on correlations with shallower properties of form that they could identify, such as a parse that delivers the noun phrase arguments of a clause. For example, toddlers might take the noun phrase arguments in a clause to match one-to-one with participants in the event it describes (Fisher, 1996; Fisher, Gertner, Scott & Yuan, 2010; Gleitman, 1990; Lidz et al., 2003; Naigles, 1990; but see Perkins et al., 2022).

2.2. Syntactic bootstrapping and attitude verbs

Attitude verbs denote internal states, which lack clear physical correlates. Syntactically, they reliably differ from action verbs in their ability to combine with sentential complements, a difference to which children and adults seem to be sensitive (Fisher et al., 1991; Gillette et al., 1999; Papafragou et al., 2007). The selection of a sentential complement seems semantically motivated: attitude verbs express an 'attitude' (of belief, hope, or desire…) towards a state of affairs, represented by a proposition semantically, and a sentential complement syntactically.

But while a sentential complement might point learners to mental states in general, different attitude verbs name different mental states, with still very few physical correlates to distinguish them. Beliefs and desires tend to co-occur: what we want partially depends on what we believe. Thus, any situation involving desire will also involve belief. What, then, might cue learners in to the particular mental state that a verb like *think* or *want*

[3]How children learn to identify subjects and objects in their language is a complex issue: do they rely on *semantic bootstrapping* (Pinker, 1984), inferring subjects and objects on the basis of some verb meanings, or might they instead rely on prosody and frequent function words (e.g., Christophe, Millotte, Brusini & Cauvet, 2010)? E. Tribushinina (p.c.) points out that the ease with which children can solve this problem is further subject to potential cross-linguistic variation, as languages differ in the reliability of various cues to subject- or objecthood, such as word order or case (see e.g., Abbott-Smith, Chang, Rowland, Ferguson & Pine, 2017; Bates, McWhinney, Caselli, Devescovi, Natale & Venza, 1984; Ibbotson, Theakston, Lieven & Tomasello, 2010, for English vs. Dittmar, Abbott-Smith, Lieven & Tomasello, 2008; Kempe & MacWhinney, 1998, for German).

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expresses? Here again, syntax might help, if it reliably tracks different semantic classes of attitude verbs.

A rich formal literature suggests that syntax tracks different semantic classes of attitudes (e.g., Anand, Grimshaw & Hacquard, 2019; Bolinger, 1968; Farkas, 1985; Ginzburg, 1995; Hooper, 1975; Moulton, 2008). For instance, many argue that mood selection in Romance languages is semantically motivated. While the precise nature of this semantic motivation is highly debated, there is some general agreement that verbs that take complements in the indicative mood tend to express a commitment of the subject to the truth of the complement (roughly, belief and speech verbs), while verbs that take complements in the subjunctive mood tend to express preferences (roughly, desire verbs) (e.g., Bolinger, 1968; Farkas, 1985; Giannakidou, 1997; Villalta, 2008). The French examples in (3) and (4) illustrate, with "*penser*" ('*think*') selecting for the indicative, and "*vouloir*" ('*want*') selecting for the subjunctive.

(3) Alex pense que Frankie **vit** ici. French
Alex thinks that Frankie lives-**IND** here
'*Alex thinks that Frankie lives here.*'

(4) Alex veut que Frankie **vive** ici. French
Alex wants that Frankie lives-**SUBJ** here
'*Alex wants Frankie to live here.*'

There are however various counterexamples to the belief vs. desire generalization for mood, throwing into doubt the viability of relying on it for syntactic bootstrapping. For instance, the counterparts of "*hope*" select for either subjunctive or indicative mood, depending on the Romance language; Italian "*pensare*" ('*think*') selects for subjunctive mood (Farkas, 1985; Portner & Rubinstein, 2012). While these counterexamples give rise to important challenges (we'll discuss each briefly in sections 3 and 4, respectively), learners might still exploit mood probabilistically to make rough initial distinctions, the way we argued they might exploit thematic-based generalizations for action verbs, despite their counterexamples.

A more general problem for the syntactic bootstrapping of attitude meanings, however, is the high degree of syntactic variation that we find across languages. While languages do tend to mark the same belief vs. desire split through syntactic selection, the syntactic and morphological correlates of this split differ from language to language. In Romance languages, it is mainly tracked by mood. English, however, lacks a productive mood distinction. Instead, the belief vs. desire split is largely correlated with the finiteness of the complement: belief verbs tend to take finite complements, as in (5), while desire verbs tend to take nonfinite complements, as in (6).

(5) Alex thinks that Frankie live**s** here.

(6) Alex wants Frankie **to** live here.

German has both mood and finiteness marking. However, the belief vs. desire split seems to be tracked by yet another syntactic distinction – namely, word order. Embedded clauses in German are canonically verb-final, as in (7). However, complements of belief verbs, but not desire verbs, optionally allow the verb in the complement to appear in second position (V2), as shown in (8). In fact, this seems to be the most prevalent word

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order for complements of verbs like "*denken*" ('*think*') in child-directed speech (Brandt, Lieven & Tomasello, 2010).

(7) a. Alex denkt, dass Frankie hier **wohnt**. German
Alex thinks that Frankie here lives
'*Alex thinks that Frankie lives here.*'
b. Alex will, dass Frankie hier **wohnt**.
Alex wants that Frankie here lives.
'*Alex wants Frankie to live here.*'

(8) a. Alex denkt, Frankie **wohnt** hier. German
Alex thinks Frankie lives here.
'*Alex thinks that Frankie lives here.*'
b. *Alex will, Frankie **wohnt** hier.
Alex wants Frankie lives here.
'*Alex wants Frankie to live here.*'

On the one hand, the fact that there are often syntactic correlates to the belief vs. desire split across languages is promising for a syntactic bootstrapping strategy. On the other, how do children figure out which syntactic correlates matter for them, when these differ from language to language? And once children distinguish two categories of verbs based on their syntactic distribution, how are they supposed to know which corresponds to which semantic class? We'll refer to the first problem as the 'clustering problem', and to the second as the 'labeling problem'.

Hacquard and Lidz (2019) propose that while languages differ in the specific marking of the belief vs. desire split, they converge in that the complements of belief verbs, but not of desire verbs, tend to show syntactic hallmarks of declarative main clauses, the clauses typically associated with assertions: in English, declarative clauses are finite (9), in Romance languages, they are in the indicative mood (10), and in German, the verb occurs in second position (11). Thus, if children expect this link between declarative syntax and belief verbs, they should be able to not only distinguish two classes of verbs (solving the clustering problem), but to further know which corresponds to the belief verbs (solving the labeling problem).

(9) Frankie lives here.

(10) Frankie vit ici. French
'Frankie lives here.'

(11) Frankie wohnt hier. German
'Frankie lives here.'

This raises a further acquisition challenge. How do children know what declarative syntax is in the first place? Presumably, by the time they are learning attitude verb meanings around age two or three, children have sorted out declaratives from other clause types. But how? Here again, our learners face a major challenge from cross-linguistic variation. Languages across the world tend to distinguish three main clause types, dedicated to three main speech acts: declarative clauses are canonically used for assertions, interrogatives for questions, and imperatives for commands. However, languages

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differ in the syntactic make-up of these clauses. In English, for instance, main clause polar interrogatives typically involve subject-auxiliary inversion (12a), while in a language like Mandarin Chinese, they instead involve either a sentence-final particle (12b), or a kind of verb reduplication (12c):

(12) a. Is this Frankie?
b. Zhe shi Frankie ma? Mandarin
This is Frankie $Q_{particle}$
'Is this Frankie?'
c. Zhe shi-bu-shi Frankie? Mandarin
This be-not-be Frankie?
'Is this Frankie?'

The same problem thus arises as for attitude verbs: we may be able to find reliable syntactic markers to distinguish different clause types in each language, but given that these markers differ from language to language, something additional is needed to help them sort out these syntactic markers to cluster and label the right clause types. In section 3, I will argue that for both clause types and attitude verbs, pragmatics can serve as the relevant filter: reasoning about speakers' intentions can provide further evidence about the meanings of the words and phrases they used. This pragmatic bootstrapping can be combined with syntactic bootstrapping in mutually constraining ways, to help learners zero in on the right meanings.

3. Boosting syntactic bootstrapping with pragmatics

It is by now relatively uncontroversial that word learning must be aided in part by children's ability to pick up on pragmatic cues: knowing the gist or at least the topic of the conversation can constrain the space of hypotheses for a given word meaning; paying attention to what speakers are tending to can help children zero in on their referential intents (e.g., Baldwin, 1991; Bloom, 2002; Tomasello & Farrar, 1986). Gleitman (1990) worries that tracking such pragmatic cues might create a 'richness of the stimulus problem,' where a learner 'who notices everything can learn nothing.' However, Gleitman, Cassidy, Nappa, Papafragou and Trueswell (2005) grant that pragmatic cues could be useful, and in fact sufficient to acquire the meaning of 'easy words' like concrete nouns, which could then serve as building blocks for the syntactic bootstrapping of 'harder words,' such as verbs. In this section, I examine the various ways in which pragmatics might help with word learning not just independently, but in conjunction with syntactic bootstrapping.

As we saw, learners can zero in on a verb's meaning by paying attention to the syntactic frames in which it occurs. For instance, hearing a verb in a transitive sentence helps learners infer that the verb describes a causal event. But what happens in so-called 'argument drop' languages like Mandarin or Korean, where nominal arguments can be omitted in contexts where they are recoverable (at least by adults)? Fisher, Jin and Scott (2020) report that Korean children draw the same kinds of inferences as their English-learning peers, suggesting that they can recover missing arguments through discourse continuity. For instance, in a discourse where a speaker is talking about Grandma and says the Korean equivalent of *"Ø is gorping the puppy"*, children recover a subject whose referent is Grandma, and infer that "*gorp*" describes a causal event, thus relying both on pragmatic and syntactic expectations to infer a novel verb meaning.

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But pragmatics can do more than highlight different parts of the world or the conversation. It can also play a distorting role, for better or worse. Speakers routinely convey meaning beyond the literal meaning of the words they utter. A speaker who says "*I ate* many *of the cookies*" can convey that they didn't eat *all* of the cookies, as they might otherwise have uttered the stronger statement "*I ate all of the cookies*". Children hear words and sentences in conversations. Thus, technically, what they can use to learn are guesses about speaker meanings, and infer from those the underlying meaning of each expression. If children can somehow recover speakers' intentions, this pragmatic distortion could potentially hinder word learning. For instance, if children always heard "*many*" in contexts where speakers intended to convey 'many but not all', couldn't they wrongly assume that "*many*" means 'many but not all', and not the more general "*many*" of the adult grammar? A learner too attuned to pragmatics could thus run into the risk of lexicalizing too rich a meaning for certain words, depending on the way speakers use them. Perhaps biases towards general word meanings could prevent such lexicalizations (Barwise & Cooper, 1981; Rasin & Aravind, 2021), and rein in a learner's potential pragmatic overdrive. And perhaps, pragmatic distortion could in fact be beneficial for word learning, by playing a kind of magnifying role, if the kinds of pragmatic enrichments associated with a particular expression systematically highlight an aspect of its underlying semantics. In section 3.1, I examine how pragmatic enrichment might both interfere with and boost the acquisition of attitude verbs. In section 3.2, I examine the related problem of how syntax and pragmatics interact in children's acquisition of clause types (declaratives, interrogatives, imperatives), and their canonical function, i.e., the speech acts that they are canonically used for (assertion, question, request).

3.1. Pragmatic syntactic bootstrapping and attitude verbs

Beliefs and desires are always implicitly present in conversations, in virtue of the fact that conversations involve agents whose beliefs and desires drive those conversations. As it turns out, these mental states are rarely conversationally salient when attitude verbs are used, at least in English, because speakers often use these verbs to indirectly assert, as in (13), request, as in (14), or question, as in (15) (Dudley, Rowe, Hacquard & Lidz, 2018). With such indirect speech acts, the mental states that the attitude verbs describe are backgrounded (Simons, 2007; Urmson, 1952).

(13) I think it's 5pm. *Indirect assertion*: It's 5pm.

(14) I want you to tell me the time. *Indirect request*: Tell me the time.

(15) Do you know what time it is? *Indirect question*: What time is it?

On the one hand, this backgrounding could obscure the literal contribution of the attitude verb, and confuse learners who have to extract literal from speaker meaning. On the other, the type of speech act triggered by each verb could provide hints as to the verb's underlying meaning, if the kinds of speech act the verbs typically trigger are principled. According to Searle (1975), the reason why utterances of (13)-(15) are so well-suited for indirect speech acts is because their literal content expresses a precondition of the indirect act: to assert *p*, one must believe *p*; to request *p!*, one must want *p*; and to ask *p?*, one must believe one's addressee can answer *p*. If learners were to perceive the intended force of speakers' illocutionary acts, they could infer: from perceiving (13) as an indirect assertion,

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that "*think*" expresses a commitment to the truth of the complement; from perceiving (14) as an indirect request, that "*want*" expresses a desire; and from perceiving (15) as an indirect question, that "*know*" expresses a relation to a true answer. Such pragmatic bootstrapping seems at least possible, given the growing evidence that young children perceive the intent of indirect requests and questions (Begus & Southgate, 2012; Evans, Stolzenberg, Lee & Lyon, 2014; Goodhue, Wehbe, Hacquard & Lidz, 2021; Grosse, Moll & Tomasello, 2010; Shatz, 1978; Spekman & Roth, 1985).

However, this strategy of using indirect speech acts to infer attitude meanings could backfire – given that, in principle, any attitude report can be used for virtually any kind of speech act: "*think*" in (16), for instance, can be used to order a child to go to bed. If learners perceived the force of the request, might they then infer that "*think*" expresses a desire?

(16) I think it's time for bed!

Hacquard and Lidz (2019) propose that syntax could help rein in this pragmatic overdrive. According to their PRAGMATIC SYNTACTIC BOOTSTRAPPING HYPOTHESIS, syntactic and pragmatic bootstrapping mutually constrain each other, and children only learn from those cases where the two kinds of cues align.[4] In the previous section, we saw that syntactic cues could in principle help learners distinguish different attitude classes, but in limited ways: on the one hand, languages tend to differentiate belief and desire classes syntactically. On the other, they do so via different syntactic means (e.g., mood, finiteness, word order). How are learners supposed to know which syntactic features matter in their language? Hacquard and Lidz propose that these syntactic cues converge, because complements of belief verbs tend to have syntactic hallmarks of declarative main clauses. This raises two questions. First, why should children expect an association between declarative syntax and belief verbs? And second, how do children know what declarative syntax is in the first place? I propose that the answer to both questions is the alignment of syntactic form and pragmatic function.

Belief verbs express a commitment of their subjects to the truth of the proposition expressed by the complement: sentences like "*Alex {thinks, says, or knows} that Frankie left*" express a commitment of Alex to the truth of Frankie having left. Similarly, assertions express a commitment of the speaker to truth of the utterance: if I say "*Frankie left*", I am committed to the truth of Frankie having left. Desire verbs express a preference of their subjects for the state of affairs expressed by the complement: sentences like "*Alex {wants, wishes} Frankie to leave*" do not commit Alex to the truth of Frankie leaving, but merely express a preference for her departure. Similarly, imperatives express a preference of the speaker for the state of affairs described in their utterance: if I say "*Leave!*", I am expressing a preference for you to leave, though I do not necessarily expect that your leaving will come true. If children associate declarative syntax with expressions of truth commitment, they might expect belief verbs to express a truth commitment. They might further expect speakers uttering belief reports like (13) to indirectly assert the complement, by endorsing the subject's truth commitment. In the case of (13), the pragmatic function (indirect assertion) and the syntactic frame (finite complement) are consistent with a belief meaning. However, in (16) they aren't: the pragmatics of an indirect request points to a desire meaning, but the finite complement points to a belief meaning. If learners only

[4]Here I only discuss the case of belief vs. desire verbs for space reasons. For a pragmatic syntactic bootstrapping account of the "*think*" vs. "*know*" contrast, see Dudley et al. (2018).

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learn from cases where syntactic and pragmatic cues align, they should refrain from drawing any conclusions from cases like (16).

This pragmatic syntactic bootstrapping proposal for attitude meanings makes various predictions. First, cross-linguistically, the resemblance of complements of belief verbs to declarative main clauses should be sufficient to differentiate them from desire verbs. Second, when figuring out attitude verb meanings, children should be sensitive to both hallmarks of declarative syntax, and to the kinds of indirect speech acts associated with each class of attitudes. In particular, they should associate belief verbs with indirect assertions. In what follows I briefly review evidence in support of these predictions.

Cross-linguistically, there is a well-documented asymmetry in children's acquisition of belief and desire verbs: children seem to master "*want*" sooner than "*think*" (Perner, Sprung, Zauner & Haider, 2003). Specifically, preschoolers tend to incorrectly reject "*think*" sentences like (17), when they report a false belief, but they don't reject "*want*" sentences like (18) that report an unfulfilled desire. This robust asymmetry shows that children somehow distinguish the two verbs early, even when they seemingly haven't mastered at least one of them. Again, given the lack of physical correlates to mental states, this early differentiation suggests that children are sensitive to the differing linguistic profiles of the two verbs, either in terms of their syntactic or pragmatic distribution, or both.

(17) Dora thinks that Swiper is behind the curtain (but he is under the bed).

(18) Dora wants Swiper to be behind the curtain (but he is under the bed).

The traditional explanation for the asymmetry in children's mastery of "*think*" vs. "*want*" is that it reflects an asymmetry in conceptual development. According to this CONCEPTUAL HYPOTHESIS, the desire concept is acquired early, while children struggle with the belief concept until around age four, as evidenced by their systematic failures at false belief tasks (Bartsch & Wellman, 1995; De Villiers, 2005; Perner et al., 2003). Over the last fifteen years, however, a substantial body of studies argues that the belief concept might in fact be in place from infancy (e.g., Onishi & Baillargeon, 2005; Song, Onishi, Baillargeon & Fisher, 2008; Southgate, Senju & Csibra, 2007), though it may not be as readily accessible (Steglich-Petersen & Michael, 2015).

Lewis et al. (Lewis, Lidz & Hacquard, 2012; Lewis, Hacquard & Lidz, 2017) propose an alternative to the conceptual hypothesis: children's errors with "*think*" do not stem from conceptual difficulties, but are pragmatic in nature. They result from a tendency to over-assume indirect assertion uses of "*think*" sentences. According to this PRAGMATIC HYPOTHESIS, children reject sentences like (17) because they assume that with it, the speaker is indirectly asserting the complement (Swiper is behind the curtain); they reject this speaker meaning when they know this complement to be false. Note that this kind of response is itself adult-like. In the following dialogue adapted from Simons (2007), speaker C can reject B's utterance not because they disagree that Frankie holds a particular belief, but rather on the basis of what they take B's speaker meaning to be – namely, an indirect assertion or proffering of the complement (Alex is in France):

(19) A: Where is Alex?
B: Frankie thinks she's in France.
C: No, she's in Italy.

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To test the predictions of the two hypotheses, Lewis et al. (2017) tested children's acceptance of sentences like (17) in false belief scenarios where, for instance, Dora believes wrongly that Swiper is behind the curtain when he is in fact under the bed, and of sentences like (20) in the exact same scenarios.

(20) Dora thinks that Swiper is under the bed.

Both the conceptual and the pragmatic hypotheses predict that children should reject (17) in these scenarios: the former because children can't ascribe a false belief to Dora, the latter, because children over-assume indirect assertions of the complement, which they know to be false. The two, however, differ for (20). The conceptual hypothesis predicts that children should accept (20), since it is true that Swiper is under the bed, and since Dora cannot have false beliefs. The pragmatic hypothesis, on the other hand, predicts that children should reject (20) on the basis of its literal meaning: Dora does not believe that Swiper is under the bed. Lewis et al.'s results support the pragmatic hypothesis: three-year-olds rejected a sentence like (20) because of its false literal meaning. This argues that children have access to the literal meaning of "*think*" sentences, and thus to the underlying belief concept. It further suggests that children's errors with sentences like (17) are pragmatic, rather than conceptual. These results are moreover consistent with the prediction of the pragmatic syntactic bootstrapping hypothesis that children should access indirect assertion uses of "*think*" sentences. In fact, they seem to do so to a fault.

Turning now to the syntactic side of the problem, are syntactic hallmarks of declarative main clauses general and robust enough to support children's bootstrapping of the belief and desire classes? And do children make use of these syntactic cues? Huang, Liao, Hacquard and Lidz (2021) address the first question by testing the viability of the hypothesis for attitude verbs in Mandarin, a worst case scenario language in terms of morphosyntactic signal, as Mandarin is a PRO DROP language, and lacks overt mood or finiteness distinctions, to the point that belief and desire verbs can appear with complement clauses that are string identical, as shown in (21). To test the hypothesis, Huang et al. annotated syntactic features that appear in declarative clauses and in complements of attitude verbs in both child-directed speech, and in a larger written adult corpus,[5] and tested whether a virtual learner could distinguish belief from desire verbs, on the basis of these syntactic features.

(21) a. Wo **zhidao** chi shuiguo.
I **know** eat fruit
'I know {I/you/he/she/it/…} eat(s) fruit.'

b. Wo **ai** chi shuiguo.
I **love** eat fruit
'I love to eat fruit.'

Huang et al.'s results show that despite the morphosyntactic paucity of Mandarin, modals, aspect markers, and overt subjects still distinguish declarative main clauses from other main clauses, and that even though these features of declarative main clauses are optional inside both declarative main clauses and the complements of belief verbs, they

[5]Child-directed speech corpora from CHILDES (McWhinney, 2000): Beijing (Tardif, 1993, 1996), Chang1 (Chang, 1998), Context (Tardif, Gelman & Xu, 1999), Zhou1 (Zhou, 2001), and Zhou2 (Li & Zhou, 2004). Adult corpus: Chinese Treebank (Xue, Jiang, Zhong, Palmer, Xia, Chiou & Chang, 2010).

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occur often enough in speech to children (and in adult speech) to be detected and used by a computational model to successfully distinguish the complements of belief and desire verbs. Thus, the abstract link between declarative main clauses and the complement of belief verbs appears to be detectable even in a language like Mandarin, where it might be hardest to find.

While Huang et al.'s study shows that the relevant information is IN PRINCIPLE detectable (see White, Hacquard & Lidz, 2018b for similar results in English), Harrigan, Hacquard and Lidz (2019) investigated whether real child learners make use of syntactic cues to infer the meaning of an unfamiliar attitude verb IN PRACTICE, by testing four-year-olds' understanding of "*hope*", a relatively uncommon verb in child-directed speech. "*Hope*" has both a belief and a desire meaning component, as it expresses a desire for a state of affairs which can't be ruled out by one's beliefs: one can "*want*" this weekend to last forever, but not "*hope*" that it does (Anand & Hacquard, 2013; Portner, 1992; Scheffler, 2008). These two components can help motivate the kind of variation that we find in mood selection in Romance, as languages might differ in which component they tend to track syntactically. They can also make sense of the fact that in English, "*hope*" can occur with both finite and nonfinite complements.

The experimental setup in Harrigan et al. was a game involving partially hidden colored hearts and stars, which made both the beliefs and the desires of a puppet, Froggy, salient: Froggy unwaveringly wanted hearts, no matter the color, and had specific beliefs about what the shape was, based on its color. Froggy's beliefs and desires were sometimes in line with reality, and sometimes weren't (sometimes the shape was a heart, sometimes it was a star). Children's interpretation of "*hope*" sentences with both finite (22a) and nonfinite (22b) complements was tested and compared to their interpretation of "*think*" (23a) and "*want*" sentences (23b). The results show the traditional split in performance with "*think*" and "*want*": children correctly judged "*want*" sentences even when the reported desire conflicted with reality, but they tended to incorrectly reject "*think*" sentences that reported false beliefs. Crucially, children's responses to "*hope*" sentences differed depending on the syntactic frame in which they appeared. With a finite complement, their responses patterned like their responses to "*think*" sentences; but, with a nonfinite complement, their responses patterned like their responses to "*want*" sentences, showing that complement syntax influences children's interpretation of an unfamiliar attitude verb.

(22) a. Froggy hopes that it's a star.
b. Froggy hopes to get a star.

(23) a. Froggy thinks that it's a star.
b. Froggy wants it to be a star.

We thus see that syntactic and pragmatic cues can in principle work together to help children figure out the meaning of attitude verbs, and that children seem sensitive to both types of cues when interpreting attitude verbs. We now turn to children's acquisition of declaratives and other clause types, and the interaction of syntax and pragmatics in the process.

3.2. Pragmatic syntactic bootstrapping and clause types

Our syntactic bootstrapping account for attitude verbs crucially relies on children's ability to identify declarative syntax. But how do children figure out declaratives and other clause

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types in their language in the first place? As seen in section 2, languages across the world tend to linguistically privilege three kinds of speech acts (assertions, questions, requests), by having a dedicated clause type for each (declaratives, interrogatives, imperatives). However, languages differ in the syntactic make-up of these clauses, posing acquisition challenges similar to what we saw for attitude verbs.

Evidence suggests that children acquire the mapping between clause types and their dedicated function (speech act) by 18 months (Goodhue, Hacquard & Lidz, 2023). This can in turn support the acquisition of basic syntax and vocabulary. For instance, distinguishing declaratives from interrogatives can help children ignore displaced arguments in interrogatives for the purposes of verb learning (Perkins, 2019). But how do children figure out clause types when their grammatical knowledge is still in development?

There are two aspects to the problem, as with attitude verbs. First, learners need to find which syntactic features are relevant to home in on the right three categories of clause types (CLUSTERING PROBLEM). Second, learners need to associate each category with the right speech act (LABELING PROBLEM). We know that children have a great capacity for tracking syntactic regularities, including those involved in clause types (e.g., Geffen & Mintz, 2015, 2017), but how do they know which of these regularities are relevant for clause types? What role can and does pragmatics play in the clustering and the labeling problem of clause types?

Clearly, children need some pragmatics for the labeling problem: they need some inkling of what speech act is typically performed with each clause category to label them correctly. But do children also need speech act information at the clustering level? Through a series of corpus analyses and computational modeling, using the Providence corpus of CHILDES (Demuth, Culbertson & Alter, 2006; McWhinney, 2000), Yang (2022) argues that they do: a computational model trained to track syntactic features alone and to find three categories on that basis could not infer the right clause types. However, when provided with the actual speech act for each utterance (as determined by the annotators), the model was able to zero in on the right clause type categories. Importantly, it was able to do so even when given the right speech act information only 30% of the time. This suggests that just a bit of pragmatic information can go a long way in helping learners bootstrap clause type categories.

But how can children glean what speech act is being performed independently of clause type information? Yang found two promising correlates to questionhood in the nonlinguistic behavior of parents in their conversations with their children. First, parents tend to pause longer after they ask a question than after they make an assertion. Second, parents tend to look at their child more after a question than after an assertion. Both of these behaviors could – among others less easily measured in video recordings – signal to the child that the parent is expecting a response from them, and help them distinguish when parents are asking vs. telling them something. Thus, as with attitude verbs, we see that syntax and pragmatics can, at least in principle, work together to help learners infer meaning categories.

4. Beyond pragmatic syntactic bootstrapping

In this last section, I consider the complicated case of modals like "*must*" or "*may*", whose acquisition may need to rely on cues beyond what syntax and pragmatics can offer. I will argue that learners can supplement syntactic and pragmatic cues to modal meanings with

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subtle semantic information inferred from the morpho-lexical context in which the modals occur.

The lexical context in which a word occurs (i.e., the words that co-occur with it) can clearly constrain what that word might mean: if a verb only occurs with noun phrases that name liquids, learners might infer that the verb means something like "*drink*" (Resnik, 1996). The semantic information of adverbs can also help learners home in on verb and adjective meanings (Arunachalam, Syrett & Chen, 2016; Syrett, Arunachalam & Waxman, 2014; Syrett & Lidz, 2010). Moreover, abstract lexical features of a verb's argument such as ANIMACY can supplement under-informative syntactic cues. For instance, Bunger and Lidz (2004) show that, with novel verbs in intransitive clauses, an inanimate subject steers two-year-olds towards interpretations of the verbs as events describing a change to the inanimate subject. The animacy of the subject can also help learners distinguish so-called '*raising*' from '*control*' verbs (Becker, 2009), which differ in whether their complement contains a silent subject, a difference obscured in surface syntax. In this section, I probe whether morpho-lexical information can also supplement syntactic and pragmatic cues to give away modal meanings.

Modals, like "*must*" or "*have to*", can be used to express different types (or 'flavors') of necessities: epistemic necessities (likelihood), as in (24a), and various kinds of so-called 'root' necessities: that is, necessities based on different preferences – such as law-based (DEONTIC), desire-based (BOULETIC), or goal-based (TELEOLOGICAL), as in (24b).

(24) a. Alex's car is in the driveway. She **has to** be home.
b. Alex has been acting up. She **has to** go home.

Just like attitude verbs, modals express possibilities and necessities based on beliefs or desires, and thus lack clear physical correlates. In the case of modals, syntactic cues are even more limited than with attitude verbs. Like attitude verbs, modals combine with a propositional complement, which surfaces as a nonfinite verbal clause. The presence of this verbal complement can steer learners toward modal or attitude meanings, but what gets them to distinguish different modal meanings?[6]

Here again, a vast literature argues for syntactic differences between modals (Cinque, 1999; Groenendijk & Stokhof, 1975; Hacquard, 2006; Stowell, 2004). Prominently, epistemic modals have been argued to appear in a dedicated position above tense, root modals in a dedicated position below it. But even if true, this pattern is obscured in children's modal input in languages like English, as the ordering of tense and modals is not morphologically transparent, and thus epistemic and root modals appear in identical syntactic strings. For instance, the sentence in (25) can either express a likelihood that Alex is a meat-eater, or a requirement for Alex to eat meat. Syntactic cues are thus limited as to the root vs. epistemic contrast.

(25) Alex must eat meat.

Corpus studies suggest that root flavors are produced first by children around age 2, with epistemic flavors lagging a year behind (Astington, 1993; Cournane, 2015; Kuczaj & Maratsos, 1975; Stephany, 1979; Wells, 1979), though this lag might be due to a sampling effect, triggered by the overall rarity of epistemic uses (van Dooren,

[6]Note that ambiguity tests show that the deontic and epistemic readings in "*must*" or "*have to*" sentences result from distinct readings, and not to a general necessity meaning (see Hacquard, 2022 for an overview).

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Dieuleveut, Cournane & Hacquard, 2022). This bias for root meanings in child productions is unsurprising when we consider children's modal input, as many aspects of the distribution of modals should bias learners toward root interpretations.

First, from a syntactic standpoint, given that modals take nonfinite complements, the bootstrapping strategy for attitude verbs should lead them to infer root (desire) meanings. Second, from a conceptual standpoint, the concepts underlying root meanings may be more easily accessible than those underlying epistemic ones, even if both types of concepts may be in place in infancy, as we saw in our discussion of attitude verbs. Third, from a frequency standpoint, modals in children's input are overwhelmingly used to express root flavors (van Dooren et al., 2022). Finally, from a pragmatic standpoint, root meanings may be particularly salient in discourse: root modals can routinely be used for indirect requests ("*you have to go!*" to urge the addressee to go), a discourse function which young children seem particularly attuned to (Shatz, 1978; Spekman & Roth, 1985). From such uses, learners might infer that modals express preferences. Now, epistemic modals are also routinely used for indirect speech acts – namely, indirect assertions. Utterances of "*it must be raining*" and even "*it might be raining*" can be used to proffer that it is raining. However, these indirect assertions may not be as salient as indirect requests. Moreover, if Hacquard and Lidz's bootstrapping hypothesis is right, it predicts that learners should refrain from drawing inferences in cases where pragmatic cues (indirect assertion) and syntactic cues (nonfinite syntax) conflict. Thus, various factors from syntax to pragmatic and conceptual salience seem to conspire to steer learners towards root meanings. And once children have mapped a modal to a root meaning, why not stop there? Why assume that modals can ALSO be used for epistemic flavors?

To investigate what might give away epistemic meanings, van Dooren et al. (2022) examined distributional cues that distinguish root and epistemic modals in speech to children, using the Manchester corpus of CHILDES (Theakston, Lieven, Pine & Rowland, 2001; McWhinney, 2000). After reviewing the various ways in which the formal literature argues that root and epistemic uses differ, van Dooren et al. show that the most promising avenue is an interpretative constraint on the 'TEMPORAL ORIENTATION' of modals (Condoravdi, 2002): root modals tend to be 'FUTURE-ORIENTED', in saying that a future state of affairs is possible or necessary. Epistemic modals, on the other hand, can be 'PAST'- or 'PRESENT-ORIENTED', in concerning the possibility or necessity of something in the past or present (Klecha, 2016; Rullmann & Matthewson, 2018; Werner, 2006). This constraint is motivated by informativity considerations: roughly, preferences are about the future, since preferences about the present or past would be trivial, as the present and past are already settled. Beliefs, on the other hand, are not so constrained: they can be about the past or the present.

The temporal orientation constraint has clear morphosyntactic correlates, as temporal orientation is largely – though not perfectly – determined by aspect (Condoravdi, 2002). When the modal's complement consists of a bare verb stem with an eventive interpretation, like "*run*" as in (26), a modal can have both future and present orientation (the running follows or overlaps the time of possibility), and both root and epistemic interpretations are possible (*Alex is allowed to run*; *Alex is a potential runner*). However, with a stative complement, as in "*love running*" in (27), or with a progressive, as in "*be running*" in (28), the temporal orientation is present, and only epistemic interpretations seem possible. With a perfect, as in "*have run*" in (29), the temporal orientation is past, and only epistemic interpretations seem possible.

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(26)	Alex may run.	Future/Present orientation	epistemic, root
(27)	Alex may love running.	Present orientation	epistemic,[??] root
(28)	Alex may be running.	Present orientation	epistemic,[??] root
(29)	Alex may have run.	Past orientation	epistemic,[??] root

Given that temporal orientation might be difficult to identify, particularly when learners are still in the process of learning modal meanings, van Dooren et al. propose that children might have to track instead aspectual correlates to the temporal constraint. Given that perfect and progressive complements can be viewed as grammatical statives, we can group them together with lexical statives, and operationalize the temporal orientation constraint as a STATIVITY GENERALIZATION: root modals tend to only take eventive complements, while epistemic modals can take stative complements. Learners privy to this generalization could exploit it to discover epistemic flavors: by observing modals with a present or a past orientation, as indicated by stative aspectual cues, learners could infer that the modal is likely not used with a root meaning, and thus must be used for epistemic modality (assuming learners somehow know that both epistemic and root possibilities are linguistically expressible).

van Dooren et al. explore the viability of this bootstrapping strategy by examining how well aspectual cues correlate with modal flavor in speech to children. Their results show that the constraint is well-reflected in children's modal input: most root uses are eventive (70%), most epistemic uses are stative (up to 98%). However, given the large skew towards root meanings, there are overall more root modals with stative complements than epistemic modals, making the stativity generalization potentially useless on its own. Might learners be able to use it nonetheless, in conjunction with other cues?

A closer look at the exceptional root uses with stative complements shows that they fall into three main categories: the first are stative complements in indirect requests, illustrated in (30a); the second are counterfactuals, illustrated in (30b), the third are ability statements with perception verbs, where the ability is actualized, illustrated in (30c): the mother not only CAN but DOES see lots of footprints. The first two disobey the stativity generalization, but still obey the temporal orientation constraint: they are future-oriented, relative to the time of the possibility or necessity. The last one violates both the stativity generalization, in that perception verbs are arguably stative, and the temporal orientation constraint, as the time of the state and of the possibility are concurrent (present-orientation).

(30) a. You **have to** *have* more than three. (Mother, Aran 2;08)
b. You **could** *have said* hello.
c. *Mother and child are reading the book the Night before Christmas*
Mother: And I **can** *see* lots of footprints, look. (Mother, Anne 2;04)

Interestingly, in each of these cases, the physical context should make it particularly salient that the state or event described by the modal complement is either true or false. For (30a) and (30b), it should be fairly obvious to the child that they do NOT have more than three at the time of the mother's utterance in (30a), and that they did NOT say hello in

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(30b). In (30c), it should be fairly clear to the child that the mother IS seeing the footprints in the book they are both looking at. This is in contrast with genuine epistemic modal uses, which are typically infelicitous when there is direct evidence for the state of affairs described in the modal's complement (von Fintel & Gillies, 2010): asserting that it must be raining when standing in pouring rain is infelicitous. van Dooren et al. propose that, when learning modal meanings, learners initially ignore exceptional modal uses like those in (30), where the complement is either clearly true or clearly false; as, in such cases, neither possibility nor necessity seems at issue, and the modal's contribution might thus be particularly obscure. If children ignore such cases, they should be able to exploit the temporal orientation constraint using the much clearer signal from the stativity generalization, to discover epistemic meanings.

van Dooren et al.'s results thus show that a combination of morpho-syntactic aspectual cues to epistemic modality are in principle exploitable in the input, in conjunction with some contextual cues from the physical and pragmatic environment. Several studies suggest that children make aspectual distinctions early in syntactic-semantic development (Wagner, 2001, 2010; van Hout, 2016). But whether children can and do make use of aspectual cues in their modal acquisition remains an open question. While a number of comprehension studies test children's sensitivity to aspectual properties of the complement when interpreting modals, the results are somewhat inconclusive, due to various biases and methodological issues (Cournane, 2015; Cournane & Pérez-Leroux, 2020; Cournane & Veselinović, 2022; Heizmann, 2006).

To sum up, we have seen that the acquisition of modals may require a combination of subtle syntactic, pragmatic, and morpho-lexical cues, which learners can only exploit if they have already figured out how aspectual features of embedded clauses mark temporal orientation.

Assuming that children can track temporal orientation via temporal and aspectual morphological features by the time they are acquiring epistemic modals around age 3, this opens up a new avenue to explore for the acquisition of attitude verbs: children may be able to deploy the same strategy to distinguish belief and desire verbs, as desires tend to be future-oriented, but not beliefs. Such cues might be particularly helpful in cases where syntactic and pragmatic cues are weak and potentially contradictory, as in Italian, where the main belief verbs ("*pensare*" '*think*', "*credere*" '*believe*') take subjunctive complements (Bou-Saboun, *p.c.*). While universal linguistic principles and general cognitive and pragmatic principles must support and guide the acquisition of modal, attitude, and other meanings in their language, how children eventually figure out these meanings depends on the syntactic, pragmatic, and morpho-lexical correlates of the relevant semantic distinctions in that language, the strength of their signal in children's input, and how much of their grammar and lexicon children have already mastered at the point they are figuring out these meanings.

5. Conclusions and further directions

The more we learn about word learning, the more we find out how hard it is, and how impossibly good children are at it. Landau and Gleitman (1985)'s landmark syntactic bootstrapping hypothesis has received much empirical support in the last forty years, demonstrating the essential role that syntax must play in this learning process, and children's surprising sensitivity to it. For instance, we see that by age two, children already seem to use thematic role-based generalizations to infer action verb meanings, and by age

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four, they can use syntactic properties of the complement of an attitude verb to infer its meaning.

Recent advances in cognitive development and various sub-disciplines of linguistics makes it a particularly exciting time to aim for the new frontier in our understanding of word learning: we can now ask not just WHETHER children use syntax to infer meaning, but HOW exactly they use it, what additional sources of information they can and must draw from, and what linguistic, pragmatic, and cognitive capacities allow them to triangulate meaning from these various sources, as their grammar and lexicon develop. First, we now have a much clearer understanding of children's perceptual and conceptual abilities, and how, by and large, they seem to align with those of their parents. Second, the last decade has seen a renewed interest in formal semantics in identifying the semantic underpinnings of syntactic selection. This is in part driven by recent methodological innovations that allow us to test theoretical generalizations through large scale semantic and syntactic acceptability judgments (e.g., White & Rawlins, 2018). Third, a growing number of corpus studies are starting to examine not just morpho-syntactic, but semantic and pragmatic features of children's input (e.g., Becker, 2015; Dieuleveut, van Dooren, Cournane & Hacquard, 2022; Dudley et al., 2018; Rasin & Aravind, 2021; van Dooren et al., 2022), providing us with a clearer picture of what information is actually available in children's input. We are thus in a much better position to ask which information children actually make use of, which they ignore, and what hypotheses they make or fail to make on the basis of that information, getting us closer to the identification of the underlying linguistic knowledge that drives children's hypotheses about meaning.

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