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Revisiting the epistemic gap: It's not the thought that counts

Ailís Cournane

New York University

ABSTRACT

This paper revisits the longstanding observation that children produce modal verbs (e.g., must, could) with their root meanings (e.g., abilities, obligations) by age 2, typically a year or more earlier than with their epistemic meanings (e.g., inferences). Established explanations for this "Epistemic Gap" argue that epistemic language production is delayed because small children can only reason about root meanings. However, root and epistemic uses of modal verbs also differ syntactically and in input representation. We present a corpus study on 17 English-learning children and their input, exploring early productions with both epistemic modal verbs and grammatically simpler and more frequent epistemic adverbs (e.g., maybe, probably). Results show that children use remarkably adult-like epistemic adverb sentences from even before age 2, when they are only producing modal verbs with root meanings. The Epistemic Gap is not well explained by general conceptual advancements. Instead, our data suggest input attestation and ease of form-meaning mapping may influence early child epistemic language. These findings are furthermore consistent with cross-linguistic differences in the timing of first epistemic uses of modal verbs, and with recent advancements in our understanding of infant and toddler modal reasoning abilities.

1. Introduction

Linguistic modality encodes our capacity to reason about non-actual events. Modality is divided into two broad "flavors": root (1a; abilities, obligations, goals, among others)[1] and epistemic (1b; knowledge-based inferences) (Bybee, Perkins & Pagliuca 1994; Kratzer 1977, 1981; Lyons 1977; Palmer 2001; Portner 2009, i.a.). Modal verbs (MVs) in many languages encode both these distinct types of modality —*must* in (1).

(1) Dino *must* eat lots of leaves ...

a....	because his vet said they'll improve his health.	Root (Obligation)
b....	because all the trees around his cave are bare.	Epistemic

Foundational work on modal flavor acquisition has repeatedly described what we will call the "Epistemic Gap" (EG): Children produce modal verbs (e.g., *must, can, have to*) with root meanings by age 2 (2a,b)—months or even years—before with epistemic meanings (2c) (Bassano 1996; Bliss 1988; Kuczaj 1982; Kuczaj & Maratsos 1975; Shatz & Wilcox 1991; Shepherd 1982; Stephany 1979; Wells 1979, i.a.; Papafragou 1998 for overview).

What explains this *Epistemic Gap* for modal verb productions (Cournane 2015a, 2015b)? Extant explanations emphasize conceptual differences between root and epistemic modalities. They argue

CONTACT Ailís Cournane ✉ cournane@nyu.edu 🖃 Department of Linguistics, New York University, 10 Washington Pl, New York, NY 10003.

[1]Within root modalities there are differing subclassifications of meanings by framework or author—for example: dispositional, deontic, teleological, desire-intentional, and circumstantial, among others.

(2)	a.	*I can ride one.*	(= a toy horse)	Sarah 2;04,12	Root (Ability)
	b.	*I can't do it.*	(=hurt her mom)	Sarah 2;11,28	Root (Deontic)
	c.	*Must be gone.*	(=missing toy dishes)	Sarah 3;00,27	Epistemic
				(Cournane 2015a, 2015b; Brown Corpus; Brown 1973)	

that epistemic uses occur later because they: (i) are based on metaphorical extensions from initial root meanings (Diessel 2011; Stephany 1979; Sweetser 1990), or (ii) require more development of Theory of Mind-related metarepresentational reasoning than root counterparts ("thinking about Papafragou 1998, 2001; also Shatz & Wilcox 1991; Dack & Astington 2011; a.o.).

However, foundational production studies predominantly sampled English auxiliary modal verbs (e.g., *must, could*) and similar modals in other languages. Most common in Indo-European languages (van der Auwera & Ammann 2005), this kind of modal verb is polysemous[2] between root and epistemic uses. And, root and epistemic uses of MVs differ in both the syntax (e.g., Brennan 1993; Roberts 1985; Ross 1967) and input (e.g., Shatz & Wilcox 1991; van Dooren et al. 2017). Focus on MVs as representative of modal reasoning in language development may thus conflate conceptual, grammatical, and input developmental factors. The Epistemic Gap observed primarily for MVs has three potential sources[3] (Cournane 2015a, 2015b; Veselinović & Cournane 2020; see also De Villiers 2007; Heizmann 2006; Papafragou 1998), laid out in Table 1.

The primary goal of this article is to revisit the Epistemic Gap by comparing epistemic uses of modal verbs (e.g., *must, might, have to*) to epistemic adverbs (e.g., *maybe, probably*) within subjects. Epistemic adverbs can express the same epistemic reasoning as modal verbs but have no competing root uses[4] and have minimal syntactic complexity as adjuncts (see also O'Neill & Atance 2000). If adult-like uses of epistemic adverbs appear within a child's Epistemic Gap for modal verbs, this would provide evidence against a root-before-epistemic conceptual asymmetry. The current study allows us to assess: (i) when and how children use epistemic adverbs vs. epistemic MVs, (ii) how adult-like early epistemic adverb uses are, and (iii) whether input and sampling frequency accounts for early epistemic language.

Results show that children reliably produce epistemic adverbs in richly adult-like contexts, significantly prior to their first epistemic uses of modal verbs. Comparison to the input within child-parent dyads shows a moderate positive correlation between adult and child epistemic adverb usage rates. These results confirm that "root-before-epistemic" development describes only MV usage, not general child modal productions. These results are furthermore consistent with advancements in our understanding of toddler reasoning abilities since the foundational corpus studies (e.g., Cesana-Arlotti et al. 2018; Onishi & Baillargeon 2005) and with other corpus studies that have found wide variation in the duration of the EG by individual and language (van Dooren et al. 2017, 2019; Veselinović & Cournane 2020). We can reject conceptual development as an explanation for the Epistemic Gap. We propose the current best explanation for the Epistemic Gap is a combination of weak input attestation and form-meaning mapping complexity.

Table 1. Key differences between root and epistemic Modal Verbs, which may underlie the Epistemic Gap.

I. Conceptual	Root and epistemic MVs express different reasoning abilities.	~ Epistemic uses require more conceptual development than roots uses.
II. Grammatical	Root and epistemic MVs are grammatically distinct. Epistemic uses take larger syntactic complements.	~ Epistemic uses require more grammatical development than root uses.
III. Input-Relative	Root and epistemic MVs differ in the input in frequency and other attributes.	~ Epistemic uses require more input experience than root uses.

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[2]We use the term *polysemous* descriptively.
[3]Another factor may be that small children do not care to talk about thinking; we set this aside because it should affect all grammatical categories used to express epistemics uniformly (see Hickmann & Bassano 2016 for overview).
[4]There are some minor exceptions to this claim, but they are not relevant to our sample.

This article is organized as follows. Section 2 covers background on modal meaning, syntax, and acquisition. Section 3 reports novel corpus studies. Section 4 discusses broader implications of the current work, highlighting: (i) input and grammatical factors in modal development, and (ii) the interplay between linguistic and conceptual representational development on the path to adult-like modality. Section 5 concludes.

2. Background

Modal words express different "flavors" (kinds of nonactuality), and different "forces" (possibilities or necessities and, for some modals, degrees of possibility (Lassiter 2010)). Root modalities concern possibilities in the actual world, relative to the participants of the event under discussion (typically the agent), based on desires, rules, goals, or circumstances ("agent-oriented modality," Bybee, Perkins & Pagliuca 1994; and "event modality," Jespersen 1924; Palmer 2001)). Epistemic modality involves speaker inferences about what is likely or possible based on what is known or in evidence ("speaker-oriented modality," Bybee, Perkins & Pagliuca 1994; and "propositional modality" Jespersen 1924; Palmer 2001). Epistemic reasoning is *metarepresentational* because it requires making inferences about propositions, or "thinking about thinking"[5] (Papafragou 1998, 2001). Modality and modal words are of particular interest in development because of the puzzles of when and how children (i) differentiate among these complex modal meanings, and (ii) discover the mapping between linguistic symbols and these non-experiential meanings (à la Gleitman 1990).

2.1. *Modal concepts in development*

Concerning when and how children differentiate among modal flavors in development, research using implicit measures (e.g., preferential looking, eye tracking) shows that many reasoning abilities underpinning both root and epistemic modal flavors and possibility reasoning (modal force) are already present in young infants (for overviews, see De Villiers 2007; Leahy & Carey 2020; Milligan, Astington & Dack 2007). For example, 9-month-old infants appear to encode agent intentions (or desires) (Woodward 1998), and several other markers of shared intentionality are present in 1- and 2-year-olds (Tomasello & Carpenter 2007). Regarding deontic modality (about permission or obligation), by 28 to 30 months old, children sometimes invoke rules and norms to explain behavior and ask about social rules (Dunn 1988). Especially relevant for speaker-oriented epistemic modality, (i) 12-month-olds point not (only) to signal appreciation but to make "epistemic requests" for what is unknown to them (Kovács et al. 2014), and (ii) 20-month-olds can monitor and report on their own uncertainty (Goupil, Romand-Monnier & Kouider 2016). And, these metarepresentation abilities extend to others as well: (iii) 15-month-olds even appear able to infer about where another person will look for a toy, based on that person's goals, beliefs, or percepts (Onishi & Baillargeon 2005), and (iv) 25-month-olds correctly predict actors' actions using false-belief attribution (Southgate, Senju & Csibra 2007).

Preschool and early school age children also show a "Deontic Advantage" with certain reasoning tasks extending on work with adults. Adults perform better on reasoning tasks (e.g., Wason's Selection Task; Wason 1966) when conditional statements (*If x, then y*) that set up the tasks are situated in a deontic context (e.g., reasoning about prescriptive obligations, *If a person is drinking beer, then the person must be over 19 years of age*), rather than an epistemic[6] one (e.g., the classic task, reasoning

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[5]Theory of Mind (ToM) components often come up in relation to epistemic reasoning. Note that while we use epistemic reasoning and language when talking about inner states (e.g., *Dino must be sleepy*), reference to inner states is not a necessary condition for epistemicity. For example, *It must be raining* is also epistemic despite no explicit inner state reference; the speaker expresses an inference based on what they know/perceive (e.g., seeing wet umbrellas).

[6]These are standardly called "epistemic," which doesn't fully square with the linguistic approaches to modal classifications taken here. Deontic versus Epistemic in this literature is best described as being about "pure" descriptive reasoning (called epistemic) versus socially embedded prescriptive reasoning (deontic) (see Dack & Astington 2011). N.B. that deontic tasks often include modal language (e.g., *must*), but the epistemic ones are typically plain conditionals.

about descriptive statements, *If a card has a vowel on one side, then it has an even number on the other side*) (Griggs & Cox 1982; Stanovich & West 1998). This adult-like asymmetry has also been reported with 3- and 4-years-olds using simplified tasks (Cummins 1996; Harris & Núnez 1996; Wellman & Miller 2008). However, debate concerns the role of modal language in tasks, whether deontic reasoning is actually easier than epistemic, and whether young children only show a deontic advantage with an authority figure present (see Cummins 2013; Dack & Astington 2011).

What about possibility reasoning—How early can children appreciate that some propositions are merely possible, rather than actual? Research shows early success with tasks that require participants to make deductive inferences about possible identities of a hidden toy (12 months; Nicoló Cesana-Arlotti et al. 2018) and with tasks that require solving the disjunctive syllogism, comparing possibilities (*A or B, not A, therefore B*) (20 and 23 months; (Mody & Carey, 2016). However, explicit reasoning tasks with preschool-aged children show certain failures related to possibility reasoning (Moscati, Zhan & Zhou 2017; Ozturk & Papafragou 2015; Piéraut-Le Bonniec 1980). For example, children fail to reliably and proactively cover both possible exits for a dropped ball in behavioral tasks until age 4 (Redshaw & Suddendorf 2016). In these tasks, 3-year-olds typically "guess" by selecting one choice from open options. Leahy & Carey (2020) argue these disparate findings can be reconciled if younger children succeed at some possibility tasks through Minimal Representations of Possibility. These possibility models involve the child considering multiple hypotheses (possibilities), based on context or prior experiences, and making a Bayesian choice, committing to one. Modal Representations of Possibility, by contrast, use a modal symbolic operator to actively hold two (or more) open possibilities in mind at once, without "ruling in" either to the model. Leahy & Carey (2020) argue that possibility reasoning is discontinuous and becomes adult-like by age 4, perhaps through experience with modal language use.

Infants and toddlers appear able to reason in several fundamental ways necessary to support adult-like modal reasoning about non-actual possibilities. These early concepts likely support earliest word learning for modal language (by age 2 in most children). However, earliest reasoning successes may not always arise through adult-like means. Studies with preschool children show non-adult behaviors for approaching possibility reasoning tasks. And, like adults, small children may have greater ease with deontic reasoning than non-socially-embedded reasoning.

2.2. *Modal syntax-semantics*

Modal meanings are expressed by multiple syntactic categories both within and across languages (Bybee, Perkins & Pagliuca 1994; Kratzer 1981; Palmer 2001). These can be split into two major syntactic types: lexical and functional (Hacquard 2013; Traugott 2006). Lexical modals (3): (i) belong to categories such as main verbs (*think, hope*), nouns (*possibility, desire*), adverbs (*maybe, probably*), and adjectives (*possible, necessary*), and (ii) are typically monosemous (~have dedicated meanings, see Rett & Hyams 2014).[7] Functional modals (i) come from categories like auxiliary or semi-auxiliary verbs (e.g., T^0: *must, might*; v^0: *have to, supposed to*), particles, or mood inflections (Palmer 2001); (ii) are typically polysemous (the same word expresses both root and epistemic meanings); and (iii) show differing syntax-semantics interactions when used as root versus epistemic. Importantly for us, essentially the same epistemic "thinking about thinking" expressed by epistemic MV *must* in (1b) can be expressed by a lexical modal like *probably* (4) despite grammatical differences. In this article, we focus on English MVs as canonically representative of functional modals and on adverbs as representative of lexical modals (rather than epistemic attitude verbs like *think, know*).

(3)   a. Dino is *obliged* to eat lots of leaves.   Root (Deontic), *Epistemic
          b. It is *likely* Dino eats lots of leaves.   *Root, Epistemic
          c. *Maybe* the baby is sleepy.   *Root, Epistemic

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[7] There are some exceptions here, not of central importance to us—for example, the adjectival *to be possible*.

(4) (*Probably*) Dino (*probably*) eats lots of leaves (*probably*).
  … because all the trees around his cave are bare!   Epistemic

Syntacticians and semanticists propose distinct structures to capture the interpretive and morpho-syntactic differences between root and epistemic MV uses (Jackendoff 1972; Brennan 1993; Cinque 1999; Hacquard 2006; Ramchand 2018; Roberts 1985, i.a.; see Hacquard 2010; Barbiers & van Dooren 2017; Veselinović 2019, for recent overviews). Most argue that epistemic MVs scope higher and take larger complements than root MVs (cf. Rullmann & Matthewson 2018). For example, *must*'s flavor relates to where in the structure it is interpreted: When interpreted below tense and aspect, *must* is root (5a); when interpreted above tense and aspect, *must* is epistemic (5b) (see Hacquard 2006, 2010). In English, with grammatical aspect marking like perfect (6), the modal verb appears overtly above aspect and is interpreted in its high position as epistemic[8] (confirmed experimentally, Cournane & Pérez-Leroux 2020).

(5) Dino *must* eat lots of leaves.
  a. [Dino *must* [eat lots of leaves]$_{VP}$]$_{TP}$
    'Dino is obliged to eat lots of leaves'   Root Deontic
  b.   *must* [Dino [eat lots of leaves] $_{VP}$]$_{TP}$
    'It is likely true that Dino eats lots of leaves'   Epistemic

(6) Dino *must* <u>have</u> eat<u>en</u> lots of leaves.   ?Root, ✓ Epistemic

The formal semantic literature links modal flavor to Temporal Orientation (TO) of the modal's prejacent (the unmodalized proposition, i.e., *Dino eats lots of leaves*). The TO linguistically arises from a combination of tense and aspect marking. Root modals are constrained to only future-oriented TOs, while epistemic modals are not and may occur with prejacents with present and past TOs (see Condoravdi 2002; Rullmann & Matthewson 2018; Werner 2006; i.a.). Whether epistemic modality can obtain with future TO is currently an active area of debate (e.g., Klecha 2016; Giannakidou & Mari 2018 for differing viewpoints). This debate affects developmental work on what counts as epistemic as codes differ, and many (if not most, including the current work) acquisition studies include future-oriented prejacents with modals as epistemic (assuming other coding criteria are also present). Some also consider future marking as epistemic (e.g., Bassano 1996), in line with Giannakidou & Mari (2018).

Lexical modals differ semantically from modal verbs, as they are full predicates of events and relatively immune to tense and aspect fluctuations of their prejacent (see Hacquard 2013). Belief verbs (e.g., *think, know*) express modal meanings but take clausal complements (Bolinger 1968; Pearson forthcoming, for overview). They thus face the same grammatical learning hurdle as epistemic uses of modal verbs: They require both complex syntax (= selection of proposition denoting structures) and complex conceptual abilities (= epistemic reasoning), in addition to having many pragmatic uses (Dudley 2017; Hacquard & Lidz 2016).[9] Modal adverbs, on the other hand, have adjunctival syntax. This means they can appear in different positions in the clause (4) and stand alone in response to polar questions, unlike modal verbs. Like epistemic modal verbs, they scope over propositions and vary by strength (weaker *maybe* vs. stronger *probably*).[10]

In sum, modal verbs are typically polysemous, and their epistemic uses are cross-linguistically more grammatically complex than their root uses. Both of these grammatical factors may contribute to the

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[8]A root interpretation is also possible but requires additional temporal operators to shift the temporal orientation of the prejacent to future-oriented (e.g., *By tonight*) or contextual support to the same effect.

[9]Belief verbs like *think, know*, and *believe* have been studied largely independently from functional modals in acquisition (Perner & Wimmer 1985; Shatz, Wellman & Silber 1983; De Villiers 2007, for overview). *Think* and *know* are the most frequent epistemic modals of any category in English usage, including to children (van Dooren et al. 2017), however, a substantial proportion of their usage occurs in formulaic expressions like *I don't know* or with otherwise epistemicity-obscuring speaker meanings (see Dudley 2017).

[10]Note we will call modal adverbs "weak" and "strong" rather than "possibility" and "necessity." This is mostly due to *probably*, which is not a clear necessity modal because it is a gradable modal (see Lassiter 2010).

delayed acquisition of epistemic modal verbs (the Epistemic Gap). On the other hand, epistemic adverbs are monosemous (unlike MVs) and adjunctival (unlike epistemic attitude verbs). Adverbs give children the best shot at mapping an epistemic input form to epistemic meaning. Also relevant for learning modal word meanings, root modals are restricted to future-oriented prejacents, while epistemic modals occur with present and past-oriented prejacents.

2.3. *Prior acquisition work on modal verbs*

Concerning when and how children discover the mapping between linguistic symbols and modal meanings, most development research has focused on MVs in Indo-European languages (though see Stephany 1979; Guo 1994; for overview see Hickmann & Bassano 2016). Most studies either look at corpus production data and examine usage flavor or run experiments on force differences (e.g., *might* vs. *must*) (Ozturk & Papafragou 2015, for overview).[11] A few studies look at flavor experimentally with children over 3 (e.g., Cournane & Pérez-Leroux, 2020; Fond 2003; Heizmann 2006; Modyanova et al. 2010; Veselinović 2019). We set aside experimental work because it focuses primarily on comprehension with older children.

Foundational production studies look at spontaneous uses of modal expressions, most commonly auxiliary verbs (e.g., *must, will, have to*), in longitudinal and cross-sectional production samples (Bassano 1996; Bliss 1988; Guo 1994; Kuczaj 1982; Kuczaj & Maratsos 1975; Shepherd 1982; Stephany 1979; Wells 1979, 1985; i.a.). While coding practices, language properties, and results from these studies vary in many respects, they repeatedly show the *Epistemic Gap* (Cournane 2015a, 2015b): Root uses arise by age 2, before first epistemic uses (anywhere from a couple months to a couple years later). This pattern is observed for the set of modal verbs, as well as individual MVs (7). Once children begin using epistemic MVs, they do so at much lower rates than in the input (van Dooren et al. 2017; see also Cournane 2015a, 2015b; Shatz & Wilcox 1991).

(7)   a. Child: I got crane out my box.
         Investigator: oh you've got your box as well yeah.
         Child: I **must**$_{root}$ get crane.   (Aran, 2;02, Manchester Corpus)
       b. Mother: oh we've got a bit of hair stuck, haven't we?
         Child: look.
         Child: it **must**$_{epis}$ be some of dolly's hair.   (Aran, 2;09, Manchester Corpus)

From early on, researchers have proposed conceptual explanations for the EG (Coates 1988; Papafragou 1998; Shepherd 1982; Stephany 1979; Sweetser 1990; Wells 1985; i.a.). One approach draws on parallels between root-before-epistemic in child development and language change (in the historical record, MVs first appear with root uses, then epistemic: see Traugott 1989). For example, Stephany (1979:400) argues that "[t]he priority of the deontic, as compared to epistemic, modality in the ontogenesis as well as in the history of languages can be considered as indicating the primacy of the social, as compared to the epistemic, function of language" (cf. "Deontic Advantage"). Similarly, Sweetser (1990) proposes a metaphorical relationship between root and epistemic uses in acquisition and change. Internal-world epistemic modality is structured metaphorically upon external-world root modality (Sweetser 1990:50). She explicitly references root-before-epistemic development to support this analysis (see also Diessel 2011). Another conceptual approach appeals to Theory of Mind (ToM) milestones to explain the modal developmental pathway (Papafragou 1998, 2001). Papafragou (1998:394) argues that

> [t]he later emergence of epistemic uses can be predicted from independent assumptions about the child's emerging theory of mind. After the full array of metarepresentational capacities is activated in the child, she will be able to detect a common possibility- or necessity-based core across root and epistemic interpretations of different modal verbs (…).

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[11]Moore, Pure & Furrow (1990) is primarily a modal force behavioral study, but they compare among different syntactic categories (adverbs, belief verbs, modal verbs) for belief tasks. They find correlations between the three categories.

Essentially, children need to conceptually advance before epistemic word learning takes place.[12]

Much prior work has looked at the input and suggested an explanatory role for modal development (and for related categories, like evidentials) (Hickmann & Bassano 2016 for overview). Recent dense corpus work has helped us understand more about the input to children for MVs by flavor. van Dooren et al. (2017, submitted) looked at input and child productions in the Manchester Corpus (*n* = 12 parent-child dyads; children aged 2;00[13]–3;00; 373,798 adult utterances, 190,827 child utterances; Theakston et al. 2001). Input uses of MVs show only about 8% epistemic uses (92% root). Notably, some MVs (*might, must, may*) are more often epistemic in the input (e.g., *must*, 80% epistemic). Children use some epistemic MVs (*n* = 51; 2% of all MV uses) in this early age window (e.g, 7b for Aran). Even for modals that are primarily epistemic in the input, child productions are primarily root (e.g., *must*, 20% epistemic). In similar work on Dutch (van Dooren et al. 2019) using the Groningen Corpus (*n* = 7 parent-child dyads; children aged 1;05–3;07; 181,003 adult utterances, 82,108 child utterances; Wijnen & Verrips 1998), the input shows a much more pronounced disparity, with only 1.5% epistemic uses of MVs. They found no child epistemic modal verb uses. Veselinović (2019) and Veselinović & Cournane (2020) looked at Bosnian-Croatian-Serbian (BCS), using the SCECL Corpus (*n* = 8 parent-child dyads; children aged 1;06–4;00; 72,305 adult utterances, 95,105 child utterances; Anđelković, Ševa & Moskovljević 2001). They found that both *morati* 'must' and *moči* 'can' have very few epistemic uses in the input (<7%, mostly with *morati*). No child uses epistemic MVs in the BCS sample.

In sum, epistemic uses of modal verbs are cross-linguistically less frequently attested in the input than root uses. This may in part be because speakers rely on epistemic attitude verbs or adverbs to express epistemic meanings (see van Dooren et al. 2017, 2019). In English, some modal verbs are more common with epistemic uses (*might, must*). These seem to be the earliest epistemic MVs produced by young children. No MV in the other languages examined have this property. Finally, English input has slightly higher proportion of epistemic uses of modal verbs and some verbs that are mostly epistemic. The data show that English-learning children may produce epistemic MVs earlier than BCS and Dutch-learning children. All of these facts suggest that input factors contribute to the delayed acquisition of epistemic modal verbs (the Epistemic Gap).

2.4. *Prior acquisition work on epistemic adverbs*

Few acquisition studies have focused on modal adverbs (O'Neill & Atance 2000), but several have included the category as part of larger studies (e.g., Bowerman 1986; Bruner & Lucariello 1989; Cournane 2015a, 2015b; Smoczynska 1993 (adjectives); O'Neill & Atance 2000, for overview). Note that modal adverbs exist for root flavors as well, but these are remarkably formal in the languages studied (e.g., *obligatorily, permissibly*), unlike *maybe* or *probably*. Beyond English (8a), we find early epistemic adverbs in: French (8b, Bassano 1996; Cournane & Tailleur, in press), Norwegian (8c; Westergaard 2008), BCS (8d; Veselinović & Cournane 2020), and Dutch (8e; van Dooren et al. 2019).

(8) a. *maybe* grandma made this.　　　　　　　　English　　　　(Violet, 2;03)
　　b. ça *peut-être* c'est un poisson　　　　　　　French　　　　(Anae, 2;00)
　　　　that maybe that.is a fish
　　　　'That, maybe that's a fish'
　　c. *kanskje* han sitt og spise kaffe.　　　　　　Norwegian　　(Ann, 2;06)

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[12]Literature on attitude verbs (lexical modals) parallels the modal verb literature, with early observations showing root attitude verbs (e.g., desire-intentional modals like *want*) preceding the belief verbs (e.g., epistemics like *think, know*) in production (De Villiers 2007, for overview). Also like with modal verbs, explanation is standardly attributed to conceptual difficulties with belief reasoning despite additional grammatical and pragmatic differences (see Hacquard & Lidz 2016). Likewise, literature on direct versus indirect evidentials (knowledge-source marking, with indirect types requiring inference from evidence; see Aikhenvald 2004) parallels the modal verb literature for both observational asymmetry (direct > indirect knowledge sources) and conceptually grounded analyses (see Aksu-Koç & Slobin 1986; also Ünal & Papafragou 2016), and syntactic approaches (Rett & Hyams 2014).

[13]The corpus begins at 1;09, but van Dooren et al. (2017) sampled from 2;00.

maybe he sit.$_{PRES}$ and eat.$_{INF/PRES}$ coffee
'Maybe he is sitting there eating coffee.'

d.   *možda* je tamo u sobi   BCS   (Antonija, 2;02)
maybe it.is over.there in.the room
'Maybe it is over there in the room'

e.   hij is *misschien* naar z(ij)n eigen huis toe   Dutch   (Peter, 2;07)
he is maybe to his own house to
'Maybe he has gone to his own house'

O'Neill & Atance (2000) examined the use of "modal adjuncts" in 10 children from CHILDES (2;00 to 4;11) with the goal of learning about how children talk about uncertainty. The authors sampled *maybe, probably*, and *might*.[14] Unfortunately, *might* is not adjunctival/adverbial, and in many cases the results are binned together. *Might* is regularly treated as monosemously epistemic, so the sample makes more sense if recast as sampling "monosemous epistemic markers." They found 517 total uses. *Maybe* was the most common (59% of total), followed by *might* (32%), and then *probably* (8%). *Maybe* and *probably* occurred from 2;01. No child used *might* before 2;05, and 72% of *might* uses occurred after 3;06. This is suggestive of the developmental priority of adverbs over MVs. On the basis of their results, O'Neill & Atance (2000:47) question the root-before-epistemic order of acquisition reported in previous work on the basis of their results (and Choi (1991), for Korean evidential particles). Instead, they suggest that earliest modal uses focus on present physical states (*maybe it's dark*) and future physical intentions (*probably I will go to that big sand pile*). These results suggest two linguistic ways in which earliest epistemic adverb utterances may be limited. First, the main event of the prejacent may initially be limited to physical events (being dark, going to the sandpile), rather than internal (inner state) ones. Second, the speech act may initially be limited to intentions (first-person subjects) or suggestions (second-/third-person subjects). The examples given in O'Neill & Atance (2000) show *will* in the prejacent of intention uses, suggesting that these may be adverb uses with future-oriented prejacents.

In sum, we have evidence that epistemic adverbs occur from age 2. We still need to investigate whether children use epistemic adverbs during their *individual* Epistemic Gaps for MV usage to provide convincing counterevidence to root-before-epistemic development. Also, how epistemic-compatible are early uses? Are they constrained in any way that may suggest they are not yet adult-like? Do earliest uses clearly combine with propositional content? Finally, epistemic adverbs are syntactic adjuncts. They can stand alone (i.e., *yes, no, maybe*), which may make them easy to learn (but if children use mostly these solo uses, it would tell us little). Or, they can be flexibly added at various positions in the clause: initial (*probably he speaks French*), medial (*he probably speaks French*), or final (*he speaks French probably*). Where do children produce these adverbs? Do earliest uses show distributional variability? From this background, we proceed to the main study.

3. Main study

3.1. *Hypotheses*

What explains the Epistemic Gap? We examine epistemic modal verb and adverb productions for children and their input to assess the following hypotheses:

H1: *Conceptual Hypothesis*: The EG exists because young children are initially conceptually limited from epistemic reasoning. They will use no adult-like epistemic adverb modals during their individual Epistemic Gap.

H2: *Grammatical Hypothesis*: The EG exists because young children are initially grammatically limited from epistemic modal verb representations. They will use grammatically simpler adult-like epistemic adverb modals during their Epistemic Gap.

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[14]And *possibly*, but no children used this modal.

H3: *Input Hypothesis*: The EG exists because young children get scarce input for epistemic modal verbs, delaying their acquisition. Parents will use more epistemic adverbs, and child early epistemic adverb productions will correlate with parental input rates.

Finally, we need to rule out the possibility that earlier uses of epistemic adverbs than epistemic MVs arise simply from the low probability of sampling epistemic MVs:

H4: *Sample Asymmetry Hypothesis*: Children only appear to produce epistemic adverbs earlier than epistemic modal verbs because in general children use more epistemic adverbs.

And to help assess whether early adverb uses demonstrate adult-like epistemic reasoning and form-meaning mapping, we further explore some of their properties (Conjectures 1–3):

Conjecture 1 (*Speaker Meaning*): Early epistemic adverb uses will occur in utterances with both *assertion* and *suggestion/intention* speaker meanings.

Conjecture 2 (*Event Type*): Early epistemic adverb uses will occur with prejacents with both *internal* and *external* events.

Conjecture 3 (*Syntactic Distribution*): Early epistemic adverb uses will occur not only *solo* but also variably distributed in *initial, medial*, and *final* sentential positions.

3.2. Methods

3.2.1. Corpora

We examined productions of 17 typically developing monolingual children (nine female) from nine corpora on the North American English section of CHILDES (MacWhinney 2000) (Table 2). We selected these children because their corpora: (i) begin at least 6 months prior to 3;00,[15] allowing opportunity for epistemic adverbs to occur prior to first epistemic MVs; and (ii) include and run 6 months past 3;00, allowing opportunity for first epistemic MVs to occur in the child's sample. Emma and Alex's corpora were just shy of this criteria, so we opted to include them.

Table 2. Summary of selected child corpora ordered by descending # of utterances in the corpus. Corpora citations: (a) Brown (1973), (b) MacWhinney (2000), (c) Kuczaj (1977), (d) Demuth, Culbertson & Alter (2006), (e) Braunwald (1985), (f) Sachs (1983), (g) Weist & Zevenbergen (2008), (h) Demetras (1989), (i) Parsons (2006).

Corpus	Child	Year born	Age range	Total # of child utterances
Brown[a]	Adam	1960	2;03,04–5;02,12	45,574
MacWhinney[b]	Ross	1977	0;07,23–5;08,06	33,676
Kuczaj[c]	Abe	1970	2;04,24–5;00,11	31,752
Brown [a]	Sarah	1961	2;03,05–5;01,06	31,075
Providence[d]	Naima	2001	0;11,26–3;10,10	24,146
Providence[d]	Lily	2001	1;01,02–4;00,02	23,552
Braunwald[e]	Laura	1971	1;03,01–7;00,14	19,573
MacWhinney[b]	Mark	1979	0;00,01–7;08,02	18,537
Sachs[f]	Naomi	1968	1;02,29–4;09,03	15,612
Providence[d]	Alex	2000	1;04,27–3;05,16	14,360
Weist[g]	Roman	1998	2;02,20–4;07,20	10,807
Weist[g]	Matt	1999	2;03,10–5;00,05	10,240
Providence[d]	Violet	2001	1;02,00–3;11,24	8,302
Weist[g]	Emily	2001	2;06,06–4;05,19	7,223
Demetras[h]	Trevor	1983	2;00,27–3;11,27	6,929
Weist[g]	Emma	1999	2;07,08–4;10,00	6,676
Goad[i]	Julia	1994	1;05,17–3;06,18	4,981

[15]We rely on age as a between-child comparison to align with previous studies.

3.2.2. *Procedure and coding*

We extracted all child words from the beginning of each corpus up to and including transcripts falling closest to 3;06. We examined word lists from the aggregate sample to identify all adverbs and modal verbs with possible epistemic uses. Modals were grouped according to their category as MODAL_VERBS (9a) or ADVERBS (9b). Only lemmas are listed, but we searched for all forms used (e.g., *have to: hasta, have 0, hafta, has_to*). For contracted forms, we extracted everything that was potentially modal (e.g., *'d, *'ll*). Futures (*going to, shall, will, would*) were included for potentially epistemic uses. We then extracted all utterances containing the words in (9) with five lines of prior discourse and five following. On first pass, we excluded all non-modal uses (e.g., n. *can*) and coded for TURN-TYPE (10). Subsequent codes only apply to spontaneous productions.

(9) Potentially epistemic modal verbs and adverbs in the aggregate child sample until ~3;06
 a. MODAL_VERBS: *can, could, going to, got to, have to, may, might, must, shall, should, supposed to, will, would*
 b. ADVERBS: *certainly, definitely, maybe, possibly, probably*

(10) TURN-TYPE [SPONTANEOUS, REPETITION]

Next, MODAL_VERB utterances were coded for FLAVOR (11a) as ROOT or EPISTEMIC. Two coders independently examined uses within their original transcripts, chronologically by child. Coders consulted audio or video where available. We used the criteria that epistemic uses express speaker inferences based on knowledge or evidence, while root uses express the agent's abilities, goals, obligations, and so on. The goal was to find epistemics, so no further coding was done with root uses. Since semantic coding is somewhat subjective, we included a SURENESS (11b) code. We used a 3-point scale: 2 = *All cues point to epistemic, unlikely root*; 1 = *Likely epistemic, given contextual and/ or linguistic cues*; and 0 = *More likely epistemic than root, but unclear (insufficient context or obscured words)*. For example, in (12) the sentence form (the modal above perfect aspect) and the context (talking about a missing toy) both point to epistemic interpretation.

(11) a. FLAVOR [ROOT, EPISTEMIC]
 b. SURENESS [0, 1, 2]

(12) An epistemic modal verb, rated "2"
 I must've lost it in the bed   Sarah, 3;05 (Brown 1973); Cournane (2015a)

The chronological search for epistemic uses of modal verbs by child allowed us to identify each individual's Epistemic Gap. For first epistemic MVs, we noted (i) age of occurrence and (ii) modal lexeme. If *might* was the first epistemic MV, we continued to search for the first non-*might* epistemic modal verb. This treatment of *might* acknowledges active debate in the field (also van Dooren et al. 2017). Only first spontaneous epistemic use of a non-*might* modal verb stopped the chronological search; otherwise, the whole sample up to the file falling closest to 3;06 remained active for further coding. After determining each child sample's endpoint, we created three groups with respect to the Epistemic Gap: (i) Resolvers, (ii) Resolvers_*might*, and (iii) Non-Resolvers.

Next, we examined the adverbs in each child's active sample, to address H1 (*Conceptual Hypothesis*) and H2 (*Grammatical Hypothesis*). We read the transcript for each adverb utterance and consulted audio or video as available for contextual information, noting age of use. To assess uses further (Conjectures 1–3), we coded for: SPEAKER-MEANING, EVENT-TYPE, and SYNTACTIC DISTRIBUTION.

We coded SPEAKER-MEANING of the adverb utterance, as ASSERTION or SUGGESTION (13). ASSERTION uses typically occurred with present- and past-oriented prejacents (e.g., *Maybe Max drew that* [looking at a drawing]). SUGGESTION uses typically occurred with future-oriented prejacents, with speaker-meanings of suggestions (e.g., *Maybe you can draw a horse* [offering an idea to someone]) or intentions (e.g., *Maybe I'll draw*). In some cases, both assertion and suggestion uses are salient (e.g., *Maybe you can open this*?), so we coded BOTH_POSSIBLE. UNCLEAR codes utterances with uninterpretable elements or insufficient context.

(13) SPEAKER-MEANING [ASSERTION, SUGGESTION, BOTH_POSSIBLE, UNCLEAR]

We also coded adverb utterances for the *EVENT-TYPE* of the main predicate (14) as EXTERNAL (e.g., *Maybe the book will fall*) or INTERNAL (e.g., *Maybe the baby is hungry*). Some predicates are consistent with both readings (BOTH_POSSIBLE, e.g., *Maybe you can break it*—because of *can*, this may be about the addressee's breaking ability or the breaking event itself).

(14) EVENT-TYPE [EXTERNAL, INTERNAL, BOTH POSSIBLE, UNCLEAR]

Finally, we coded *SYNTACTIC DISTRIBUTION* of the adverb in the sentence (15). SOLO uses are full turns, in response to polar questions. INITIAL uses begin with the adverb or a filler particle (e.g., *um maybe S*), linker (e.g., *and probably S*), or embedding verbs with the adverb prior to the embedded subject (e.g., *I said [that] maybe S*). MEDIAL uses occurred between the subject and the verb phrase (e.g., *He maybe V*) or the auxiliary and main verb (e.g., *She would maybe V*). FINAL uses followed the sentence (e.g., *S, maybe*).

(15) SYNTACTIC DISTRIBUTION [SOLO, INITIAL, MEDIAL, FINAL, UNCLEAR]

To assess the *Sample Asymmetry Hypothesis* (H4) we sampled epistemic modal verb and adverb uses from a post-Epistemic Gap production sample for the Resolver group ($n = 7$). This sample is needed to run Binomial Tests for Concurrent Acquisition, summarized in (16) (Snyder 2007; Stromswold 1996).[16] This tests the probability, based on post-EG usage rates, of sampling alone accounting for the number of occurrences of adverbs during the EG (16a, Null Hypothesis), contrasted to a significant result rejecting this null hypothesis (16b, Alternative Hypothesis).

(16) Binomial Test formula: $p = (\# \text{EAdv}_{\text{POST-EG}}/(\# \text{EAdv}_{\text{POST-EG}} + \# \text{EMV}_{\text{POST-EG}}))^{\#\text{EAdvEG}}$
   a.   Null Hypothesis: Epistemic Adverbs and Epistemic Modal Verbs are acquired at the same time; apparent priority of adverbs arises from higher rate of usage. $p > .05$
   b.   Alternative Hypothesis: Epistemic Adverbs are acquired earlier than Epistemic Modal Verbs; priority of adverbs is not expected given post-EG usage rates. $p \leq .05$

Duration of post-EG samples was chosen so that they: (i) began with the file closest to 2 months after EG resolution, and (ii) ended when the transcripts totaled ~6 hours of speech. Metadata is provided in Table 3. We extracted and coded all modal uses as for the main sample.

To address the *Input Hypothesis* (H4), we sampled epistemic adverbs and modal verbs from input samples commensurate with the child samples reported in Table 5.[17] We sampled only the parent with the most speech. Metadata for these samples are reported in Table 4. Julia's corpus includes no input, and Emily's includes so little that it yielded no non-root modals, so we omit these from here on ($n = 15$). We extracted and coded modal uses as for the child data.[18]

Table 3. Post-Epistemic Gap sample information by child by age of first epistemic MV.

	Child	First clear epistemic	Post-EG age range sampled	Total # child utterances
EG Resolvers	Naima	2;00,04 *must*	2;02,02–2;03,24	1,652
	Laura	2;03,00 *must*	2;05,02–3;00,09	2,280
	Ross	2;11,14 *may*	3;01,05–3;03,27	2,465
	Sarah	3;00,27 *must*	3;02,23–3;05,07	2,905
	Violet	3;01,19 *could*	3;04,00–3;11,24	1,379
	Adam	3;01,26 *must*	3;03,18–3;05,29	5,228
	Abe	3;02,07 *must*	3;04,08–3;06,29	3,802

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[16]We did not use the first of repeated uses ("FRU") metric because epistemic uses are rare and semantics is paramount (unlike for, e.g., productivity of regular past tense marking). Instead we rely on our "sureness" metric.

[17]The MacWhinney corpus reports from newborn. To better align with other samples, we sample input from 1;00.

[18]With one exception. We excluded futures (*going to, shall, will*) and hypothetical/counterfactual *would* to save efforts because these yielded no relevant data in the child samples.

Table 4. Summary of input samples (*n* = 15) by descending # utterances.

Corpus	Child	Input speaker	Child age range of sample	Total # of input utterances
Providence	Lily	Mother	1;01,02–3;05,28	59,570
Providence	Alex	Mother	1;04,27–3;05,16	36,004
Providence	Naima	Mother	0;11,26–2;00,04	29,311
Providence	Violet	Mother	1;02,00–3;01,19	20,764
Brown	Sarah	Mother	2;03,05–3;00,27	9,091
Brown	Adam	Mother	2;03,04–3;01,26	9,073
Weist	Matt	Mother	2;03,10–3;05,14	8,344
MacWhinney	Ross	Father	1;00,09–2;11,14	8,108
Sachs	Naomi	Mother	1;02,29–3;05,07	7,320
Demetras	Trevor	Father	2;00,27–3;03,12	6,602
Kuczaj	Abe	Father	2;04,24–3;02,07	6,230
MacWhinney	Mark	Father	1;01,11–3;06,02	6,097
Weist	Roman	Father	2;02,20–3;05,29	2,205
Braunwald	Laura	Mother	1;03,01–2;03,02	1,912
Weist	Emma	Father	2;07,08–3;06,24	1,413

3.3. *Results*

3.3.1. *Child production*
Table 5 provides results for first epistemic MVs for all 17 children: (i) "EG Resolvers" (*n* = 7), (ii) "EG Resolvers (*might* only)" (*n* = 4), and (iii) "EG Non-Resolvers" (*n* = 6).[19] A clear use was one that received a "2" ꜱᴜʀᴇɴᴇꜱꜱ rating by both coders.[20] *Might* and other MVs are listed separately. Age of first epistemic *might* ranges from 1;07,10 to 3;04,00, and for non-*might* from 2;00,04 to 3;02,07. All child utterances referenced are provided in (17) and (18).

(17) First epistemic MV uses, Resolvers

a.	i. *you might get sick when you eat peelings.*	Abe	3;01,08
	ii. *Mommy I think a long time ago it must been.*	Abe	3;02,07
b.	i. *you might fall down.*	Adam	3;01,26
	ii. *dat must be a (.) you was (.) dat bus.*	Adam	3;01,26
	(responding to noise of car brakes screeching outside)		
c.	*must be cat fight.*	Laura	2;03,00
d.	i. *might be a she.*	Naima	1;07,10
	ii. *that must be Arthur's mommy.*	Naima	2;00,04
e.	i. *you might hurt him.*	Ross	2;05,14
	ii. *and Celia may not come to our house.*	Ross	2;11,14
	(discussing friend's arrival by train recently)		
f.	*must be gone.* (=toy dishes)	Sarah	3;00,27
g.	*it could be a hermit crab.*	Violet	3;01,19

(18) First epistemic MV uses, Resolvers_*might*

a.	*it might be.* (response to whether wool is in the house)	Emma	2;10,26
b.	*yyy it might be in my room.*	Lily	2;10,28
c.	*Abbot said he might still drink on the dead man …*	Mark	3;04,00
d.	*it might fell down if he stand on the edge.*	Naomi	3;04,00

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[19]Coders only disagreed on a few items (*n* = 8). This was a "find the first usage" search rather than a coding of a predefined sample, so a Kappa test was not run. Items coders disagreed on were discussed. In some cases a coder missed a clue to meaning. Others were genuine gray cases, which we treated as not eligible for "2"-level sureness.

[20]Some children used no epistemic MVs that passed our criteria for a clear use, but did use MVs with low sureness ratings. These children were: Alex (*might* at 2;10,25), Emily (*have to* at 2;06,06, *might* at 2;09,02), and Trevor (*have to* at 3;03,12). All were either unclear in general (*might*) or were too likely intended as root (both *have to* uses).

Table 5. Epistemic functional modal onset and sample information by child group.

	Child	Age range sampled	Total # child utterances in sample	First clear *might*	First clear epistemic
EG Resolvers	Abe	2;04,24–3;02,07	13,085	3;01,08	3;02,07 *must*
	Adam	2;03,04–3;01,26	19,724	3;01,26	3;01,26 *must*
	Laura	1;03,01–2;03,00	19,573	–	2;03,00 *must*
	Naima	0;11,26–2;00,04	10,999	1;07,10	2;00,04 *must*
	Ross	0;07,23–2;11,14	7,101	2;05,14	2;11,14 *may*
	Sarah	2;03,05–3;00,27	8,537	–	3;00,27 *must*
	Violet	1;02,00–3;01,19	6,923	–	3;01,19 *could*
EG Resolvers (*might* only)	Emma	2;07,08–3;06,24	3,211	2;10,26	–
	Lily	1;01,02–3;05,28	21,060	2;10,28	–
	Mark	0;00,01–3;06,00	1,109	3;04,00	–
	Naomi	1;02,29–3;05,07	14,181	3;04,00	–
Non-Resolvers	Alex	1;04,27–3;05,16	14,360	–	–
	Emily	2;06,06–3;04,09	6,193	–	–
	Julia	1;05,17–3;06,03	4,811	–	–
	Matt	2;03,10–3;05,14	4,955	–	–
	Roman	2;02,20–3;05,29	5,778	–	–
	Trevor	2;00,27–3;03,12	5,571	–	–

Table 6. Aggregate spontaneous adverb counts by modal by group and percentage total utterances.

	Resolvers (*n* = 7)	Resolvers_*might* (*n* = 4)	Non-Resolvers (*n* = 6)	Total (*n* = 17)
# of utterances	85,942	39,561	41,668	167,171
Maybe	58	120	64	242 (0.14%)
Probably	3	0	15	18 (0.01%)
Possibly	0	0	1	1 (<0.001%)
Certainly	0	1	0	1 (<0.001%)
Definitely	0	0	1	1 (<0.001%)
Total	61 (0.07%)	121 (0.31%)	81 (0.19%)	263 (0.16%)

The majority of first non-*might* epistemic MVs are with *must* (5/7), and all but one occur with stative *be* as the main verb (17e-ii, *come*). Most first uses of *might* are equivocal for metaphysical versus epistemic usage, as they involve complements with likely future orientation (e.g., *get sick, fall down, hurt him, still drink*). However, the *might* uses with stative *be* are candidates for epistemic inferences about the present state, based on speaker knowledge (17d; 18a,b).

Table 6 shows counts of all uses of epistemic adverbs by modal, excluding repetitions (*n* = 39, all *maybe*) and self-repetitions (*n* = 42, all *maybe*). Percentage of modal adverb marked utterances relative to total number of utterances is given by modal and by child group. The majority of adverb uses are with *maybe* (242/263, ~93%), followed by *probably* (18/263, ~7%), and there are single uses each of *possibly, certainly*, and *definitely*. Most uses of *probably* are from the same few children from the Weist Corpus (15/18, ~83%). The three single use modals occur after 2;11.

Table 7 shows counts and usage rates (percentage of total # utterances) for epistemic adverbs by child by group. Most children (16/17) produce epistemic adverbs; Sarah uses epistemic *must* at 3;00,27 (17f), but no epistemic adverbs during her EG. We observe a generally later skew of adverb usage for the Non-Resolver group. The low rates of adverb usage for the Resolver group are primarily due to Adam, Sarah, and Laura. Alex from the Non-Resolvers also has a low rate (0.07%), despite a large sample. Lily from the Resolvers_*might* group has a very high usage rate. She individually contributes 94 *maybe* uses (~38% of all *maybe* uses). Adverb usage rates are higher for the Resolvers_*might* and Non-Resolvers, likely driven by older sampling.

Table 8 reports SPEAKER-MEANING of modal adverb utterances. The majority of uses are in ASSERTIONS (42.6%). Table 9 reports usage counts cumulatively over 6-month intervals. We see ASSERTION uses from

Table 7. Individual, group, and aggregate modal adverb counts and rates.

	Child	Age range sampled	Total # child utterances in sample	Adverb count	% Total utterances in sample	Age range with adverb utterances
EG Resolvers	Abe	2;04,24–3;02,07	13,085	16	0.12%	2;09,08–3;01,22
(n = 7)	Adam	2;03,04–3;01,26	19,724	4	0.02%	2;06,03–2;11,13
	Laura	1;03,01–2;03,00	19,573	3	0.02%	1;10,10–2;02,28
	Naima	0;11,26–2;00,04	10,999	13	0.12%	1;06,04–2;00,04
	Ross	0;07,23–2;11,14	7,101	9	0.13%	2;06,27–2;10-22
	Sarah	2;03,05–3;00,27	8,537	0	0	NA
	Violet	1;02,00–3;01,19	6,923	16	0.23%	1;10,12–2;10,28
	TOTAL	0;07,23–3;02,07	85,942	61	0.07%	1;06,04–3;01,22
EG Resolvers	Emma	2;07,08–3;06,24	3,211	11	0.34%	2;08,18–3;01,20
(might)	Lily	1;01,02–3;05,28	21,060	94	0.45%	2;02,01–3;05,28
(n = 4)	Mark	0;00,01–3;06,00	1,109	2	0.18%	3;04,15–3;05,26
	Naomi	1;02,29–3;05,07	14,181	14	0.10%	2;01,25–3;05,06
	TOTAL	0;00,01–3;06,24	39,561	121	0.31%	2;01,25–3;05,28
Nonresolvers	Alex	1;04,27–3;05,16	14,360	10	0.07%	2;10,11–3;04,10
(n = 6)	Emily	2;06,06–3;04,09	6,193	13	0.21%	2;06,06–3;03,02
	Julia	1;05,17–3;06,03	4,811	11	0.23%	3;00,05–3;06,03
	Matt	2;03,10–3;05,14	4,955	15	0.30%	2;07,07–3;05,04
	Roman	2;02,20–3;05,29	5,778	23	0.40%	2;05,01–3;05,29
	Trevor	2;00,27–3;03,12	5,571	9	0.16%	2;06,05–3;01,17
	TOTAL	1;04,27–3;06,03	41,668	81	0.19%	2;05,01–3;06,03
Total (n = 17)		0;00,01–3;06,24	167,171	263	0.16%	1;06,04–3;06,03

earliest uses. Sample child uses by meaning are given in (19).[21] We noted that ASSERTION uses often had third-person subjects.

(19) Assertion

a.	*maybe they Max's.*	Naima	1;11,22
b.	*maybe grandma made this.*	Violet	2;03,05
c.	*maybe it's Kimberly* [pause] *or Nadine.*	Naomi	2;06,05
d.	*maybe Jean is trying to sleep.*	Abe	3;00,25

Suggestion

e.	*maybe Erin can play with these.*	Matte	2;07,07
f.	*maybe I will draw.*	Roman	2;08,14
g.	*maybe I'll eat those on the potty.*	Lily	3;00,25
h.	*maybe we can go ice skating.*	Abe	3;01,05

Both Compatible

i.	*maybe you will fix it.*	Lily	2;04,28
j.	*maybe we can get that off.*	Emily	2;10,26

Table 12 shows SYNTACTIC DISTRIBUTION by adverb. Most adverbs occur in initial position (78.7%), followed by medial positions (9.5%). Final (1.5%) and solo (8%) uses are uncommon. Table 13, Table 14 gives cumulative counts by syntactic distribution. Medial uses are low frequency and skew later. Example child utterances are given in (21).

(20) Internal

a.	*maybe Gabby likes Jello.*	Lily	2;08,13
b.	*maybe Jean is trying to sleep.*	Abe	3;00,25

External

c.	*maybe his hands are scratchy.*	Lily	2;02,15
d.	*maybe find the babies.*	Naomi	2;03,19

Both Possible

e.	*because her maybe will be sick.*	Abe	3;00,16
f.	*maybe you can.*	Lily	2;08,13

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[21]All modal sentences were double-coded, and the interrater reliability for the raters was Kappa = 0.90.

Table 8. Aggregate spontaneous adverb counts and percentages (of total) by modal and speaker meaning.

Modal	Assertion	Suggestion	Both possible	Unclear	Total
Maybe	96	70	31	45	242
Probably	14	1	2	1	18
Possibly	1	–	–	–	1
Certainly	–	–	1	–	1
Definitely	1	–	–	–	1
Total	112 (42.6%)	71 (27.0%)	34 (12.9%)	46 (17.5%)	263

Table 9. Cumulative counts over six-month intervals by speaker meaning (excluding unclear cases).

Distribution	< 24mos	< 30mos	< 36mos	≤ 42mos/total
Assertion	5	15	59	112
Suggestion	1	10	47	71
Both possible	0	3	19	34
Total	6	28	125	217

(21) Initial

a.	*maybe today*	Naima	1;06,04
b.	*maybe grandma made this.*	Violet	2;03,05
b.	*probly* [sic] *this doesn't stick.*	Emily	2;06,06
c.	*maybe a monster eats seeds.*	Abe	3;01,08

Medial

d.	*Dad maybe get the Poppa Bear.*	Naima	2;00,04
e.	*it's probably raining a little bit in here.*	Emily	2;06,20
f.	*I would probably like some cheese balls.*	Abe	2;09,08
g.	*that roar haven't defin(ite)ly not come from him!*	Emily	2;11,15
h.	*this egg's[?] probably a plant eater.*	Matte	3;04,07

Final

i.	*Daddy can drive us home maybe.*	Laura	2;01,20
j.	*Here maybe?*	Lily	3;00,25

Table 10 Shows EVENT TYPE of the main predicate in the prejacent. EXTERNAL events greatly outnumber INTERNAL. Table 11 shows cumulative distribution by 6-month intervals. The ratio of EXTERNAL: INTERNAL gradually shifts from 9:1 to ~6:1. Example utterances are given in (20).[22]

Figure 1 plots all spontaneous epistemic uses of modal verbs (when present) and adverbs by age of use by group by child. The picture for modal development shows that most children use epistemic adverbs prior to their first uses of epistemic modal verbs (Resolvers and Resolvers_*might*). Children vary considerably for age of first uses for both categories, but 15/17 use epistemic adverbs before age 3 (dotted line). Even among earliest modals there are clear, adult-like epistemic uses, with some

Table 10. Aggregate adverb counts and percentages (of total) by modal and event type.

Modal	Internal	External	Both possible	Unclear	Total
Maybe	28	175	5	34	242
Probably	3	15	–	–	18
Possibly	–	1	–	–	1
Certainly	–	–	1	–	1
Definitely	–	1	–	–	1
Total	31 (11.8%)	192 (73.0%)	6 (2.3%)	34 (12.9%)	263

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[22]All modal sentences were double-coded, and the interrater reliability for the raters was Kappa = 0.92.

Table 11. Cumulative counts over six-month intervals by event type (excluding unclear cases).

Distribution	< 24mos	< 30mos	< 36mos	≤ 42mos/total
Internal	1	3	20	31
External	9	34	110	192
Both possible	0	0	3	6
Total	10	37	133	229

Table 12. Aggregate adverb counts and percentages (of total) by modal and distribution.

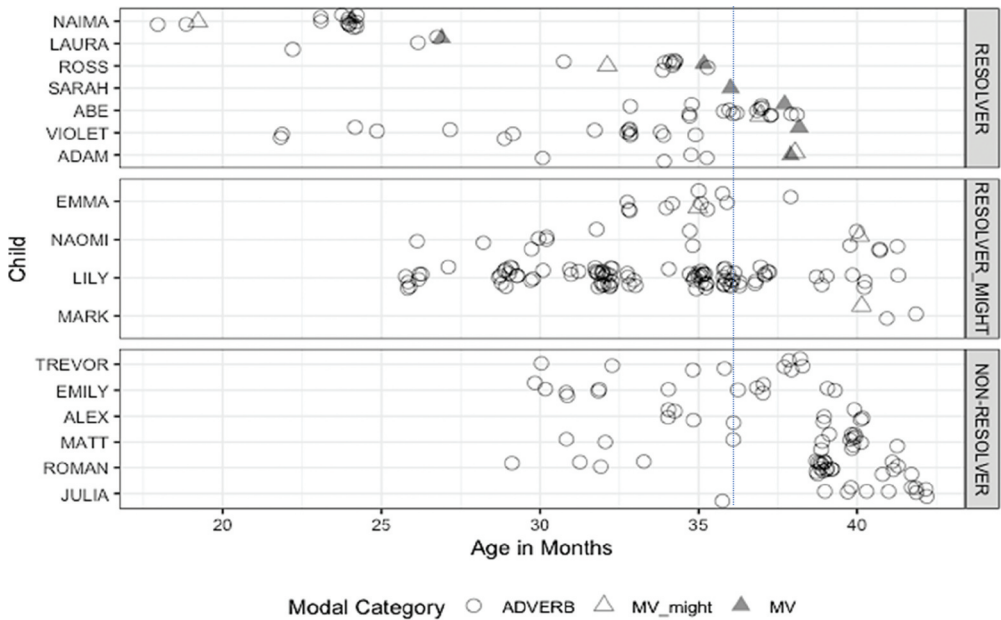| Modal	Initial	Medial	Final	Solo	Unclear	Total
Maybe	199	11	4	21	7	242
Probably	7	11	–	–	–	18
Possibly	1	–	–	–	–	1
Certainly	–	1	–	–	–	1
Definitely	–	1	–	–	–	1
Total	207 (78.7%)	24 (9.1%)	4 (1.5%)	21 (8.0%)	7 (2.7%)	263

Figure 1. All epistemic adverb and modal verb uses plotted by age for child by group.

assertions referencing internal states (e.g., *wanting*) and some distributional variability. Overall, epistemic adverbs are well attested in remarkably informative utterances in early child production.

3.3.2. *Post Epistemic Gap sample*

Post-EG samples for the children in the Resolvers Group (*n* = 7) yielded epistemic adverb and MV uses for all children. We opted to run three versions of the Binomial Test for each child based on our coding sureness metrics. We used ASSERTION as a proxy for likely epistemic use for the adverbs. We determined counts for the binomial tests according to the metric in (22):

(22) Metrics for determining child counts for Binomial Test
   a. Liberal: All uses of likely epistemic verbal and adverbial modals
   b. Moderate: Only modal verbs rated 1 and 2 (all *might*s), only adverbs coded "ASSERTION" or "BOTH-POSSIBLE"
   c. Conservative: Only modal verbs rated 2 (only *might*s with past- or present-oriented prejacents) and only adverbs coded "ASSERTION"

Table 14 shows counts for epistemic adverbs Pre- and Post-EG and modal verbs Post-EG, reported according to the metrics in (22). The *p* values for binomial tests are based on different counts from (22). Liberal counts allow us to reject the null hypothesis that epistemic adverbs and MVs are productive at the same time in 5/7 cases. Moderate counts allow us to reject the null hypotheses in 3/7 cases. Conservative counts allow us to reject the null hypothesis in 1/5 case (marginally 2/7). Counts with zero adverbs during the epistemic gap lead to one result (Sarah, Laura). Most children use more epistemic adverbs than MVs in their Post-EG sample (all but Adam). Of the 37 Post-EG epistemic MVs, there are 15 *might*, 12 *must*, four *may*, two *could*, two *should*, and one *would. Should* and *would* uses were not adult-like (rated 1 or 0). Intercoder Kappa = 0.86.

3.3.3. *Input sample*
Input samples yielded both epistemic adverbs and MVs for all 15 adults (Table 15). Sample sizes vary considerably (Range = 1,413–59,570 utterances), as do percentages of input utterances with epistemic MVs (Range = 0.05%–0.78% including all uses) and epistemic adverbs (Range = 0.11–2.05%).[23] Each adult uses more adverbs than epistemic MVs, with an aggregate ratio close to 3:1 ($1446_{Adv}:486_{EMV}$). Input uses with several MVs are provided in (23). Intercoder Kappa = 0.81.

(23)	a.	you **can't** be that hungry if you're giving me food	Naima (Mother) 1;00,26	
	b.	he **must** be very sleepy	Naomi (Mother) 1;10,11	
	c.	they smell good, they **might** be begonias maybe	Lily (Mother)	2;04,16
	d.	there's **gotta** be an ant hill in here	Roman (Father) 2;05,28	
	e.	they **must** not have put their seat belts on, huh?	Trevor (Father) 2;06,05	
	f.	that **could** be a Captain Hook's thing sure it kind of looks like that	Matt (Mother) 2;09,05	
	g.	there **might** not be any apples	Abe (Father) 2;09,30	
	h.	**must** have been a scary experience	Mark (Father) 3;00,18	

Table 13. Cumulative counts over six-month intervals by distribution (excluding unclear cases).

Position	< 24mos	< 30mos	< 36mos	≤ 42mos/Total
Initial	8	33	125	207
Medial	0	1	11	24
Final	0	2	2	4
Solo	2	4	11	21
Total	10	40	149	256

Table 14. Child epistemic usage counts within time samples (EG, Post-EG) and binomial test *p* values.

	Epistemic usage counts (Lib./Mod./Con.)			Binomial test *p* values		
Child	Adverbs EG	Adverb post-EG	Modal verb post-EG	Liberal counts	Moderate counts	Conservative counts
Abe	16/12/8	26/20/14	6/6/3	0.04	0.04	0.21
Adam	4/4/3	7/3/2	12/11/3	0.02	0.002	0.06
Ross	9/7/7	2/2/1	3/3/2	<0.001	0.002	<0.001
Violet	16/3/3	11/7/6	4/1/1	0.007	0.67	0.63
Naima	13/5/5	10/7/5	7/4/1	0.001	0.10	0.40
Laura	3/0/0	9/6/4	4/3/2	0.33	1.00	1.00
Sarah	0/0/0	4/3/3	1/1/1	1.00	1.00	1.00
Totals	62/31/26	69/48/35	37/29/13	–	–	–

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[23]Since epistemic MVs have both root and epistemic meanings, it was crucial to hand-code all items, but for the modal adverbs we only did this for one parent (Abe's Father) to get a sense of the data.

Table 15. Input counts for epistemic MV and Adverb modals ordered by descending total # of utterances.

| Corpus | Total # utterances | Usage counts (% of total utterances) | | | % Advs$_{Epi}$ /Adv+Verb$_{EpiALL}$ |
| | | Epistemic modal verbs | | | |
		All	"2" Only	Adverbs	
Lily	59,570	196 (0.33%)	154 (0.26%)	520 (0.87%)	72%
Alex	36,004	47 (0.13%)	33 (0.09%)	102 (0.28%)	68%
Naima	29,311	81 (0.28%)	68 (0.23%)	221 (0.75%)	73%
Violet	20,764	28 (0.13%)	22 (0.11%)	168 (0.81%)	86%
Sarah	9,091	9 (0.10%)	9 (0.10%)	10 (0.11%)	53%
Adam	9,073	19 (0.21%)	17 (0.19%)	32 (0.35%)	75%
Matt	8,344	34 (0.41%)	23 (0.28%)	149 (1.79%)	87%
Ross	8,108	18 (0.22%)	13 (0.16%)	33 (0.41%)	65%
Naomi	7,320	11 (0.15%)	10 (0.14%)	39 (0.53%)	78%
Trevor	6,602	11 (0.17%)	8 (0.12%)	49 (0.74%)	82%
Abe	6,230	10 (0.16%)	8 (0.13%)	48 (0.77%)	83%
Mark	6,097	8 (0.13%)	6 (0.10%)	25 (0.41%)	76%
Roman	2,205	3 (0.14%)	2 (0.09%)	15 (0.68%)	83%
Laura	1,912	1 (0.05%)	0	6 (0.31%)	86%
Emma	1,413	11 (0.78%)	7 (0.50%)	29 (2.05%)	72%
Total (Avg %)	212,248	486 (0.23%)	379 (0.18%)	1447 (0.68%)	75%

Table 16. Input epistemic modal verb counts by modal verb in descending frequency.

Modal Verb	Counts (% total)	Counts by rating "2"/"1"/"0"
might	192 (39.5%)	127/61/4 = 192
must	175 (36.0%)	165/6/4 = 175
could	46 (9.5%)	36/7/3 = 46
may	41 (8.4%)	34/4/3 = 41
can't[24]	12 (2.5%)	11/0/1 = 12
got to	10 (2.1%)	9/1/0 = 10
supposed to	8 (1.6%)	0[25]/5/3 = 8
have to	2 (0.4%)	1/1/0 = 2
Total	486 (100%)	383/85/18 = 486

Table 16 shows epistemic MV usage counts for input speakers. They use a variety of modal verbs epistemically, but *must* and *might* are by far the most common, together accounting for over 75% of uses. Note that *might* uses with future-oriented prejacents were coded as "1" (*n* = 61).

Table 17 reports epistemic adverb counts and usage rates for the 15 corpora with both input and child samples. There is a moderate positive correlation between input and child uses for epistemic adverbs based on usage rates (*R* = 0.56; *p* = .03). Emma's mother is an outlier, but removing that dyad only shifts the correlation to (*R* = 0.58; *p* = .03).

Compared to children, parents use a greater proportion of stronger force adverbs (*probably, definitely, certainly*), especially *probably*, and more individual speakers use multiple different adverbs. To get a sense of this difference by strength, we binned adverbs by strength, dividing between weaker modals (*maybe, possibly*) and stronger ones (*probably, certainty, definitely*). All speakers use weak modals. But 13/15 adults use strong modals, while only 5/15 children do (6/ 17 from the larger child sample). In aggregate, strong adverbs make up 25% of adult uses but

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[24]We sampled *can*, but as only negated occurrences were epistemic, we list this modal more narrowly as *can't*.

[25]None of these were rated as "2." Both coders agreed there was always a possible deontic flavor, but both coders also agreed uses like "That's supposed to be a pig" in contexts where the speaker or addressee has no agency over the present-oriented prejacent event (i.e., not while drawing a pig, but when looking at a drawing) showed inferences.

Table 17. Input and Child$_{EG}$ counts and percentage of total utterances for epistemic adverbs in descending order of frequency.

| | Counts (% total utterances) | |
| | Input | Child |
Corpus	Adverbs	Adverbs$_{EG}$
Abe	48 (0.77%)	16 (0.12%)
Adam	32 (0.35%)	4 (0.02%)
Alex	102 (0.28%)	10 (0.07%)
Emma	29 (2.05%)	11 (0.34%)
Laura	6 (0.31%)	3 (0.02%)
Lily	520 (0.87%)	94 (0.45%)
Mark	25 (0.41%)	2 (0.18%)
Matt	25 (0.30%)	15 (0.30%)
Naima	221 (0.75%)	13 (0.12%)
Roman	15 (0.68%)	23 (0.40%)
Naomi	39 (0.53%)	14 (0.10%)
Ross	33 (0.41%)	9 (0.13%)
Sarah	10 (0.11%)	0 (0%)
Trevor	49 (0.74%)	9 (0.16%)
Violet	168 (0.81%)	16 (0.23%)
Total (Avg %)	1,446 (0.68%)	239 (0.15%)

only 5% of child uses. A chi-squared test[26] for equality of proportions rejects the null hypothesis that distributions by strength are the same for adults and children (χ^2 = 51.03, df = 1, p = <.0001).

4. Discussion

In this article, we have revisited the longstanding and robust Epistemic Gap observation that modal production shows a root-before-epistemic asymmetry. Our aim has been to refocus on epistemic adverbs (instead of MVs) and assess three possible explanations for the EG: (I) conceptual, (II) grammatical, or (III) input asymmetry. To achieve this, we looked at epistemic MV and epistemic adverb uses for 17 young children and their input. Children's first epistemic uses of MVs were very variable in our sample (1;07–3;02, including *might*) (see also van Dooren et al. 2017), though most occurred around age 3, as in previous work. The main finding is that children use many remarkably adult-like epistemic adverb utterances during their Epistemic Gaps (the period of time when they use MVs only with root meanings). This refutes the *Conceptual Hypothesis*.

Epistemic adverb uses during an individual's EG for MVs contradict the *Conceptual Hypothesis* (H1). This hypothesis states that young children are initially conceptually limited for epistemic reasoning and therefore cannot learn nor use any epistemic modals.[27] The results are consistent with the *Grammatical Hypothesis* (H2) that young children are initially grammatically limited for epistemic modal verb representations. Epistemic adverbs are potentially easier to map to epistemic meanings as they are not also used with root meanings, nor do they require as much syntactic development to represent (as adjuncts). The results are also consistent with the *Input Hypothesis* (H3) that scarcer input for epistemic modal verbs may delay their acquisition. Children get more input for epistemic adverbs than for

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[26]The chi-square assumption of independence of observations is sometimes thought to be violated by corpus samples, as the same speaker supplies multiple uses per cell. However, this is not straightforwardly a true violation as we are comparing spontaneous utterances, not individuals, so each independent use is taken as a proxy for independence.

[27]Sweetser's (1990) theory of metaphorization is meant to apply to specific lexical items' meanings, so this is consistent with root-before-epistemic applying only to individual modal verbs. However, her work is couched in the larger context of conceptual priority of physical over mental.

epistemic uses of modal verbs (about 3:1).[28] Early epistemic adverb productions moderately correlated with parental input rates. Finally, exploring parental versus child modal adverbs revealed a significant bias toward weaker force *maybe* in the child sample (children use 95% *maybe*, while adults use <75%).

We were able to largely rule out the risk that early child use of epistemic adverbs arises solely from the low probability of sampling epistemic modal verbs (*Sample Asymmetry Hypothesis* [H4]). For children in the Resolver group (*n* = 7), we ran binomial tests for concurrent acquisition. These showed that 5/7 produced epistemic adverbs significantly earlier than epistemic modal verbs (on liberal counts) (3/7 on moderate counts). Even on conservative metric counts, 2/7 samples were able to reject the null hypothesis (one of these marginally, *p* = .06). Note that all of our counts, even liberal, should be viewed as conservative relative to most prior studies because of our sureness metric (where even "0" was a use that was *More likely epistemic than root*) and robust intercoder reliability measures. This result further casts doubt on the *Conceptual Hypothesis*: If epistemic adverbs occur earlier than epistemic MVs, it would be surprising if later-produced epistemic MVs reflected conceptual advancement.

We found support for all three conjectures, which assessed whether early epistemic adverb uses appear to demonstrate adult-like epistemic reasoning and usage. We found support for *Conjecture 1* (Speaker Meaning) that early epistemic adverb uses would occur in both ASSERTION and SUGGESTION speech-acts, and our results are compatible with O'Neill & Atance's (2000). Children used mostly ASSERTIONS, even from earliest uses. SUGGESTION uses occur with future-oriented prejacents, and typically included *can* or *will*. These also occurred from earliest uses. ASSERTION uses are most convincing for epistemic reasoning, as they typically occur with present/past-oriented prejacents (e.g., *maybe Grandma made this*, Violet 2;03,05). The reasoning expressed is about the possibility of a present or past state, rather than a less convincingly epistemic suggestion for future possibilities (see Klecha 2016).[29] These uses also lack the "additional layer" of speaker meaning for suggestions/intentions. Note also that the subjects of ASSERTION uses included third-person referents, further suggesting that children may be reasoning about others' actions or beliefs (see also Choi 2006). We also find such early epistemic adverbs with third-person subjects and present-oriented prejacents in other languages (8b–e).

We also found support for *Conjecture 2* (Event Type) that early epistemic adverb uses would occur with prejacents with both INTERNAL and EXTERNAL events. While both event types may involve epistemic reasoning, early use of epistemic marking to signal reasoning about internal states would count as particularly compelling evidence for child epistemic reasoning. Initially children use adverbs with very few internal main events (9_{EXT}:1_{INT}), and this increases with age (~6_{EXT}:1_{INT}). This pattern replicates previous reports that explicit reference to internal events with epistemic modals (adverbs, attitude verbs, modal verbs) is uncommon until after 2;06 (O'Neill & Atance 2000; Shatz, Wellman & Silber 1983). Internal events often had second- or third-person subjects (20a–c), perhaps suggesting that young children use epistemic adverbs to signal the uncertainty inherent to reasoning about others. While generally less common, clear early examples of epistemic adverbs modifying prejacents with internal main events occur during the Epistemic Gap for MVs.

And, we found support for *Conjecture 3* (Syntactic Distribution) that early epistemic adverb uses would occur with proposition-denoting content (not just solo) and in variable clausal positions. Most uses are initial, especially early on. Medial uses showing more integration within the sentence (rather than "appended" pre- or post-sententially) increase with time. Medial uses were mostly with *probably*, and most occurred after 3;00. This pattern reminds one of sentential negation usage, another semantic operator. Negation also reportedly shows clause-external early uses before integration into the

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[28]Similarly, while direct comparison is not possible given different sampling processes and time ranges, children's first uses of EMVs (Table 5, Examples 17 and 18) largely reflect which EMVs are used most often in the input (Table 16). For adults, *might* and *must* are the most frequent EMVs in terms of raw counts. In the main study, including the *might* uses, children's earliest EMVs include eight *might*, five *must*, one *may*, one *could* (Table 5).

[29]A generous analysis is that children know the suggestion uses are possible precisely because *maybe* encodes epistemic possibility. *Maybe* serves the purpose of politely contributing a demand (e.g., going to the park) by hedging it as possibility that may or may not come true (e.g., *maybe we can go to the park*) (see also Dieuleveut et al. 2019).

sentence (Bloom 1970; Déprez & Pierce 1993; Klima & Bellugi 1966; Pea 1978, i.a.). However, early child uses of negation are sometimes ungrammatical, while early uses of epistemic adverbs are overwhelmingly grammatical.

Are early uses of epistemic adverbs convincingly epistemic? Usage data alone cannot confirm that children have adult-like concepts linked to the forms used. However, taken together, the results for the three conjectures suggest that early epistemic adverb uses may indeed reflect metarepresentational "thinking about thinking" (Papafragou 1998) (see also O'Neill & Atance 2000). Mounting evidence about infant and toddler metacognition about their own epistemic states suggests this is reasonable. For example, 20-month-olds' behaviors reflect awareness of their uncertain states (Goupil, Romand-Monnier & Kouider 2016). Moreover, the "Deontic Advantage" seen in reasoning tasks with small children and adults may not be that relevant to learning grammatical representations for modal concepts (cf. Cummins 2013). We did not find a root-before-epistemic pattern for modal language. Rather, we found that children use more epistemic early language than assumed in most prior literature. And, work considering early root modal verb uses shows that these vary widely by subflavor and are not predominantly deontic[30] (Cournane 2015a, 2015b; van Dooren et al. 2017).

What about the possibility meanings of early modal uses? Leahy & Carey (2020) argue that language experience with modals helps children become adult-like and transition from Minimal to Modal Representations of Possibility. They say:

> [t]he fact that even 2-year-olds are using modal language in ways that reflect its frequency in the speech they hear shows that they can identify contexts in which it is appropriate (even if it is not yet encoding adult modal concepts). Perhaps learning modal vocabulary and the relationships between various modal words provides a workspace that helps children construct appropriate meanings for those words and, hence, the concepts themselves.(Leahy & Carey 2020:75)

Our data do suggest early difficulty with force (weak modal bias). This is consistent with experimental results for possibility tasks with 3-year-olds (Leahy & Carey 2020) and with force asymmetries between children and input for MVs (Dieuleveut et al. 2019; Jeretič 2018; Moscati & Crain 2014). Some early examples suggest that children erroneously commit to one possibility (24a), but others suggest they understand that the prejacent is unsettled (24b).

(24) a. Father: maybe we'll go to the zoo, too?
          Child: why ?
          Father: why what, Abe ?
          Child: why are we going at that zoo?   Abe 2;07,11
      b. Mother: maybe little sardines or something.
          Child: maybe they're fish.
          Mother: yeah.
          Child: are they fish?   Lily 2;07,16

How might language experience help children learn Modal Representations of Possibility, given the language data covered in this article? It appears that at least for English, and perhaps the other Indo-European languages studied with MVs and epistemic adverbs, epistemic adverbs are likely the "way in" to gaining more experience with modal language. So, can learning and using epistemic adverbs help children attain adult-like possibility representations? Children guessing and using a minimal representation may get a response from a parent that offers an alternate possibility (25a) or that suggests that guesses require verification ("avoid committing"; 25b). These experiences may train a child that Minimal Representations of Possibility are insufficient for many situations.

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[30]N.B. that "deontic" is often used as a cover term for all root modalities, e.g., in Neill & Atance 2000.

(25) a. Child: maybe the bears will bite us.
Father: maybe.
Child: maybe they will.
Father: I doubt it though. If they're nice, they won't bite us.   Abe 3;01,22
b. Child: maybe his hands are scratchy. [Dog's paws]
Mother: really? do you wanna check and see?   Lily 2;02,15

Perhaps the Epistemic Gap arises from a form-meaning mapping challenge: Children first learn that MVs have root uses, and they need to discover that epistemic uses are also mapped to the same words (van Dooren et al. 2017, 2019). This goes against basic one-to-one word learning assumptions (see Papafragou 1998:387). How do children surmount this challenge? Recall that one emerging universal about modal meanings is that root modalities are restricted to future-oriented prejacents. van Dooren et al. (2017, 2019) propose that children can use tense and aspect information in the prejacent to discover epistemic uses. Because root modalities are restricted to future-oriented prejacents, a modal verb with a present- or past-oriented prejacent cannot be root.[31]

Can learning and using epistemic adverbs help children discover the epistemic uses of modal verbs in their input? Using epistemic adverbs like *maybe* may help small children tune in to the associated prejacents and situational contexts that occur with epistemic language. For example, *maybe* co-occurs with present- and past-oriented prejacents (e.g., *maybe it's raining, maybe it rained*). Modal verbs with past or present TOs cannot be root, so experience with epistemic adverbs may help children with the hard mapping task of identifying the epistemic uses of modal verbs (van Dooren et al. 2017).

5. Conclusion

This article shows that young children produce epistemic adverbs (e.g., *maybe, probably*) from earliest modal productions. These occur during individual children's Epistemic Gaps: the time when modal verbs (e.g., *must, could*) occur with only their root meanings. Early epistemic adverb uses modify propositions and occur in a variety of sentential positions, with both internal (i.e., inner state) and external main predicates. Early adverb use is generalizable beyond English-learning children: Epistemic adverbs also occur in very early adult-like uses in BCS, Dutch, Norwegian, and French. These production facts for epistemic adverbs, along with controls for input attestation and potential sampling biases, allow us to reject long-standing explanations for root-before-epistemic modal use that appeal to conceptual changes in the developing child.

We propose that epistemic uses of modal verbs are observed relatively late in most studies because they are likely hard to learn. Modal verbs are polysemous (one-to-many form-meaning mappings) and infrequently represented as epistemic in the input. Another possibility not assessed directly here is that epistemic uses of modal verbs may be harder for children to produce because they involve greater syntactic representational complexity. Young children appear to readily map epistemic meaning to words as soon as they are able to identify those words in their input language. Adverbs—syntactic adjuncts with one-to-one form-meaning mapping—give children the best shot at detecting and using early epistemic language.

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[31]There are some principled exceptions, like counterfactuals (see van Dooren et al., submitted).

Funding

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