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Learning modals: A grammatical perspective

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Abstract

In this study, we address the mapping problem for modal words: how do children learn the form-to-meaning mappings for words like *could* or *have to* in their input languages? Learning modal words poses considerable challenges as their meanings are conceptually complex and the way these meanings are mapped to grammatical forms and structures is likewise complex and cross-linguistically variable. Against a backdrop of how cross-linguistic modal systems can vary, we focus on new work highlighting the developmental roles of the following: (a) syntactic categories of modal words, (b) interrelationships between modal 'force' (possibility and necessity) and 'flavour' (root and epistemic), (c) semantic representations for modal forms and (d) children's own emerging modal systems, as a whole, which show that the way they map forms to the 'modal meaning space' (considering both force and flavour dimensions) diverges from how adults do, even if the same forms are present. Modality provides a rich natural laboratory for exploring the interrelationships between our conceptual world of possibilities, how concepts get packaged by the syntax–semantics of grammatical systems, and how child learners surmount these form-meaning mapping challenges.

1 | INTRODUCTION

In this study, we focus on the mapping problem (Gleitman, 1990) for modal words: How do children learn the form-to-meaning mappings for modal forms like *could* or *have to* in their input languages? MODALITY is a category of language defined by meaning (Kratzer, 1981),

allowing speakers to express non-actual possibility meanings via diverse grammatical strategies (MODAL EXPRESSIONS). Within modality, two broad meaning divisions exist, cutting between 'FORCES': what is POSSIBLE (1a,b) versus what is NECESSARY (1c,d), and 'FLAVOURS': ROOT (1a,c), concerning a subset of meanings about the circumstances of the event and its participants, versus EPISTEMIC (1b,d), concerning what the speaker (or attitude holder) knows or perceives (Hacquard, 2011).

(1)[1]	a. Chiara **could** go to work	Root possibility
	b. Chiara **could** be Italian	Epistemic possibility
	c. Chiara **has to** go to work	Root necessity
	d. Chiara **has to** be Italian	Epistemic necessity

Modal meanings may be especially hard to learn from association with the world in the 'here-and-now' (word-to-world mapping), because they are non-actual: concerning possibilities either in future worlds, unknown worlds, hypothetical or as yet unrealized worlds. Furthermore, languages have modals that express fixed (e.g., only root modality like *need to*) or variable (e.g., variable root or epistemic like *have to* [1c,d]) meanings along both flavour and force dimensions (Bochnak, 2015; Rullmann, Matthewson, & Davis, 2008; Vander Klok, 2013, i.a.), and the syntactic category of a given modal (e.g., verb, adverb) affects its grammatical distribution. In what follows, we discuss how children work out what force and flavour meaning combinations the modals in their input express, with particular reference to syntactic and semantic representation of modal verbs.

Prior acquisition research focuses primarily on modal verbs, like the variable-flavour English auxiliaries and semi-auxiliaries (e.g., *can*, *must* and *have to*), and the acquisition of modal force and modal flavour are standardly treated separately. However, modal meanings get packaged together by modal forms in variable ways, arbitrated by syntactic properties of the modal words and grammatical system (Hacquard, 2013; Traugott, 2006), especially tense, aspect and evidentiality (other elements in the T-A-M-E system: Condoravdi, 2002; Ramchand, 2018; Rullmann & Matthewson, 2018; Vander Klok, 2012, i.a.) and other scope-bearing elements like negation (Iatridou & Zeijlstra, 2013, i.a.). Thus, modality provides a developmental laboratory for exploring word learning for grammatically constrained, complex, form-meaning mappings. While we focus on what we know about modal development, which comes primarily from English learners, we consider how existing and emerging acquisition findings fit into a syntactically informed, cross-linguistic perspective. Major questions include the following: (A) How do the syntactic properties of modal forms, within the grammar of the target language, affect learning paths? (B) How might learning modal force relate to learning flavour and vice versa? and (C) How can cross-linguistic knowledge about the kinds of modal systems possible in languages help generate new hypotheses about how children solve the mapping problem for modals in their input languages?

To facilitate discussion, we will use a simplified 'modal meaning space' and consider how modal forms jointly cover this space in any given language (Table 1), inspired from Vander Klok (2012). Examples from English (1a–d), show how one set of forms map to this meaning space. The term 'modal meaning space' describes the broad 2×2 force and flavour dimensions involved in modal meaning, and 'modals' describes the forms languages use to express the meaning cells. Note that variable-meaning modals may get keyed to particular interpretations by situational, conversational or grammatical factors (Hacquard, 2010; Kratzer, 2012;

TABLE 1 A 2 × 2 modal meaning space, crossing flavour and force

		FORCE	
		POSSIBILITY	NECESSITY
FLAVOUR	ROOT	'could go'	'has to go'
	EPISTEMIC	'could be'	'has to be'

Note: Examples with *could* and *have to* show English has modals that are fixed for FORCE and variable for FLAVOUR.

Ramchand, 2018; Marasovic et al., 2016, i.a.); In (1), the main verb is eventive (*go*) to bring out a root interpretation for *could* and *have to*, and stative (*be*) to bring out an epistemic interpretation.

A modal may express more than one distinct meaning, across the broad root versus epistemic distinction (like *could* and *have to*). And, there can be considerable overlap, as many modal forms can express the same concepts (e.g., *must*, *should*, *need to* and *have to* can all express root necessity). Assuming that one-to-one form-meaning relations are easiest to learn (Clark, 1993, i.a.), modals contravene this simplest relation in both directions, with one-to-many mapping and many-to-one mappings (Cournane, 2014; van Dooren, Dieuleveut, Cournane, & Hacquard, 2017). The system as a whole becomes especially relevant for solving the mapping problem when we consider the cross-linguistic typologies of what modals and modal systems can be like. We take as fundamental that languages vary systematically in how their modals cover the modal meaning space, and that children must be both constrained enough and flexible enough to learn any such modal system.

In Section 2, we cover essential background on modal force, flavour and syntactic variation, highlighting major acquisition questions. In Section 3, we cover major findings for each meaning dimension, staying close to considerations of form-meaning mapping and how cross-linguistic variation in modal systems can inform our understanding of developmental pathways. In Section 4, we discuss new elicited production work, testing the modal meaning space jointly for both force and flavour (Hirzel, Hacquard & Cournane, in preparation). Throughout, we acknowledge that children are developing conceptually in addition to linguistically, and non-adult concepts may also contribute to input-divergent representations or usage (Leahy & Carey, 2020; Shtulman & Phillips, 2018).

2 | MODAL VARIATION: FLAVOUR, FORCE AND FORM

2.1 | Flavour

Modal meanings divide into two major 'flavours': ROOT (2a) and EPISTEMIC (2b). Root modality is a cover term for non-epistemic flavours (Hoffmann, 1966): bouletic (desire), deontic (permission and obligation), teleological (goals) and ability, among others. This root versus epistemic distinction characterizes many syntactic and semantic differences within and between languages, a longstanding observation in the syntactic literature (e.g., Brennan, 1993; Jackendoff, 1972; Ross, 1967; for overviews: Hacquard, 2011; Barbiers & van Dooren, 2017). For example, root uses tend to be agent-oriented[2] (2a: the obligation is linked to Mina), while epistemic uses are speaker-oriented (2b: the inference is linked to the speaker; Bybee, Perkins, & Pagliuca, 1994).

(2) Mina **has to** attend every hockey practice session...

    a. ... to qualify for the team.   Root: Deontic (according to the rules...)

    b. ... because she's super good.   Epistemic (according to what I know...)

In one-fourth of the world's languages (van der Auwera & Ammann, 2005), there are modals like English *could* or *have to* (1, 2), which can express both major flavour types.[3] This kind of modal meaning variability has long been recognized in the linguistic literature, likely as variable-flavour modals are ubiquitous across Indo-European languages (Jespersen, 1924; Palmer, 2001, i.a.). Variable-flavour modals like English *must* or *have to* show syntactic differences depending on flavour. For example, in English *must* with a bare verb complement (3a) is interpreted as either root (~Maxime is required to eat meat) or epistemic (~Maxime is likely a meat-eater). With grammatical aspect marking (progressive or perfect), *must* tends to be interpreted as epistemic (3b).

(3)   a. Maxime *must* eat meat   Root, Epistemic

    b. Maxime *must* [be eating/have eaten] meat   *Root,[4] Epistemic

In (4), the modal verb (*must*) is interpreted in two different positions depending on flavour: when interpreted above the verb phrase (VP) and below tense (TP), *must* is root (4a), when interpreted above TP *must* is epistemic (4b; Cinque, 1999; Hacquard, 2006, 2010; cf.; Rullmann & Matthewson, 2018). In (3b), *must* is overtly above aspect, keying an epistemic interpretation, interpreted above tense and aspect (4b).

(4)   Maxime must eat meat.

    a. Maxime must [eat meat]$_{VP}$

        'Maxime is obliged to eat meat'   Root (Deontic)

    b. Must [Maxime eat meat]$_{TP}$

        'It must be the case that Maxime eats meat'   Epistemic

Variable-flavour modal interpretations as root or epistemic are constrained in part by the temporal-aspectual properties of the prejacents (the unmodalized proposition) they combine with. Root flavours appear to be restricted to future-oriented prejacents (Condoravdi, 2002; Rullmann & Matthewson, 2018; Werner, 2006). This property may help children solve the mapping problem (van Dooren et al., 2017), though note that modal-temporal interactions are currently an active area of debate (Giannakidou & Mari, 2018; Klecha, 2016; Rullmann & Matthewson, 2018).

Many different root flavours of modality exist (see Hacquard, 2011; Palmer, 2001), which may be expressed by the same modal (5a,b,c). Grammatical effects covarying with root sub-flavour are less prominent than between the major root versus epistemic divide. However, root sub-flavours may be distinguished lexically (e.g., ability *be able to* vs. deontic *be permitted to*) and contribute to making the mapping task between modals and meanings conceptually more complex.

(5)   a. Annemarie **has to** sneeze. (dispositional, relative to biological needs)

    b. Annemarie **has to** learn to behave. (deontic, relative to social norms)

    c. Annemarie **has to** take the bus to get to school. (teleological, relative to goals)

Major questions in modal flavour development from a mapping perspective include: When and how do children work out the flavour(s) of modals in their input languages (Cournane, 2014, 2015; Papafragou, 1998; van Dooren et al., 2017)? How does syntactic category affect modal flavour learning (Bassano, 1996; Cournane, 2014, 2015; O'Neill & Atance, 2000; Shatz & Wilcox, 1991; Veselinović & Cournane, 2020)? How might input frequency and distributional factors help or hinder modal flavour learning (Cournane & Pérez-Leroux, 2020; van Dooren et al., 2017, van Dooren, Tulling, Cournane, & Hacquard, 2019)? And, for variable-flavour modals, how do children work out that the same modal can express both root and epistemic modal meanings (Papafragou, 1998; van Dooren et al., 2017, 2019)?

2.2 | Force

Modal meanings also divide into two main 'forces', encoding either possibility like *could* (6a), or necessity like *have to* (6b).[5] English modal verbs are fixed for force, encoding either possibility or necessity, and may form Horn scales (Horn, 1972). Modals may give rise to pragmatic scalar implicatures, similar to *some* and *all* (Grice, 1975; Noveck, 2001). For example, in a deontic context, the example in (6a) expresses a possibility for Anouk, and since the stronger *have to* (or *must*) was not used (6b), the listener can infer that (6a) further implies no obligation holds and Anouk *can but need not* take Intermediate Spanish. For the child to compute scalar implicatures like those that arise for (6a), she needs to know that *could* is a possibility modal, that there are stronger alternative modals in her language, and be able to do the reasoning involved in generating and comparing alternatives, as discussed with *some/all* (Barner, Brooks, & Bale, 2011; Skordos & Papafragou, 2016).

(6)   a. Anouk **could** take Intermediate Spanish.

        b. Anouk **has to** take Intermediate Spanish.

Contra English fixed-force modals, some languages show variable-force modals, which may express either possibility or necessity in various usage contexts (Bochnak, 2015; Deal, 2011; Matthewson, Davis, & Rullmann, 2007; Peterson, 2010).[6] For example, Gitksan *ima* (7) can translate either 'might' or 'must'. Many of the languages with variable-force modals are spoken in or near the North American West, from several language families.

(7)   mukw=**ima**=hl maa'y...   (Peterson, 2010)

      ripe=MOD=CD berries

      'The berries might/must be ripe'.

      a. ... because they sometimes are this time of year. (possibility, Epistemic)

      b. ... because people have berry-stains on their hands. (necessity, Epistemic)

Languages may use only distinct modals for each cell of the modal-meaning-space (e.g., Javanese, Vander Klok, 2012), or lexicalize with fixed-flavour or fixed-force. Variable-force forms may occur only in one flavour family (Gitksan, Peterson, 2010) or across both (Washo, Bochnak, 2015). How do learners work out the target form-meaning mappings for these modals given their input properties? While variable-flavour modals have long been recognized as challenging for learners given their polysemy[7] (one-to-many form-meaning mapping), the

polysemy challenges of variable-force modality have only recently begun to be considered (Dieuleveut, van Dooren, Cournane, & Hacquard, 2019). This includes not only how these are learned in languages that have them, but also whether learners of languages like English ever entertain analyses of their input modals consistent with variable-force modals. For example, English children could go through a stage when they treat *have to* as variable-force, contra their input, but consistent with modals cross-linguistically.

Children face inherent learning challenges when working out the force of modal forms in their input. For one, necessity logically entails possibility (within the same flavour): if something must be true, it also might be. If a child learns a necessity modal as having a possibility meaning, it is not obvious how the situational or linguistic context provides counterevidence[8] (Dieuleveut et al., 2019). Individual modals also interact with negation differently according to their flavour and force (Iatridou & Zeijlstra, 2013), adding idiosyncrasy to the usefulness of negation for modal force learning. I point the reader to the following acquisition studies on modals and negation: Jeretič (2018), Koring, Meroni, and Moscati (2018), and Moscati and Crain (2014). The negation facts for the modals, and input-languages more generally, are likely relevant in learning, as is what modals are in the system and whether they form scale-mates (e.g., *have to > could*).

Major questions in modal force development include: How is force distributed in the input to children (Dieuleveut et al., 2019; Jeretič, 2018)? When and how do children learn the semantic force of the modal forms in their input languages (Dieuleveut et al., 2019; Noveck, 2001; Ozturk & Papafragou, 2015)? What situational and grammatical contexts are helpful or required to work out which force or forces a modal expresses (Dieuleveut et al., 2019; Moscati & Crain, 2014)? When and how do children work out which sets of modals constitute scale-mates, and in which contexts implicatures are triggered (Bleotu et al., 2019; Noveck, 2001; Ozturk & Papafragou, 2015)?

2.3 | Form

The syntactic categories and constructional strategies languages use to grammatically represent modal meanings vary widely (Hacquard, 2013; Palmer, 2001; Rullmann & Matthewson, 2018; i.a.). Modals differ in morphosyntactic category within and across languages, with a useful distinction between FUNCTIONAL (auxiliary and functional verbs)[9] and LEXICAL modals (verbs, adverbs, adjectives and nouns; Hacquard, 2013; Traugott, 2006). Lexical modals are full predicates of events and typically maintain their flavour and force across grammatical and situational contexts. Functional modals typically vary in flavour depending on where they are interpreted in the syntactic structure, especially relative to tense and aspect: many argue that epistemics scope over larger complements (e.g., TPs or complementizer phrases [CPs]) and above tense and aspect, while roots scope lower, below tense and aspect (e.g., Cinque, 1999; Hacquard, 2006).

Category differences are essential to consider in acquisition. In English, modal meanings are expressed via multiple categories, both functional (auxiliary verbs [*can* and *must*] and semi-auxiliary verbs [*have to* and *supposed to*]) and lexical (verbs [*know* and *doubt*], adverbs [*maybe* and *probably*], adjectives [*possible* and *obligatory*] and nouns [*possibility* and *necessity*]). This list of formal categories is non-exhaustive, and languages may also rely on constructional strategies (e.g., Korean deontics, ~*If X, good*, Chung, 2019) or mood marking (e.g., subjunctive or irrealis) to express modality (see Palmer, 2001). While *maybe*, *think* and *could* all can express the same

concept (epistemic possibility), they are grammatically distinct and show different syntactic distributions corresponding with their category, and syntactic bootstrapping is especially important for unobservable meanings like for modality (Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Papafragou, Cassidy, & Gleitman, 2007). Learning adverbs that are adjunctival in the syntax, like *maybe* or *probably* (Cournane, submitted, 2014, 2015; O'Neill & Atance, 2000), is a grammatically different task from learning attitude verbs like *think* or *want* (de Villiers, 2007; Hacquard & Lidz, 2018), or functional modals like *could* that differ in interpretation depending on their grammatical and situational context (van Dooren et al., 2017).

Grammatical category splits have forged separate lines of acquisition research (e.g., attitude verbs are usually studied independently from modal verbs). But, modality-expressing categories are intertwined in principled ways for learners, who are learning to map meanings to forms within their linguistic systems and using grammatical information to help in the task. In what follows, we focus on modal verbs (the primary focus of existing and ongoing acquisition literature), and especially consider modal adverbs (e.g., *maybe* and *probably*) as a contrasting syntactic category to illustrate how grammatical differences are relevant for modal development.

Major questions in modal form acquisition include: How do modals' syntactic properties affect acquisition paths (Bassano, 1996; Cournane, 2014, 2015, submitted; Modyanova et al., 2010; Veselinović, 2019)? How do distributional facts in the input, related to the syntax of particular modal categories, affect the availability of cues for modal meanings (Dieuleveut et al., 2019; van Dooren et al., 2017, 2019)? and, Can distributional differences by flavour or force give away modal polysemy, that is, do syntactic environments in the input for root versus epistemic uses of a variable-flavour modal cue the learner to the fact that one form expresses the two broad modal flavours (Cournane & Pérez-Leroux, 2020; Heizmann, 2006; van Dooren et al., 2017, 2019)?

3 | LEARNING TO MAP THE MODAL SPACE

3.1 | Flavour: Syntactic representations as a developmental factor

Most acquisition work on modal flavour has focused on a robust, early observation from naturalistic studies tracking modal verb usage in children's speech (Kuczaj & Maratsos, 1975; Shepherd, 1982; Stephany, 1993; Wells, 1979; i.a.): children produce modal verbs with ostensibly root meanings from around age 2, but with epistemic ones only around age 3 (Shatz & Wilcox, 1991; Papafragou, 1998 for overview). Examples from Sarah (Brown, 1973; from CHILDES, MacWhinney & Snow, 1985) show the typical pattern: root modal uses occur from the beginning of the corpus, first with ability uses (8a), then deontic (8b), and her first epistemic use is at age 3 (8c).

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

Why is there this 'Epistemic Gap' in production (Cournane, 2014, 2015, submitted)? The most common and longstanding proposal is that root meanings are conceptually available prior to

epistemic ones. Epistemic meanings come online following conceptual metarepresentational milestones (Dack & Astington, 2011; Papafragou, 1998; Shatz & Wilcox, 1991; i.a.) or are metaphorically built upon root ones via conceptual extension (Diessel, 2011; Sweetser, 1990). Similar production asymmetries to the Epistemic Gap for modal verbs exist for other categories within modality, notably for attitude verbs (non-representational verbs like *want* precede representational ones like *think*, see de Villiers, 2007), and evidential markers (direct evidentials precede indirect, see Ünal & Papafragou, 2016). In all of these domains, a general tension exists over whether to attribute asymmetries to conceptual, grammatical or pragmatic developments (see also Hickmann & Bassano, 2016). Several lines of criticism have been levelled against conceptual approaches in recent years (for discussion, see Cournane, 2014, 2015, submitted; Cummins, 2013; Hacquard & Lidz, 2018)[10]; here we focus on how foundational studies for the Epistemic Gap observation primarily sampled variable-flavour modals from Indo-European languages (cf. Deen, 2005; Guo, 1994; Stephany, 1993).

Cournane (2014, 2015, submitted) investigates early English modal productions with reference to syntactic category, asking whether children lack the productive grammatical representations necessary to support epistemic uses of modal verbs (see also de Villiers, 2007; Heizmann, 2006). English modal auxiliaries are interpreted above tense and aspect when epistemic, which suggests children must learn to scope these modals above TP structures[11] before they can grammatically represent epistemic interpretations of functional modals. First epistemic uses of modal verbs follow the onset of sentential embedding (measured via indicators of a second TP-layer), just before age 3, and in line with syntactic and semantic analyses of modal auxiliaries (e.g., Hacquard, 2006). Looking at Sarah's (Brown, 1973) utterances, she begins productively using infinitival-*to* and embedded subjects for the second verb in her utterances at 2;10 (9a,b), and embedding attitude verb epistemics (*know* and *think*) within the same month as her first epistemic modal verb (8c), at 3;01 (9c). These markers of TP-embedding emerge before age 3 cross-linguistically (de Villiers & Roeper, 2016), suggesting this grammatical milestone generalizes.

(9) a. *I want to see him*   (2;10,05)

   b. *I want that write on*   (2;10,05)

   c. *I think I am go in there*   (3;01,10)

Veselinović and Cournane (2020), extended this line of research to Bosnian/Croatian/Serbian (BCS), exploring input and production of modal verbs *moči* 'can' & *morati* 'must' and epistemic adverbs in a large BCS corpus (SCECL, 95,105 child utterances by eight children; Anđjelković, Ševa, & Moskovljević, 2001, on CHILDES). BCS modal verbs are variable-flavour, but the syntactic constructions they occur in are mutually exclusive: when root, they occur in monoclausal structures, agree with the subject, and have a perfective main verb. When epistemic, they occur in biclausal structures with two CPs, with the modal in the higher clause showing default agreement and an imperfective main verb (Veselinović, 2019). Results showed no BCS child epistemic verb productions in the entire corpus from 1;06 to 4;00. Thus, epistemic uses were absent a year longer than for English (i.e., none within the 3–4 years window). How can we explain this longer Epistemic Gap? Veselinović and Cournane argued BCS epistemic uses of modal verbs await children's development of CP-embedding to be syntactically supported. While some children reliably demonstrate CP-embedding (e.g., complements of verbs of saying) towards the end of their corpora at age 4;00, no epistemic uses

obtained. Clear embedded CPs generally emerge around age 4 or later in production (see de Villiers & Roeper, 2016 for overview).

Aside from distinct syntactic representations by flavour for variable-flavour modals, children produce LEXICAL modals with ostensibly epistemic meanings: adverbs like *maybe* and *probably*. If the Epistemic Gap occurs because of a conceptual lack, then other forms representing epistemic meanings should be similarly delayed, as epistemic uses of modal verbs. Adverbs are syntactic adjuncts, flexible in their syntactic distribution (10a), able to stand alone (10b), often have one-to-one mappings in usage (e.g., *maybe* is only epistemic) and do not require sentential embedding like epistemic uses of variable-flavour modal verbs or attitude verbs.

(10) a. (*Probably*) Dino (*probably*) eats lots of leaves (*probably*).

b. Speaker A: Is Dino hungry?

Speaker B: *Probably*.

The relative grammatical simplicity of epistemic adverbs compared to modal verbs gives children the best chance to map epistemic meanings at an early age. Epistemic adverbs occur in adult-like contexts from as early as age 2 in English (11a; O'Neill & Atance, 2000; Cournane, submitted, Providence Corpus [Demuth, Culbertson, & Alter, 2006]), BCS (11b; Veselinović & Cournane, 2020, SCECL), French (11c; Bassano, 1996; Cournane & Tailleur, submitted, Paris Corpus [Morgenstern & Parisse, 2012]), Norwegian (11d; Westergaard, 2008) and Dutch (11e; van Dooren et al., 2019, Groningen Corpus [Wijnen & Verrips, 1998]).

(11) a. *maybe* grandma made this. English (Violet, 2;03)

b. *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'

c. ça *peut-être* c'est un poisson French (Anae, 2;00)

that maybe that.is a fish

'That, maybe that's a fish'

d. *kanskje* han sitt og spise kaffe. Norwegian (Ann, 2;06)

maybe he sit.$_{PRES}$ and eat.$_{INF/PRES}$ coffee

'Maybe he is sitting there eating coffee'.

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'

Cournane (submitted) shows early adverb uses are not just responses to *yes-no* questions, but appear to genuinely modify propositions in over 90% of child uses, looking at uses ($n = 263$) up to 3;06 by 17 North American English children on CHILDES. The conceptual approach to the Epistemic Gap, based heavily on modal verbs, is undercut by these early, relatively common and adult-like uses of epistemic adverbs.

Syntactic factors may play a role in when modals appear in children's productions. But, being in productive command of the representations necessary to support epistemic uses of modal verbs does not address how children work out that some modals in their input language

are variable-flavour. If a child has worked out a root meaning for a particular modal, say *must*, what motivates positing an epistemic meaning for that same form, contravening one-to-one mapping (Papafragou, 1998, p. 387, based on Clark, 1993)? Are different syntactic and semantic patterns by flavour demonstrated in the input, and apparent to the child learner (van Dooren et al., 2017, 2019, submitted)?

Van Dooren et al. (2017, 2019, submitted) explore the role of input in English (43,189 modal verb input utterances; Manchester Corpus: Theakston, Lieven, Pine, & Rowland, 2001) and Dutch (20,765 modal verb input utterances; Groningen Corpus: Wijnen & Verrips, 1998), to learn more about the mapping task children face for variable-flavour modal verbs. They hypothesize that children first get root meanings for modal verbs, and that Temporal Orientation of the modal's prejacent as present or past, as expressed by tense and aspect marking, helps give away that these modals also map to the more rarely attested epistemic uses. Since root uses appear restricted to future orientation, use of a modal with clear present or past Temporal Orientation, if apparent in the situational context, may cue children to posit an additional epistemic meaning for variable-flavour modals. Van Dooren et al. found that input epistemic uses of variable-flavour modals are overwhelmingly less common than root uses (e.g., English: approx. 9% vs. 91%).[12] They looked at relative distributions of prejacents for temporal orientation, tracking grammatical aspect and the lexical aspect (stativity vs. eventivity). In both languages, these distribute significantly differently by flavour: epistemic uses occur mostly with stative prejacents (e.g., *must be*, *must have eaten* and *must like*), while root uses occur mostly with eventive prejacents (e.g., *must eat* and *must go*). However, exceptions to this pattern exist (e.g., counterfactuals with root modals with stative prejacents: e.g., *you could have said hello*), and may muddy the signal (though see van Dooren et al., submitted, for arguments that these are principled exceptions for which the situational context appears to disambiguate). Because epistemic uses of modal verbs are dwarfed by root uses in the input to children, van Dooren et al. argue that learners need to expect that modal flavours are constrained by something like the Diversity Condition (Condoravdi, 2002) on non-vacuity (Thomas, 2014). If so, learners would be able to make use of the temporal orientation of the modal prejacent (cues from tense and aspect properties) to learn variable-flavour modal verb interpretations.

In sum, variable-flavour modal verbs appear with root uses prior to epistemic uses, but at different times for different children within and between languages, and when looking at more children or denser corpora, sometimes much earlier than age 3 (Cournane, submitted; van Dooren et al., 2017). Epistemic modal adverbs occur from age 2. The Epistemic Gap observation appears most amenable to grammatical or input-signal analyses, both related to mapping challenges for form-meaning relations between modal words and modal concepts.

3.2 | Force: Semantic representations as a developmental factor

Modal force development has almost exclusively been studied using experimental methods (cf. modal flavour). General findings show that preschool and early school age children both over-accept possibility modals in necessity contexts, and necessity modals in possibility contexts (see Dieuleveut et al., 2019, Dieuleveut, van Dooren, Cournane & Hacquard, submitted; Moscati, Zhan, & Zhou, 2017, for recent overviews). Why do children show persistent bidirectional difficulty with modal force tasks? Proposed explanations for non-adult child force behaviours fall into three broad categories: (A) pragmatic, attributing difficulties to generating scalar

implicatures (SIs; e.g., Noveck, 2001), (B) conceptual, attributing difficulties to reasoning about more than one open possibility at the same time (e.g., Moscati et al., 2017; Ozturk & Papafragou, 2015) and (C) grammatical-representational, attributing difficulties to delay in working out the underlying forces of the modals being compared (Dieuleveut et al., 2019, submitted).

Whether a given modal expresses possibility or necessity must be learned, and input languages vary in their inventories and in how modals are used (critical for diagnosis as fixed-force or variable-force and for what evidence the child has to learn from). A new approach to the non-adult behaviours observed in prior studies suggests that children may not have robust adult force representations (e.g., knowledge that *can* encodes possibility, *have to* necessity) of the modals involved in the tasks (Dieuleveut et al., 2019, submitted). An important step towards answering the basic question of whether preschool children know the logical force of their modals, and how and when they work this out, is exploring how modal force is distributed in the input to young children, and in children's earliest productions.

Dieuleveut et al. (2019, submitted) report the first extensive corpus study of both input and child usage (aged approx. 2–3 years old) for modals by force, for all 12 mother–child dyads in the Manchester Corpus (Theakston et al., 2001). Results show differences between children and adults: children use proportionally more possibility modals than in their input (mostly *can*; adults use $n = 19,986$ modals, 72.5% possibility; children use $n = 4844$ modals, 79.3% possibility) and there is a significant interaction with negation, as small children use negated possibility modals (e.g., *cannot*) more often than adults, and negated necessity (e.g., *do not have to*) less often[13] (children negate 51% of their possibility modals, adults only 20.9%). To test the informativity of actual input conversational contexts from the Manchester Corpus for modal force, they use a version of the Human Simulation Paradigm (HSP; Gillette, Gleitman, Gleitman, & Lederer, 1999). Results show that even short snippets of conversation allow adult participants to accurately recover modal force from maternal input uses (assessed by blanking out a modal use and having participants guess whether a possibility or necessity modal was used, selecting between, e.g., *can* vs. *must*; *be able to* vs. *have to*). This suggests that the conversational context is rich enough for learners to rely on for force learning, assuming children can access the same kinds of cues adults can (e.g., desirability of the prejacent, see also Ozturk & Papafragou, 2015, Experiment 3). For modal uses by 2-year-old children, using the same method, the HSP shows adult participants are able to accurately guess children's possibility uses, but not their necessity uses (adults guess possibility for these). This suggests small children use possibility modals, but not necessity modals, in an adult-like way that is recoverable by adult participants.

The effect of flavour on force tasks may at times introduce experimental confounds. In order to focus on the force dimension of modals, researchers have made the overall experimental contexts epistemic,[14] using hidden-object/character paradigms with one hiding place (necessity) or two (possibility). However, epistemic scenarios do not rule out root interpretations, and these interpretations are consistent with results that have been taken to be the result of Scalar Implicature failures—for when children accept possibility modals in necessity contexts, and Premature Closure—for when they accept necessity modals in possibility contexts (Hacquard, p.c.). For example, in Experiment 1 from Ozturk and Papafragou (2015), a character hiding game using *can/may* versus *have to*, it may be that children interpret the modal as root despite the epistemic paradigm. If one hears 'the cow has to be in the red box' in a scene with two closed boxes (red and blue), the adult-like response would be 'no (because the cow could also be in the blue box)', but children often say 'yes' in such situations. On a root reading of *have to*

(~'The cow *has to* [=is obliged to] be in the red box'), children's acceptance of necessity in possibility situations is force-appropriate. That is, children may interpret the flavour of the modal differently from the researchers' intent, unlike adults, and this may affect the truth-conditions and felicity of the modal force.

As prior experiments have relied on epistemic contexts to test force, is difficulty with force linked to epistemic contexts only? Do children even have robust epistemic meanings for the modals standardly tested (*may*, *must* and *have to*), especially given that natural usage skews strongly to root uses, exacerbated in child usage (van Dooren et al., 2017, 2019)? Cournane, Repetti-Ludlow, Dieuleveut, and Hacquard (in preparation) explore whether 3- and 4-year-olds demonstrate understanding of differences between *can* and *have to*—both richly attested for root uses—in teleological (goal-oriented) root modality situations (cf. deontic, which is more complex to depict given authority and norms, and shows clear task effects, Hirst & Weil, 1982), with and without negation. They use the same design structure as Ozturk and Papafragou (2015) but with roads rather than boxes, and protagonist Cat using the roads to get to various shops. In necessity conditions, one road is blocked by construction (Figure 1).

Initial results on the positive conditions (*can* and *have to*) show both children and adults accept *can* in necessity contexts, not computing SIs (as with epistemics, Ozturk & Papafragou, 2015). Most children treat *have to* like *can* in positive contexts, contra adults and contra Ozturk and Papafragou (2015), where chance behaviour with *have to* was taken to support Premature Closure (this may have been chance due to children interpreting *have to* as obligation, but see Moscati et al., 2017). With non-epistemic modality, pre-schoolers behave as if they think *have to* is a possibility modal. These results show differences in results for force when flavour is taken into consideration. This is also consistent with the corpus and HSP results from Dieuleveut et al., (2019, submitted), suggesting children get possibility modals early, and necessity modals are non-adult-like for longer. In sum, emerging evidence suggests young children may not know that modals like *must* or *have to* encode necessity, a finding that complicates interpretation of force development work.

4 | FORM-MEANING MAPPING THE WHOLE MODAL MEANING SPACE

We have seen that corpus studies tend to focus on flavour, showing that children produce modals with root meanings more often and earlier than with epistemic. And, comprehension studies tend to focus on force, mostly in the epistemic flavour, showing that children accept possibility modals in necessity contexts and necessity modals in possibility contexts. What forms do speakers use to encode the whole modal meaning space (Table 1)? Hirzel et al. (in preparation) use a sentence-repair task (Cournane, 2014) to probe the extent to which children's difficulty with modal flavour and force stems from the complex mapping of meanings to forms. This approach allows us to see how children themselves lexicalize modal meanings, and how that differs from adults.

They elicited production of modals with 3- and 4-year-old children ($n = 46$) and adults ($n = 24$) for a 2×2 set of contexts, crossing modal flavour (teleological [=root], epistemic) and force (possibility and necessity) giving four unique combinations (Figure 2). Children heard stories about going to stores via different coloured roads (teleological) and hiding in different coloured boxes (epistemic). The task was to repeat story sentences with obscured
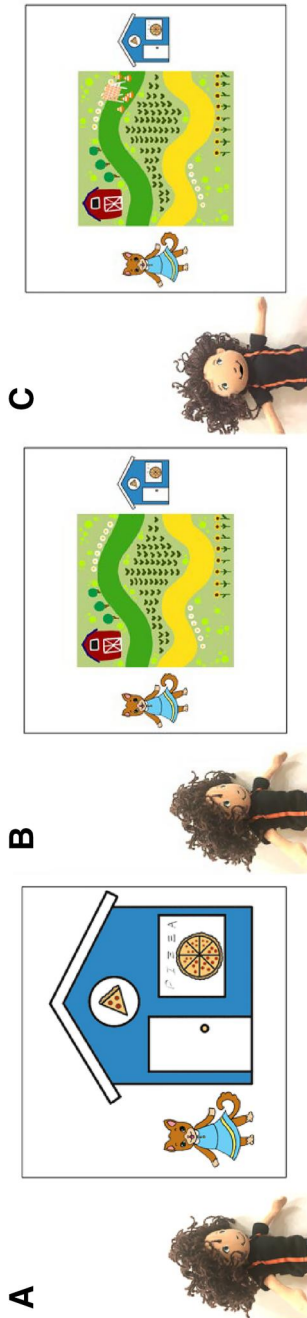
A Narrator: *Cat is going to the pizzeria to get a pizza for the party.*

B Narrator: *There are two ways to get to the pizzeria: the green road and the yellow road.*
[Animation – construction drops on] *But uh oh! The green road is blocked!*

C Logan [Animation – mouth moves] *To get to the pizzeria, Cat has to go down the yellow road.*

Prompt (Narrator): *Is Logan right?*

FIGURE 1 Stimuli and procedure for sample item (Exp. 1. modal: *have to*, scenario: TargetOpen)

FIGURE 2 Sample trials in each condition: FORCE(POSSIBILITY, NECESSITY) × FLAVOR(EPISTEMIC, TELEOLOGICAL)

modals to a shy snail puppet, so he could hear them. Pink noise blocked the modal but preserved the syntactic frame with cues towards intended flavour conspiring with the story contexts: teleological with eventive *go* (12a) and epistemic with stative *be* (12b). Participant's corrected the glitch with a modal of their choosing.

(12)   a. Kat <<noise>> go down the red path (given goal to get to the bakery)

        b. Nick <<noise>> be hiding in the red box (given evidence the other is empty)

Adults behave as expected for English using different lexical items by force: in epistemic contexts, they primarily produced *could* for possibility and *must* for necessity. In teleological contexts, adults prefer *could* for possibility and *should* and *have to* for necessity. In necessity contexts, adults tended to differentiate by both force and flavour. Overall, children produced fewer modal sentence-repairs than adults (36% vs. 99%), often producing non-modal or non-frame-compliant material (modal, but not fitting the syntactic frames in the prompts). For example, if a child produced 'Nick *maybe* is hiding in the red box' this supplies a modal (*maybe*) but also alters the frame (*be > is*). Child modal results are given in Figure 3, including possibility (light grey), necessity (dark grey) and future (medium grey) forms. Children prefer possibility modals for all conditions, but appear to differentiate by flavour: they use more *might* in epistemic contexts. In teleological contexts, children prefer *can*. Those children who used *have to* used it for both possibility and necessity. Note children use *must* but not *have to* in epistemic contexts (cf. force experiments using *have to* for epistemic tasks). Children also use future modals, but similarly across flavours and forces. Children appear to use particular modals for both forces (cf. variable-force modals) and contra adults.

These results suggest children may not yet have adult linguistic representations for the modals used in comprehension studies, and development of target form-meaning relations along both dimensions of the 'modal-meaning-space' is protracted, even if children produce the 'same' forms adults do. Child productions of possibility modals are more in line with adult productions than necessity modals, consistent with similar asymmetry in spontaneous corpus data (Dieuleveut et al., 2019) and experimental data (Cournane et al., in preparation; Ozturk & Papafragou, 2015).

This sentence-repair method could be productively employed beyond first language acquisition. The materials are carefully controlled for force and flavour distinctions and can thus serve as non-translation-based materials for modal fieldwork (see e.g., Matthewson, 2013; Vander Klok, 2014). The translational language can be used to help set up the stories and context, without priming by using modal translations, as this is equally important to avoid in child experimental work. Similarly, this method could be used to measure change-in-progress in speakers' productive patterns (Cournane, 2014, 2019; Cournane & Pérez-Leroux, 2020). A common theoretical proposal is that children advance changes during first language acquisition (Labov, 2001; i.a.), and modal systems are well-known to be in directional flux (Bybee et al., 1994) over generational time. The same methods that allow cross-linguistic (e.g., English vs. Gitksan) and developmental (e.g., children vs. adults) comparison can experimentally test for change-in-progress and age-graded variation. How do speakers of different ages or social-groups within a speech-community differ in how their modals jointly map the modal meaning space? How do individual patterns relate to syntactic and semantic change predictions?
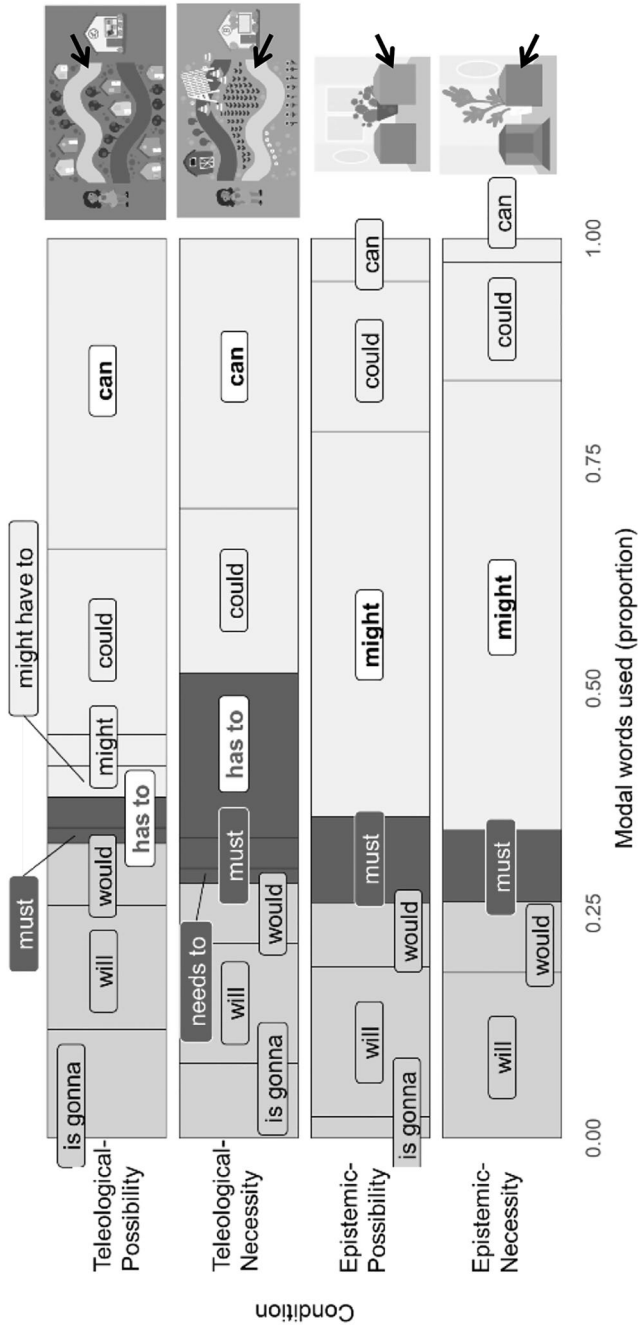
FIGURE 3 Children's modal word responses by condition. Possibility = light grey. Necessity = dark grey. Future = medium grey

5 | CONCLUSION

How do children arrive at target syntactic (form) and semantic (meaning) representations for the modals in their input languages? We have discussed modal development using a simplified 2×2 meaning space, crossing flavour (root and epistemic) and force (possibility and necessity). We have shown that grammatical representations may play a critical role in modal developmental milestones, for both flavour and force. We have stressed that cross-linguistic modal systems provide a blueprint for how modals can and do jointly express the modal meaning space in language-specific ways and taken the view that child learners may entertain possible modal representations for modality in human language on the way to the language-specific modal representations exemplified in their input. Considering cross-linguistic modal systems sheds new light on older findings and opens new avenues for exploring how children solve the form-meaning mapping relations for the modal systems of their particular input languages.

The modal-meaning-space for form-meaning mapping is larger than what we have covered here. Several topics only briefly mentioned, or not at all, are relevant to learning the modal systems of language, including but not limited to: (A) other scope bearing elements, especially negation; (B) evidentiality, the grammatical representation of knowledge source; (C) attitude verbs; (D) future modals/tenses; (E) imperatives, counterfactuals and other 'constructional modals' and (F) prosodic factors affecting the interpretation of modal constructions. The modal system is richly complex, with force and flavour dimensions interacting with each other, and with negation and other TAME elements, all constrained by language-specific syntactic properties of modal constructions. Much further work remains to be done to better understand the interrelationships between the acquisition of modal verbs and the other components of language listed here, particularly with learners beyond the relatively well-studied Indo-European languages. In turn, acquisition experimental materials and methods designed with cross-linguistic variation in mind may prove useful for fieldwork.

Practical challenges exist, as most L1A work is heavily burdened by convenience sampling, and widely spoken languages in wealthy areas remain the primary focus of child language research. We encourage researchers to think beyond English (or other relatively well-studied languages), even when designing materials for English learners. Semantic and syntactic fieldwork continues to improve our understanding of the boundaries of the learning space and make this work more practicable.

Why look more at modal development? Why consider cross-linguistic variation when looking at child development in any one particular language? Modality provides a rich natural laboratory for exploring the interrelationships between our uniquely human conceptual world of possibilities and symbolic language systems. We can learn more about both language and complex thought by exploring: (A) how modal concepts get packaged by the syntax-semantics of language systems and (B) how child learners approach and surmount modal form-meaning mapping challenges over developmental time for their specific input languages.

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ENDNOTES

[1] English modals are variable-flavour, so the meaning designations of root and epistemic here are not absolute, that is, for the root examples an epistemic reading is also possible.

[2] More precisely, associated with the participants of the verbal event (Hacquard, 2011; Wurmbrand, 1999).

[3] Variable-force modals are not counted in van der Auwera and Ammann (2005), therefore the one-fourth of the typological report reflects only flavour-variability, underestimating meaning-variability more generally (Matthewson, 2013).

[4] These can regain root interpretation with the addition of temporal adverbials like *by tonight*, or clear contexts to the same effect, shifting the prejacent to future orientation.

[5] In Kratzerian semantics, modals are quantifiers over possible worlds, existential ($\exists$) or universal ($\forall$) (Kratzer, 1981).

[6] Note that analyses differ for how to formally capture variable-force modality.

[7] I use this term descriptively (cf. Sweetser, 1990).

[8] Evidence from adult judgements of other adults' uses suggests modal force is largely recoverable from discourse, suggesting the conversational context may be useful (Dieuleveut et al., 2019).

[9] Functional modals, especially English auxiliaries (e.g., *must*, *can*) and verbs in Indo-European languages (e.g., German *müssen*) are sometimes taken to be co-extensive with 'modals', but are only one subset.

[10] Research on infant reasoning has advanced in the past decades, allowing us to appreciate that the conceptual abilities of infants are more advanced than previously assumed; infants may have precursors for belief-state reasoning (Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007) and possibility reasoning (Cesana-Arlotti et al., 2018).

[11] Cournane (2015, 2015) argues that children need to learn to bind the event variable of the modal when it is above a proposition, adopting Hacquard (2006)'s anaphoric analysis of modal verbs, syntactically represented by a TP.

[12] Epistemic talk may be relatively common with lexical modals (like *think* and *know*), which mark about 5% of all utterances in the Manchester Corpus input (van Dooren et al., 2017), however these are mostly used in parentheticals or with various speaker-meanings in the input and may not show their epistemicity (Dudley, 2017).

[13] Jeretič (2018) conducted a corpus study focused on root modal uses, in Spanish and French, primarily exploring interrelationships between modals and negation. Jeretič assesses the strength of modal expressions with and without negation, taking into consideration lexical scope for individual modals. She argues production results show children generally avoid using weak modal-negation expressions (cf. prevalence of plain possibility modals).

[14] Early task effects emerged with the deontic condition in the first force experiment, showing the epistemic condition as a better paradigm moving forward (Hirst & Weil, 1982).

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