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If they *must*, they will: children overcommit to likeliness inferences from deontic modals

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Modal verbs like *must* express two distinct non-actual meanings: deontic (e.g. obligation) and epistemic (e.g. likelihood inference). How do young children understand these modals? What factors affect their interpretation as deontic or epistemic? We report a picture preference task testing preschool children's interpretations of Bosnian/Croatian/Serbian (BCS) *morati* 'must' as deontic or epistemic. Prior work on English *must* shows that despite an early deontic comprehension bias at age 3, by age 5 children have flipped to a strong epistemic bias, including constructions for which adults prefer deontic interpretations (*must* + eventive verbs). However, properties of English leave open multiple explanations for this non-adult behaviour, as *must* is primarily epistemic in the input, and *must* + eventive verb constructions can also receive epistemic interpretations. BCS *morati* provides a natural comparison: *morati* is overwhelmingly deontic in the input, and BCS syntax provides categorical cues to deontic versus epistemic interpretation. Our results show that BCS children are more adult-like at age 3 than English children, a difference we attribute to clearer syntactic cues to flavour in BCS. But, by age 5, BCS children behave like English counterparts, selecting epistemic scenes even for constructions that are deontic-only in BCS. We argue this cross-linguistic result is best explained pragmatically: deontic uses of both *morati* and *must* invite a likelihood inference that obligations will be normatively carried out. This inference was first proposed to explain diachronic meaning changes from *root > epistemic*. We show older preschool children commit to this likelihood inference more than adults.

1 Introduction

This paper reports a comprehension study of the Bosnian/Croatian/Serbian (BCS) modal verb *morati* 'must' with 3-to-6-year-old children and adults. Modals like *morati* express two distinct 'flavours': deontic[1] (1a; obligation) and epistemic (1b; inference from evidence or knowledge) (Palmer 1986; Kratzer 1991; Hacquard 2011; i.a.). This flavour-variability poses a learning challenge, as the same modal verb maps to more than one non-actual meaning, closed to observation (Stephany 1979; Papafragou 1998; van Dooren et al. 2017; i.a.). They are quintessential "hard words" (Gleitman et al. 2005). How do children learn and navigate modal flavours for flavour-variable modal verbs of their input languages? How does modal verb interpretation develop over the preschool years? And, what factors most influence children's modal verb interpretations as deontic vs. epistemic? Our results suggest that syntactic bootstrapping (Gleitman 1990) and pragmatic inferences specific to modal meanings (Traugott & Dasher 2002) play central roles in modal flavour development, the former earlier on than the latter.

(1) a. Djeca   **mora**-ju   da po-jed-u   povrće   **DEONTIC**, *EPISTEMIC
         children.$_{\text{NOM}}$ must-$_{\text{3PL.PRS}}$ DA $_{\text{PFV}}$-eat-$_{\text{3PL.PRS}}$ vegetables
         'The children must eat the vegetables.'

     b. **Mora**-∅   (bi-ti) da djeca   jed-u   povrće   *DEONTIC, **EPISTEMIC**
         must-$_{\text{3SG.PRS}}$ be-$_{\text{INF}}$ DA children.$_{\text{NOM}}$ eat-$_{\text{IPF.3PL.PRS}}$ vegetables.
         'The children must be eating the vegetables.'   (Veselinović 2019: 15–16)

We compare our BCS study to prior work on English modal verb *must* that used the same methodology (Cournane & Pérez-Leroux 2020). While English *must* and BCS *morati* are both flavour-variable necessity modals, they differ in several ways that may affect their learning paths. Firstly, they differ syntactically. *Morati* is a main verb that occurs in different syntactic constructions when deontic than when epistemic. For example, *morati* shows subject agreement only when used deontically (1a), and only occurs in default 3SG.PRS form when epistemic (1b). English *must*, on the other hand, is a form-invariant auxiliary verb that shows only partial deontic versus epistemic syntactic differences. Speakers prefer deontic interpretations when *must* combines with eventive verbs (2a) (see Cournane & Pérez-Leroux 2020), but epistemic interpretations with the event as habitual are also possible. And, speakers readily get epistemic interpretations for *must* when it combines with a stative (*be* or grammatical aspect) (2b), but can still get a deontic interpretation if the state is future-shifted (i.e. "be wearing his boots" is obliged to hold after the utterance time) by context or temporal adverbials (e.g. *by tonight*).

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[1] Among other 'root' interpretations (Hoffmann 1966; Hacquard 2011), like teleological (i.e. goal-oriented). We set these aside because our experiments support deontic interpretations, and roots pattern together in BCS syntax.

(2) a. Scott *must* wear_{BARE} his rainboots (…his mother insists)   **DEONTIC**

              (…that's just what he always does)   *EPISTEMIC*

  b. Scott *must* <u>be</u> wearing_{PROG} his rainboots

              (…when his mother picks him up)   *DEONTIC*

              (…I see his boot prints in the mud) **EPISTEMIC**

                    (Cournane & Pérez-Leroux 2020)

Second, English *must* and BCS *morati* differ in how they are used in the input to children. Corpus work shows that *must* is used primarily as epistemic in the input to young children (about 80% Epistemic; van Dooren et al. 2017, based on the Manchester Corpus, Theakston et al. 2001). This epistemic usage bias is also apparent in sociolinguistic corpora of casual spoken English (Tagliamonte & D'Arcy 2007, i.a.). *Morati*, on the other hand, is overwhelmingly used as root (deontic and other root meanings) in the input. It occurs only 3.6% (18/494 uses) of the time as epistemic (Veselinović & Cournane, 2020, based on SCECL Corpus, Anđelković et al. 2001).

Cournane & Pérez-Leroux (2020) ran a picture preference task with English-speaking preschoolers and adults, testing preferred interpretations (deontic or epistemic) of *must* with eventive verbs (2a) and the same verbs marked with grammatical aspect (2b). Adults behaved as expected, choosing more deontic pictures than epistemic for sentences like (2a), and primarily epistemic pictures for those like (2b). However, children never distinguished by sentence type. Three-year-olds had an overall deontic bias, consistent with early modal verb production patterns (see Papafragou 1998; Hickmann & Bassano 2016; Cournane 2021). By age 5, children had a strong epistemic bias for both sentence types, even though adults significantly preferred deontic interpretations for (2a). What explains these non-adult behaviours? Properties of English modal verb syntax and usage patterns for *must* leave open several possibilities for why these differences obtained.

By age 5, English children's epistemic bias may reflect the fact that *must* is used mostly epistemically in their input. Or, they may tune in to the fact that *must* is overtly above aspect marking in sentences like (2b) (related to the epistemic interpretation, see §2.1) and overextend the high epistemic interpretation to sentences that don't reveal *must*'s position relative to aspect (like with bare verbs, 2a) (Cournane & Pérez-Leroux 2020). Finally, children may overcommit to pragmatic inferences from deontic to epistemic, of the type *If you are obliged to p, you likely p* (Traugott 1989; Traugott & Dasher 2002). For example, 5-year-olds may hear the sentence in (2a) and interpret it – like adults – as deontic, but then quickly move from the obligation to the inference that the obligation is carried out, causing them to select the epistemic pictures (depicting indirect evidence of the subject carrying out the VP).

BCS *morati* provides an ideal, natural counterpoint to English *must* to help adjudicate between these competing hypotheses. Unlike *must*, *morati* is primarily deontic in the input, so

input frequency by flavour should not drive an epistemic bias in BCS children. And, unlike English, BCS morphosyntax provides unambiguous cues to deontic vs. epistemic interpretations in the majority of sentences. BCS children should thus have clearer input cues for using syntactic bootstrapping to learn when *morati* is deontic and when it is epistemic. Only the pragmatic story predicts the same epistemic picture-selection bias for BCS *morati* as for English *must*; this inference is available to adult speakers of English and BCS (for any deontic necessity modal).

Our results show that BCS children begin with a weak but significant distinction between *morati* sentence types (1a vs. 1b) at age 3, in the adult-like direction. This result differs from English, where 3-year-olds showed a significant overall deontic picture preference. BCS syntax plausibly supports this early distinction, as the BCS constructions show rich morphosyntactic cues to modal interpretations, in many ways more akin to attitude verbs (e.g. *want, hope, think*) than modal verbs of English (see Hacquard & Lidz 2016). But, by age 5, BCS children show the same non-adult pattern as age-matched English children: they over-select epistemic pictures for *morati* (compared to adults), including for sentences like (1a). We thus argue that our results support a pragmatic story: older preschoolers commit more to the likelihood inference from deontic *morati/must* than do adults. This behaviour may be related to findings in the developmental psychology literature showing preschool children endorse strong conformity to rules (see Kalish 1998, i.a.) and that the ability to treat adherence to social rules as violable, unlike adherence to physical laws, develops over the preschool years (see Shtulman & Phillips 2018).

We discuss our results in light of pragmatically-driven models of semantic change from *root > epistemic* (a commonplace, unidirectional change observed for modal verbs, e.g. Lightfoot 1979; Traugott 1989; Bybee et al. 1994), which argue that epistemic uses of modal verbs arise from conventionalization of pragmatic inferences like those we argue for here (Traugott & Dasher 2002; i.a.). We make one major alteration: historical linguists who support this theory of semantic change assume adults must be the drivers, arguing children are not pragmatically sophisticated enough to perform this kind of inference (Nerlich & Clarke 1992; Traugott & Dasher 2002). Our results show preschool children are more likely to commit to this inference than adults, and at a time when they are still learning the semantics of modal verbs.

2 Background

2.1 Modal verb syntax

Here we discuss the syntactic constructions associated with root and epistemic modal verb interpretations, focusing on BCS and English. Syntactic bootstrapping is known to be critical for unobservable word meanings like those of modal verbs (Gleitman 1990). For example, for attitude verbs (e.g. *want, think, know, hope*) that express the same kinds of modal meanings as modal verbs (Traugott 2006; Hacquard 2013), syntactic distributions, especially differences in

complement types (e.g. finite vs. non-finite, indicative vs. subjunctive), have been shown to be critical for learning the meanings of these verbs (Hacquard & Lidz 2016; Harrigan et al. 2016; White et al. 2018). Thus, we are interested in whether children could, in principle, use any syntactically-represented cues to modal flavour for the interpretation of *morati*, and how those cues compare to English cues (see van Dooren et al. 2017; accepted, for corpus work with the same goals).

Starting with English, consider the example in (3), where the same sentence can have both root and epistemic interpretations.

(3)   Penguin *must* eat a lot of fish…
      a.   … his vet says they are required for better health!   (Root (Deontic))
      b.   … just look at his shiny coat and winter-ready plumpness!   (Epistemic)

In its first interpretation (3a), *must* expresses a necessity[2] that applies to the predicate (*eat a lot of fish*), attributing that necessity to the agent (*Penguin*). Paraphrasing, *Penguin is obliged to eat lots of fish*. In the second interpretation (3b), *must* expresses a likelihood judgement that applies to the entire unmodalized proposition (the "prejacent": *Penguin eat(s) a lot of fish*). This judgement is attributed to the speaker. Paraphrasing, *It is necessarily the case that Penguin eats a lot of fish*. Epistemic modality is also called "speaker-oriented modality" (Bybee et al. 1994; Hacquard 2011, for overview). For root *must*, the obligation holds in the future, with epistemic *must*, the likelihood is in the present (see Ramchand 2018; Rullmann & Matthewson 2018; i.a.).

From the 1960s, researchers have proposed structural differences for these interpretive differences (Ross 1967; Barbiers & van Dooren 2017, for overview). While syntactic accounts vary considerably in their details, they aim to capture the broad compositional differences between root and epistemic interpretations, as described for the example in (3). Generalizing, most argue that root modals select (or scope over) smaller complements than epistemic modals (e.g. Brennan, 1993; Cinque 1999; Hacquard 2006; Ramchand 2018; Veselinović 2019). While *must* and other auxiliary modal verbs are exponents of T^0 (Pollock 1989, i.a.), always in the same surface position, they can be interpreted at different locations. For example, Hacquard (2006) treats flavour-variable modal verbs as anaphoric to events: when the modal verb is interpreted low, just above the VP, its event variable is bound by aspect, and it is interpreted as root. When it is high, above TP, its event variable is bound by the speech act, and it is interpreted as epistemic. This captures the general syntactic effects for modal verbs in English, including flavour-specific interactions with tense and aspect, without homophonous modal lexemes (cf. Cinque 1999).

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[2] Kratzerian semantics treats modal verbs as quantifiers over possible worlds (either existential, like BCS *moći* 'can', or universal, like BCS *morati* 'must'), and depending on the modal base they quantify over, they are interpreted as root (circumstantial base) or epistemic (epistemic base) (see Kratzer 2012).

A sentence like (4a) is ambiguous between two interpretations, because when *must* combines with a bare verb, it can be interpreted either low, below TP and closer to the VP, or high, above the propositional level (TP). English wears no overt tense or aspect marking on its sleeve in this case. In English, auxiliary modal verbs either occur with bare verb complements (4a) or aspect-marked complements (4b,c). With aspect marking, the modal verb occurs overtly above aspect, keying its high epistemic interpretation[3] (see Hacquard 2006). This alternation is more obvious with eventive verbs, like *eat,* as grammatical aspect takes these events and renders them states. When modal verbs combine with stative verbs, like *be,* they are also most readily interpreted as epistemic.[4] But, context plays a considerable role in modal verb interpretations notwithstanding the syntax (Kratzer 1991; 2012), and most sentences are at least in principle ambiguous.

(4) a. Penguin *must* [eat a lot of fish]$_{bare}$ ✓root, ✓epistemic
   b. Penguin *must* [have eat<u>en</u> a lot of fish]$_{perfect}$ (*)root, ✓epistemic
   c. Penguin *must* [be eat<u>ing</u> a lot of fish]$_{progressive}$ (*)root, ✓epistemic

Turning to BCS, we find that the syntax-to-flavour mapping of modal verbs is more clear-cut, with categorical morphosyntactic cues for root versus epistemic interpretations. Unlike in English, BCS flavour-variable modal verbs (*moći* 'can', *morati* 'must', *trebati* 'need') are main verbs, that inflect for phi and tense. They are not involved in thematic relations with arguments that denote individuals, or arguments of the verbs embedded under them. We focus on *morati,* as our test modal, in its root and epistemic uses (5) (see Besters-Dilger et al. 2009; Veselinović 2019 for overviews of more BCS modals).

(5) a. [$_{CP}$ Djeca$_i$ [$_{MoodP}$ **mora**-ju   da $\underline{t_i}$ po-jed-u   povrće]]   **ROOT**, *EPISTEMIC
   children.$_{NOM}$ must-$_{3PL.PRS}$ DA$_{2 \; PFV}$-eat-$_{3PL.PRS}$ vegetables
   'The children must eat the vegetables.'

   b. [$_{CP}$ **Mora**-∅ [$_{CP}$ da   djeca$_i$ $\underline{t_i}$ jed-u   povrće]]   *ROOT, **EPISTEMIC**
   must-$_{3SG.PRS}$ DA$_1$ children.$_{NOM}$ eat-$_{IPF.3PL.PRS}$ vegetables.
   'The children must be eating their vegetables.'   (Veselinović 2019: 15–16)

In root uses (5a), *morati* bears the subject's φ-features (plural *djeca*) and may be marked with morphology compatible with past, present or future orientation. The embedded verb also shows agreement with the subject, but can only bear what is commonly referred to as subjunctive morphology – the perfective form of the present tense.[5] This type of complement is licensed in

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[3] It is possible to get a root interpretation too, with the help of future-shifting the prejacent with a temporal adverb or strong context to the same effect, e.g. *By tonight.*

[4] Here too it is possible to get root readings, like with *Penguin must be nice* in the context of an obligation to be nice at some future event.

[5] In many dialects, including standard Croatian, the embedded verbs only appear as infinitival. Our test population is in Sarajevo, Bosnia & Herzegovina, so we focus on features of that dialect region.

conditional and future-oriented temporal clauses (see Veselinović 2019 and references therein for BCS, and Giannakidou 2009, for parallel forms in Greek) and is commonly a complement of such attitude verbs as *željeti* 'want', which associate with future-oriented prejacents, like root modal verbs do (see Rullmann & Matthewson 2018). In epistemic uses (5b), *morati* bears 3SG default morphology,[6] while the embedded verb may appear in any syntactic form permissible in a standalone CP. In epistemic constructions *morati* can be optionally followed by *biti* 'be.INF'.

BCS differs from English (and other languages, notably French), which formed the basis of analyses like Hacquard (2006). For root modal syntax, the analysis in (4a) holds, but for the epistemic syntax we need to make a modification. BCS epistemic uses of modal verbs scope over CP rather than a smaller TP (cf. 4b). This difference is syntactically important, but does not change too much with respect to semantics, as both high positions (above TP in a monoclausal structure, or above CP in a biclausal structure) have the modal scoping high, above a proposition.

Root and epistemic modal verb constructions in BCS also differ in default word orders: *morati* occurs after the subject in root uses (5a), and sentence initially in epistemics uses (5b). *Morati* is followed by DA in both cases, but researchers agree that there is more than one DA in BCS (Browne 1986; Tomić 2004, i.a.). DA1 is a traditional complementizer, heading CPs embedded under verbs such as *misliti* 'think', and taking fully clausal indicative complements (see 5b). DA2 takes subjunctive complements following verbs such as *željeti* 'want' and licenses the use of the perfective verbs in the present tense (BCS subjunctive marking, see 5a). Here we treat the DA in root constructions as a Mood head (in line with Veselinović 2019; see also Tomić 2004; 2006; Giannakidou 2009 for Greek *na*; cf. Wurmbrand et al. 2020). This distinction between complement types parallels that of attitude verbs in languages with indicative-subjunctive contrasts (e.g. Spanish): those with root meanings (e.g. *want*-type) typically take subjunctive complements and those with epistemic meanings (e.g. *think*-type) typically take indicative complements (Villalta 2008).

Summarizing, BCS root modal verbs agree with the subject, occur in monoclausal (one CP) constructions, and the verb embedded under the modal verb also agrees with the subject and occurs in perfective form. Epistemic modal verbs show default agreement, and occur in the matrix clause of biclausal constructions (two CPs). BCS cues for modal interpretation are semantically similar with respect to the broad tense and aspect properties of the modal prejacents as with English (and cross-linguistically, see Hacquard 2011; Rullmann & Matthewson 2018). But, unlike English, BCS wears these cues on its sleeve: they are syntactically overt, and modal sentences are reliably linked to flavour interpretations.

Experimental work shows that BCS adults use these morphosyntactic cues to categorically distinguish modal verb interpretations as root or epistemic. Veselinović (2019) conducted an online questionnaire study with adult native speakers of BCS, primarily from Sarajevo, Bosnia &

[6] *Morati* cannot bear agreement morphology and get interpreted as epistemic, so flavour-ambiguous sentences are restricted to those with 3SG subjects.

Herzegovina. Materials were based on the modal questionnaire developed for cross-linguistic study (Vander Klok 2014). She tested the grammaticality of different morphosyntactic constructions with BCS modal verbs (e.g. *morati* 'must', *moći* 'can') for several modal meaning contexts (deontic permission and obligation, circumstantial possibility and necessity, epistemic possibility and necessity). Participants had to judge the grammaticality of specific modal verb constructions for the clear modal meaning contexts. Relevant to the current study, results confirmed that *morati* in constructions like (5a) is rated high with deontic necessity and low with epistemic necessity contexts. *Morati* in constructions like (5b), gets the opposite rating pattern.

2.2 Modal flavour in spontaneous child productions

Acquisition work on modal flavour has focused on the emergence and usage patterns for modal verbs in production, primarily on English modal auxiliary verbs (for overviews, Papafragou 1998; Hickmann & Bassano 2016; Cournane 2021). Foundational corpus work observed a priority and dominance of root uses (like ability, deontic, and teleological): by age 2 children use modal verbs with root meanings, but epistemic uses occur only from around age 3 (Kuczaj & Maratsos 1975; Stephany 1979; Wells 1979; i.a.). Earliest uses tend to be ability, while clear deontic uses occur a few months later. However, more recent work on English with denser child corpora (van Dooren et al. 2017, using the Manchester Corpus, Theakston et al. 2001) and more corpora (Cournane 2021, using 17 North American English children on CHILDES, MacWhinney & Snow 1985) identifies potentially adult-like epistemic uses of modal verbs at age 2 for some children, up to 1 year earlier than standardly reported. Nonetheless, these child samples still show modal verbs first with root uses, both in aggregate and for particular modals in individuals (6).

(6)	a.	Child:	it's got mud over it.	
		Mother:	I see.	
		Mother:	right.	
		Child:	**must**$_{root}$ wash it.	(John, 2;08, Manchester Corpus)
	b.	Child:	my yellow one.	
		Child:	can't see it.	
		Child:	**must**$_{epis}$ be gone.	(John, 2;09, Manchester Corpus)

Recent work has also looked more closely at modal verb input, and found that while root uses are much more frequent than epistemic, 2- and 3-year-old children use even more root uses and fewer epistemic than their parents (van Dooren et al. 2017; accepted). In the Manchester Corpus (n = 12 parent-child dyads; children aged 2;0–3;0;[7] 373,798 adult utterances, 190,827 child utterances), adult modal verb uses are 8% (696/8863) epistemic. Notably, some MVs (*might, must, may*) are more often epistemic in the input (e.g. *must*, 80% epistemic; 67% of *may*; 65% of

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[7] The Manchester Corpus runs past this age, but the van Dooren et al. (2017) study only sampled this range.

might[8]). These are the modal verbs English-learning children tend to first produce as epistemic (van Dooren et al. 2017; Cournane 2021). Children use some epistemic modal verbs (n = 51; 2% of all modal verb uses) at this early age (6b). In the Manchester corpus, 20% of child *must* uses are epistemic. This is lower than adult uses, but these children are only two years old.

Veselinović & Cournane (2020) explored child and input production for BCS, using the SCECL corpus (n = 8 parent-child dyads; children aged 1;6–4;0; 72,305 adult utterances, 95,105 child utterances; Anđelković et al. 2001). They found that both *morati* 'must' and *moći* 'can' have very few epistemic uses in the input (1%, mostly with *morati*; 18/494 *morati* uses; cf. only 5/1958 *moći* uses). BCS children begin producing modal verbs in root contexts at age 2 (7), as in prior studies on modal verb production. By age 3, they use root modals at close to adultlike rates. However, the BCS children's corpora contain no epistemic uses of modal verbs before the age of 4;0 (end of SCECL corpus). While this is a null result, it obtains despite the corpus being relatively dense for a child corpus and children using modal verbs relatively frequently, in 2371 utterances.

(7)   Spontaneous root uses of *morati* by 2-year-olds (SCECL, Anđelković et al. 2001)
        a. **moram** naći jelena (=I have to find the deer)   2;02, NIK
        b. **moram** da ga popravim (=I have to fix it)   2;04, LUK
        c. **mola** [: mora] Tinu da xxx[9] da legnem (=I have to lie Tinu (*doll*) down)
                                                                                2;04, ANE

Why do children produce epistemic modal verbs later than root? And, why does BCS appear to show a longer "epistemic gap" (Cournane 2015a; b; 2021) than English? Earliest explanations appealed to a conceptual lag in epistemic reasoning relative to the reasoning involved for root modalities (Sweetser 1990; Papafragou 1998, i.a.). More recent developmental psychology work suggests younger children than we previously supposed can do complex belief and knowledge reasoning (Onishi & Baillargeon 2005; Goupil et al. 2016), undermining conceptual lag stories for the epistemic gap. And, early acquisition work focused heavily on English modal verbs; languages have other means to express modality, a notionally defined category (Kratzer 1991). For example, English and BCS have epistemic adverbs (e.g. *možda* 'maybe', *sigurno* 'surely'), attested from early age 2, during the epistemic gap for modal verbs (8).

(8)   a. *mo(ž)da* je tamo u sobi (=maybe it's over.there in.the room)   2;02, Antonija
        b. me [:ma] je siguo [//] *sigurno* je aut! (=it was surely, surely it is out!) 2;05, Vjeran
        c. *možda* će biti skubidu (=maybe it.will be Scooby-Doo)   2;08, Vjeran
                                                        (Kovačević Corpus; Kovačević 2003)

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[8] Or 100% epistemic for *might*, depending on whether one thinks *might* has root metaphysical uses or not (see Condoravdi 2002; Rullmann & Matthewson 2018). We report the more conservative rate.

[9] Unintelligible word.

Another proposal for the epistemic gap is that grammatical representations of epistemic modal verbs are more complex (=involve more structure) than for root modal verbs (Cournane 2015a; b; 2021; see also Heizmann 2006; De Villiers 2007). Cournane (2015a,b) argues that the typical age 3 milestone for first epistemic uses of English modal verbs is linked to grammatical change in the developing child. She uses Hacquard (2006)'s analysis of modal verbs to support the argument that TP-embedding (as a proxy for propositional embedding) is what is essential for the grammatical representation of flavour-variable modal verbs in their epistemic use (where they scope over propositions). Markers of TP-embedding occur in the months leading up to the 3rd birthday (see de Villiers & Roeper 2016). If using modal verbs in epistemic contexts in BCS relies on representing CP-embedding (Veselinović 2019), then we expect epistemic uses to be absent potentially until age 4, consistent with what is reported for developmental patterns for the onset of productive CP-embedding (see de Villiers & Roeper 2016). This grammatical account better captures the different findings for BCS and English than a conceptual one. Another possible reason for the epistemic gap, and for it being longer in BCS, is the input disparity between abundant root and sparse epistemic uses (Shatz & Wilcox 1991; Papafragou 1998; van Dooren et al. 2017; accepted). While BCS adults (in aggregate) use both main modal verbs with both root and epistemic uses in the corpus sample, epistemic uses of *morati* are at very low rates. In English, overall rates of epistemic usage are also low in aggregate, but not as low, and unlike for BCS, some individual modals (*might, must, may*) are actually used more often epistemically. In BCS it may be harder for learners to detect epistemic uses of particular modal verbs in a sea of root uses.

Summarizing, corpus research shows that children produce root modal verbs and epistemic adverbs around age 2 in many languages, while first epistemic uses of flavour-variable modal verbs occur around age 3 in English, but remain absent in BCS children through to the 4th birthday. The absence of epistemic modal verb uses in early BCS is consistent with: (a) greater syntactic complexity in BCS, or (b) input effects, as BCS modal input contains fewer epistemic uses of modal verbs and there are no modals that are mostly used epistemically (unlike in English).

2.3 Experimental acquisition studies on modal flavour

Few studies explore modal verb flavour development experimentally.[10] Heizmann (2006)'s study was the first to test the role of grammatical factors in child modal flavour interpretation. She tested preschoolers' interpretations of English *must* and German *müssen* (v. 'must') in a referent selection task. This paper does not report inferential statistics and the samples are small, but English preschoolers (aged 3–5) appeared able to select an epistemic interpretation with *must +*

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[10] Most experimental studies on modal verbs have focused on the 'force' component of modal meanings (e.g. necessity *must* vs. possibility *might*) (see Ozturk & Papafragou 2015 for an overview).

progressive sentences. And, for *must* + bare verb sentences, 3-year-old children in both languages appear to exhibit an early preference for deontic readings.

Employing the same kind of picture preference task as we do in this paper, Cournane & Pérez-Leroux (2020) tested 3-to-5-year-old English children and adult controls from the same speech community (Toronto, Canada) to see how they interpreted sentences with *must*. They used *must* sentences with grammatical aspect (progressive or perfect) (9a,b) and with bare eventive verb complements (9c). They asked how interpretations developed over the preschool years, whether children could use cues from grammatical aspect to access epistemic interpretations (9a,b), and whether children have non-adult biases for how to interpret ambiguous bare verb sentences (9c).

(9) a. Doggy **must** <u>be</u> eat<u>ing</u> his dogfood   *must* + progressive aspect
     b. Doggy **must** <u>have</u> eat<u>en</u> his dogfood   *must* + perfect aspect
     c. Doggy **must** eat his dogfood   *must* + bare verb

Adult controls showed clear contrasts by sentence condition, at ceiling for epistemic picture selections for modal-aspect sentences (9a,b), and preferred deontic interpretations for bare verb sentences. Three-year-olds showed a small, significant, deontic preference overall, regardless of sentence condition. By age 5[11] children strongly preferred epistemic pictures regardless of sentence type, significantly beyond adults for sentences like (9c). Children went from a deontic bias, consistent with corpus production results for 3-year-olds, to a strong epistemic bias, without showing sensitivity to the sentence manipulation. Put another way, children became more adult-like for aspect marked *must* sentences (9a,b), but less adult-like for bare verb *must* sentences (9c).

However, while Cournane & Pérez-Leroux's results show significant patterns of divergence between adults and older preschool children for root vs. epistemic interpretations, they do not address *why* children diverge from adults in their interpretations of ambiguous modal + bare verb sentences. They suggest that English only provides overt syntactic evidence for the high epistemic position, above aspect marking (*must* > aspect) (9a,b): Once children fully clue into the high surface position of *must*, they over-generate that higher interpretation, even for ambiguous strings (9c). This syntactic story is an open possibility, but both input and pragmatic explanations are also possible. English *must* is primarily epistemic in the input to children (van Dooren et al. 2017), and in adult-to-adult speech in the test community (Toronto, Canada; Tagliamonte & D'Arcy 2007). Thus, it is possible that older preschool children are attuned to the input usage patterns for *must* in their speech community and over-assign epistemic interpretations to sentences with *must* (including for sentence types where epistemic readings are less common for adults). Or, the children may access interpretations as adults do, informed by the temporal-aspectual information in the modal's complement, but they may differ from adults pragmatically

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[11] Four-year-olds showed a mixed pattern.

by committing more strongly to inferences of the type *If you must p, you likely p*, increasing their choices of epistemic pictures over deontic compared to adults. This is especially compelling since root modalities are robust earlier and more prevalent in child language productions, even for epistemic-biased input modals like *must*, so it is surprising children would become less attuned to them. This pragmatic approach suggests that children remain attuned to deontic modality, but quickly infer that the deontic interpretation implies carrying out of the obligation, allowing them to select the epistemic picture despite interpreting *must* as deontic. BCS *morati* should be able to help us decide among these explanations: the syntax is categorical by flavour, the input patterns are reversed from English, and the inferences available are the same.

2.4 Pragmatic inferences from deontic necessity

Modals can convey several pragmatic meanings related to their basic truth-conditional meanings. Truth-conditionally, modals are quantifiers over contextually-determined sets of possible worlds (see Kratzer 1977; 1981, i.a.). Two particularly common pragmatic layers of meaning for modals involve politeness uses in indirect speech acts (e.g. *can you pass the salt*?; *I might have the cheeseburger* (said to a waiter)) and scalar implicatures (e.g. *you can check-in at 3pm* (you don't have to, you can also check in later)). In the former case these "soften" an order: the possibility modal renders the content of the order merely a possibility in the literal encoding, and we understand this as a politeness maneuver. And, in the latter, their use shows the speaker chose not to use a stronger necessity modal (*have to, must*), suggesting, along the lines of Gricean conversational reasoning (Grice 1975), that the stronger meaning must not hold. Both of these pragmatic meanings from modal uses involve possibility modals (*can, could, might, maybe*).

In general, pragmatic meaning is highly heterogenous (e.g. indirect speech acts, sarcasm, scalar implicatures, reference disambiguation, presupposition assumptions) and children seem to be very good at understanding some types of pragmatic meaning early in development—for example, speaker meanings for indirect speech acts (e.g. Grosse & Moll & Tomasello 2010), while others show a protracted developmental trajectory towards the adult target (for example, scalar implicature computation, Skordos & Papafragou 2016). Relevant to modals, lexical epistemic modals like the attitude verb *think* are frequently used to make indirect assertions (e.g., *I think it's your bedtime*); children understand this from very early on, and indeed, this pragmatic meaning has likely interfered with young children's judgements about *think* sentences in False Belief Tasks (see Lewis & Hacquard & Lidz 2017; Hacquard & Lidz 2018). Their studies show that 3-year-olds reject *think*-sentences in False Belief Tasks because they assume that the *think* signals an indirect assertion of a proposition they know to be false (rather than a belief attribution which is true of the attitude-holder). Also relevant to modals, much work on scalar implicature computation has relied on epistemic uses of modal verbs like *may* or *might*. Children remain not fully adult-like for scalar implicature computation for modals and other scalar elements (e.g. *or, some*) through

the preschool years (Noveck et al. 1996; Noveck 2001; Ozturk & Papafragou 2015, i.a.). Younger preschoolers appear to be "more logical" (Noveck 2001), as they accept underinformative utterances as true (e.g. *Some elephants have trunks*; *There might be a parrot in the box* [when there *has to* be]) while adults reject such utterances as underinformative (though see Katsos & Bishop 2011; Barner & Brooks & Bale 2011).

Here we look at a different kind of modal inference, namely that an obligation normatively implies that the obligatory action is likely to be realized. This type of modal inference is discussed in historical linguistics, but to our knowledge, has not been examined in developmental linguistics. Notably, compared to the other pragmatic meanings associated with modals, at least those best-studied, this one arises from the use of necessity modals like *must* (though it is possible it also arises, more weakly, from possibility modals).

Root modal uses may imply that the predicate associated with the modal will likely happen; this fact has been widely discussed in the historical literature on modal verbs (see especially Traugott 1989). Modal verbs are observed to change unidirectionally in the history of languages, from historically older root uses to newer epistemic ones (e.g. Lightfoot 1979; Traugott 1989; Bybee et al. 1994). Firstly, modal verbs with only root meanings (e.g. *to wish, to owe money, to know how*; Lightfoot's 'premodals') gain additional epistemic meanings (root > epistemic), creating a flavour-variable modal verb. Then, change-in-progress ensues with flavour-variable modals shifting to increasingly more epistemic usage to the detriment of the more conservative root usages (see Tagliamonte & D'Arcy 2007 for an overview of this stage). One theory for why modal verbs change unidirectionally in this manner is the Invited Inferencing Theory of Semantic Change (Traugott & Dasher 2002). This theory argues that pragmatic inferences arising from root modal uses (particularly salient for deontic necessities) lead language users to conventionalize these inferences as additional epistemic meanings for the modal. For example, if I know Alex is obliged to walk the dog, deontically, then I can infer the dog is likely to get walked, epistemically (10). In other words, modals change from root to flavour-variable because pragmatic inferences regularly called-up with root uses can get newly encoded as part of the semantic meaning of the modal.

(10)   *Alex $\textbf{must}_{\text{deontic}}$ walk the dog* ⇢ The dog $\textbf{must}_{\text{epistemic}}$ be walked

We consider here that the spirit of this approach fits preschool child comprehension, if these children are especially prone to generating or "falling for" this inference in their modal interpretations. This could help account for existing English results (Cournane & Pérez-Leroux 2020). Especially important, child overcommitment to epistemic inferences from deontic rules can be embedded in a body of literature on how child reasoning about obligation, normative behaviour, and physical laws versus social rules, differs compared to adults. While these studies

do not speak directly to the root > epistemic inference, they show that preschoolers differ from adults in how they reason about the deontic modality tested in our study and Cournane & Pérez-Leroux (2020).

First, preschool-aged children take future-oriented predictions or statements as a commitment to action in non-adult ways (Mant & Perner 1988; Kalish & Cornelius 2007, i.a.). For example, a child who states she thinks she might go swimming after school, but then doesn't, is deemed naughty as if she violated an obligation. Second, young children reason differently about the consequences of rule-breaking than adults, ascribing punishments too severe for the crimes (Smetana 1981, i.a.). This suggests they may be more likely than adults to infer rules are followed through upon. Third, the understanding that rule-violation is in the hands of individual actors – one can choose to violate a social rule, unlike a physical law – is not consistently demonstrated until children are about age 5, and does not appear to be appreciated by 3-year-olds (Kalish 1998). Finally, many studies show that children initially treat deontically prohibited events as outright impossible, a conflation with physical impossibility that is only gradually overcome in childhood (see Shtulman & Phillips 2018 for study and overview). For example, preschoolers (approximately age 4-to-6) judge that morally bad events cannot happen, are impossible, or require magic. In sum, child reasoning associated with deontic modality appears more categorical and deterministic than that of adults. These non-linguistic developmental factors may contribute to child overcommitment to the pragmatic inference from obligation to likelihood.

2.5 Hypotheses

From this background, we test the following hypotheses for *morati* with a picture preference task of the same type used in Cournane & Pérez-Leroux (2020), with similar age groups (3-year-olds, 4-year-olds, 5-year-olds, 6-year-olds and adults). We are interested both in the developmental path relative to adults in BCS, and comparing BCS to English.

INPUT FREQUENCY HYPOTHESIS: Child groups will undergenerate epistemic interpretations of *morati* relative to adult controls and English-learning peers because, unlike *must*, *morati* is used primarily as deontic in the BCS input. Children ≠ Adults; *morati* ≠ *must*

SYNTACTIC BOOTSTRAPPING HYPOTHESIS: Child groups will be adultlike for structure-to-meaning mapping for *morati* earlier than English-learning peers because *morati* has categorical syntactic cues for flavour interpretation. They will comprehend MONOCLAUSAL constructions as deontic and BICLAUSAL as epistemic. Children = Adults; *morati* ≠ *must*

PRAGMATIC INFERENCE HYPOTHESIS: Child groups will over-select epistemic pictures for MONOCLAUSAL constructions (=deontic for adults) relative to adult controls, but in line with English-learning peers, because both *must* and *morati* invite the same pragmatic inferences in their deontic uses. Children ≠ Adults; *morati* = *must*.

3 Flavour Preference Task

3.1 Methods

3.1.1 Participants

Participants were 56 typically-developing monolingual-BCS children and 9 dialect-matched adults from Sarajevo, Bosnia and Herzegovina. An additional four children were excluded (three ended participation early, one only chose the right-hand side of the screen). Children were divided into four age groups: 3-year-olds ($n = 14$, $M = 42$ months, $SD = 3.7$ months), 4-year-olds ($n = 15$, $M = 54$ months, $SD = 3.4$ months), 5-year-olds ($n = 15$, $M = 66$ months, $SD = 3.9$ months), and 6-year-olds ($n = 12$, $M = 77.5$ months, $SD = 3.3$ months). Children were recruited through one public pre-school in Sarajevo. Testing was done at the preschool, after obtaining parental consent and child assent. If parent and child consented to audio-recordings, the session was recorded. Adult controls ($M = 34.6$ years, range $= 23$–62, $SD = 10.46$) were recruited by word of mouth. Education ranged from vocational high school to post-graduate degrees.

3.1.2 Audio and visual stimuli and norming procedure

Based on Veselinović (2019)'s grammaticality task testing BCS modal sentence interpretations by syntactic constructions, we decided to make all of our test sentences fit two morphosyntactic formulae, one that clearly and only aligned with root interpretations (including Deontic), which we refer to as MONOCLAUSAL (11a), and the other that clearly and only aligned with epistemic interpretations, which we refer to as BICLAUSAL (11b). These language-specific morphosyntactic considerations dictated the use of plural subjects to reveal lack of agreement on the modal verb in the epistemic contexts, as well as specific embedded verbs to be used (those with imperfective forms). Due to these considerations, the materials from Cournane & Pérez-Leroux (2020) could not be directly adopted for BCS and new stimuli were created.

(11) a. MONOCLAUSAL: *Subj Mod.$_{SUBJ\varphi}$ DA V.$_{PFV}$*
      b. BICLAUSAL: *Mod.$_{3SG}$ Subj DA V.$_{IPF}$*

The subject was always two bear cubs, referred to by the childlike term *mede*. We aimed to have the morphosyntactic frame as consistent across test sentences as possible, so the predicates were chosen based on the following criteria: (i) the aspectual pair of verbs had to exist, and (ii) the imperfective had to be the simple form, while the perfective had to be formed via prefixation from the imperfective. The full list of normed predicates is in (12).

(12) a. (u)beru – 'pick'   b. (o)brišu – 'wipe'   c. (na)crtaju – 'draw'
      d. (po)jedu – 'eat'   e. (po)kose – 'mow'   f. (sa)kriju – 'hide'
      g. (o)kupaju se – 'bathe'   h. (sa)melju – 'grind'   i. (is)peku – 'bake'
      j. (o)peru – 'wash'   k. (na)prave – 'make'   l. (na)pune – 'fill'

We then designed twelve stories, each consisting of an introductory context picture and sentence or two (as in **Figure 4**, Section A), three test pictures (ACTUAL, DEONTIC, EPISTEMIC; as in **Figure 4**, Section C), and three test sentences with the predicates from (12): UNMODALIZED, MONOCLAUSAL (11a), BICLAUSAL (11b). The context was intended to suit any of the test sentences. Deontic pictures depicted a future-oriented scenario relative to the predicate of the test sentence (e.g. for the bathing scenario the bears are muddy and bathing has not yet occurred) and an authority figure (thought to help young children access deontic interpretations, e.g. Dack & Astington 2011). The epistemic pictures show obscured ongoing events (e.g. for the bathing scenario there are clues that the bears are in the bathtub, but we cannot see them). The epistemic pictures are essentially indirect visual evidence scenes (Papafragou et al. 2007). In what follows we focus on the deontic and epistemic pictures, and the monoclausal and biclausal sentences.[12]

We conducted an online norming study to ensure our stimulus pictures were good depictions of deontic and epistemic interpretations, and to test compatibility of our set-up and test sentences with the pictures we'd created (see Veselinović 2019, for further details on the norming process). The goal was to use the results as guidance for omitting stories (we designed two more than we intended to use), and improving the pictures where necessary before conducting the main study. Participants were adult native speakers of BCS, primarily from Sarajevo, Bosnia & Herzegovina (n = 108 included in the final analysis), who were recruited through social media.

Participants completed a 15-minute Qualtrics survey, where they rated sentence-picture matches on a 1–5 Likert-like scale for how well the sentence served as accompanying text for the picture. They rated all three sentence types for each picture. Each participant saw only one of the pictures for each story, rating sentences for 12 pictures total (4 of each of the 3 types). Participant exclusions meant that each picture was rated variable amounts, by between 27 and 38 participants. We counterbalanced order of presentation of sentences and randomized order of pictures.

In order for our story pictures to be considered successful for use in the main study, the Deontic pictures should receive a higher rating for the monoclausal sentence than for the biclausal sentence, and the Epistemic pictures should show the reverse pattern. We z-transformed all results to account for variation in how participants use the scale (Schütze & Sprouse 2014), and created plots like **Figure 1** for each predicate. Predicates varied in the magnitude of the difference between sentence ratings by pictures across and within stories.

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[12] The actual pictures and unmodalized sentences were included because of early intentions to also run a task comparing epistemic sentences to non-modal ones (Experiment 3 in Cournane & Pérez-Leroux 2020). These pictures showed direct evidence for the event, for example in the bathing story, the two little bears visibly taking a bath.
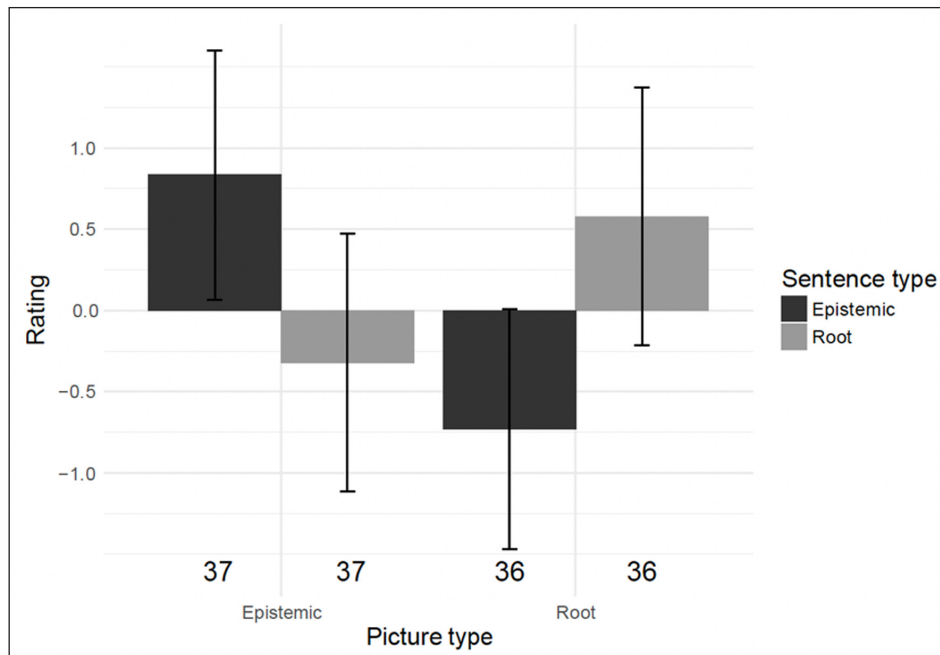
Figure 1: Sample results of average z-transformed ratings for sentences from the Hiding Story, with the predicate *kriti se* 'hide', plotted by picture type (Epistemic left, Root (Deontic) right) and sentence type (biclausal dark grey, monoclausal light grey). Number of judgements per sentence-picture pair is reported below plot.

We used the result plots for each story to make decisions and changes related to the story items. Most importantly, we completely omitted the two stories where the pictures did not show the required pattern of differences between ratings for sentence types (as in **Figure 1**), these were *(po)jedu,* 'eat' (12d) and *(po)kose,* 'mow', (12e). We also made small modifications to some pictures in an effort to strengthen the magnitude of difference for deontic or epistemic interpretations (n = 5/35 pictures; 2 context pictures, to remove possible biasing to the deontic follow-up; 2 deontic pictures to reinforce the obligation/imperative feeling; 1 epistemic picture). For example, for the Washing Story (12j), about washing up after dinner, the epistemic picture did not show a strong contrast, with a weaker preference for the biclausal sentence than desired. In an effort to increase the epistemic reading of the picture, we removed a few visible dirty dishes, as they likely constituted direct evidence for some speakers that the bears were washing them). The full list of stories used in the main study, following post-norming adjustments, and including filler stories, is available in the folder "BCS Experiment" at www.osf.io/v9ure/.

3.1.3 Main study procedure and materials

Participants were invited to play a picture preference game with a character, Penguin, presented on a laptop computer using MATLAB_R2014a with Psychtoolbox (Brainard 1997). Responses

were recorded using the left and right arrow keys. Penguin's pre-recorded speech has happy affect and natural prosody, spoken by a male actor who is a native speaker of BCS with experience in voice acting for children's TV.

Penguin is first shown holding a book (**Figure 2**). He lets participants know he will tell them stories. For the first two training items, involving identifying nominals referents, the book is turned so the pictures are presented at the same time as Penguin says the training sentences (**Figure 3**). In the next two training items, the prompt is heard before the inside of the book is turned to face the participant, and the sentences involve identifying events (more similar to test items). Participants are taught to point to the page that "Penguin was looking at" when the inside of the book was only visible to Penguin. During this phase, participants' wrong answers are corrected.

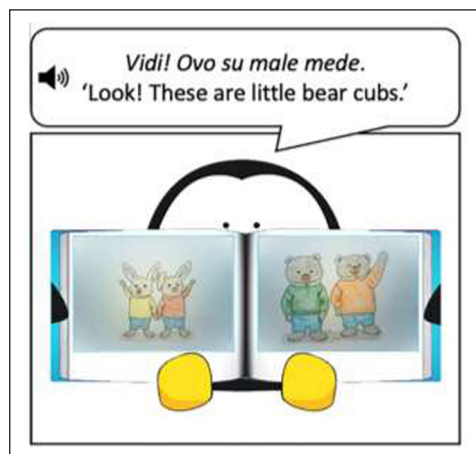**Figure 2:** Introduction: Penguin and his book.

Figure 3: Sample training item.

A sample experimental trial is provided in **Figure 4**. The experimental trials first display an initial picture (**Figure 4-A**), with Penguin's voice providing a short context. Then Penguin turns the book back to face himself, flips the page (an audible page turn noise plays), and says the target sentence, either MONOCLAUSAL or BICLAUSAL (**Figure 4-B**). The book is reoriented towards the participant, as Penguin says *Pogledaj*! 'Look!' and reveals the two pictures (**Figure 4-C**). The participant is prompted to point to which picture Penguin was looking at. One page of the book presents a picture compatible with a deontic interpretation (**Figure 4-C**, left page), the other a picture compatible with an epistemic interpretation (**Figure 4-C**, right page). After choosing the picture, the child participants were sometimes asked *Kako znaš?* 'How do you know?' to make the task more interactive and gain qualitative insights. Not all children responded, and for some that did, this yielded feedback like, *Ja sve znam!* 'I know everything!' or *Naučio me tata* 'Daddy taught me.' On following trials, those children were instead asked to say what Penguin said and/or what they saw in the picture that made them choose it.

For the sample item, if participants interpret the test sentence as deontic ('according to the household rules or normative behaviour') they will choose the picture in which the bears are covered in mud. This represents a future-oriented interpretation consistent with deontic *morati* (bathing has not yet occurred, but needs to), the target response for the monoclausal sentences. The alternative picture is not readily compatible with the deontic reading – there is evidence the bears are already in the bath. If the participant interprets the test sentence as epistemic ('according to what can be seen and what I know about bathing'), they will choose the picture in which the bathing bears are not directly visible, but all clues point towards the bears taking a bath. This illustrates a present-oriented interpretation, consistent with epistemic *morati*. The alternative picture is not readily compatible with the epistemic reading – bathing is not depicted.

3.1.4 Design

Each participant saw 4 training items, followed by 10 test items and 5 fillers, in random order (the first post-training item was always a filler). Fillers used the verbs *voljeti* 'love', *mrziti* 'hate' and *htjeti* 'want', which, unlike *morati*, are not meaning-variable. They were similar to test items in terms of syntactic complexity, but only required attending to depicted emotional states (happy vs. crying face). We used filler accuracy as an exclusion criterion, as a way to filter out participants who may not have been doing the task as intended.[13] Since chance performance would be 2.5, we set the limit to 4/5 as unambiguously above chance. Every participant saw the same 10 test stories. Which sentence type appeared with which story was randomized and balanced for each participant (5 monoclausal, 5 biclausal). Onscreen position of the test pictures was also counterbalanced (left vs. right).

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[13] Training also served this purpose, but the training items were very easy and we initially helped children with training items, so they could understand the task. The task is demanding on children's working memory and attention, so we opted to include a filtering metric using our filler items.
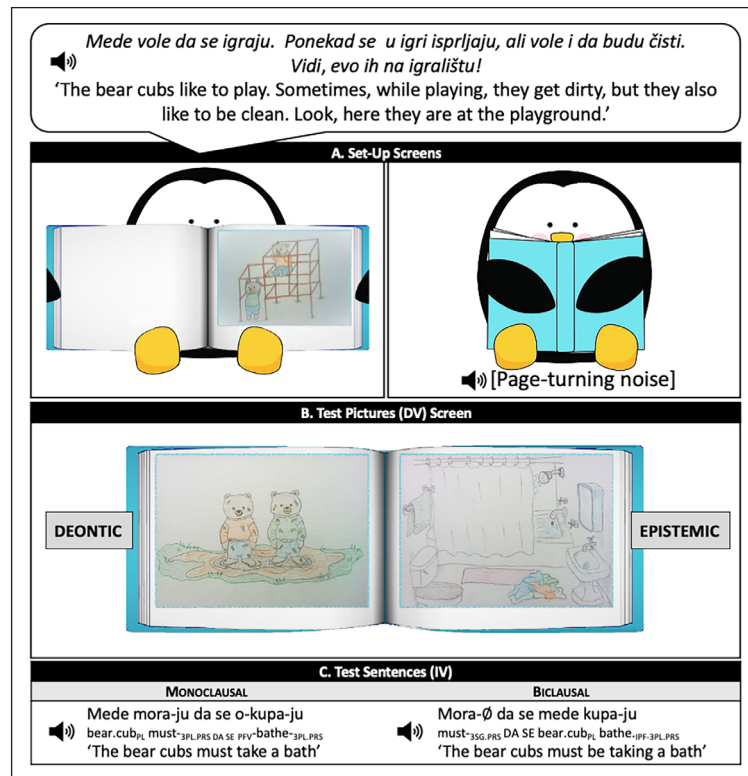
Figure 4: Sample trial with stimuli for set-up (A), test (B), and selection (C) presentations.

3.2 Results

3.2.1 Quantitative

All analyses were conducted with R (R Core Team 2013). Anonymized data and R scripts are available in the folder "BCS Experiment" at www.osf.io/v9ure/. Participants with filler accuracy at or below 3/5 correct were excluded from analysis. No adults or 6-year-olds were excluded, and only one 5-year-old was (leaving n = 14). Four 4-year-olds were excluded (leaving n = 11). Three-year-olds fared more poorly, with half of participants excluded (leaving n = 7), with only slight change to age distribution (M = 41 months, SD = 4.5 months). Impressionistically, the younger children in general were more likely to struggle with the task, with more of them acting confused (i.e. hesitating, looking for help responding), which is in line with these exclusion patterns.

Table 1 reports aggregate group means for epistemic picture choices, by sentence type. As expected, adults chose overwhelmingly epistemic pictures for biclausal sentences (no adult chose fewer than 4/5), and mostly deontic pictures for monoclausal sentences, differentiating interpretations by sentence type. However, for monoclausal sentences adults chose the unexpected epistemic picture an average of 1.67/5 times. For children, there is less difference

between average epistemic picture choice rates between sentence types. That said, 3-year-olds chose epistemic pictures on average 2.29/5 trials for monoclausal sentences, the closest to the adult rate, while six-year-olds were the least adult-like on these trials, averaging 3.5/5 epistemic picture choices, with some children at ceiling. For biclausal sentences, older child groups chose somewhat more epistemic pictures for biclausal sentences than younger groups.

	Monoclausal	**Biclausal**
3-year-olds	2.29 (1.11)	3.29 (0.49)
4-year-olds	3.09 (1.14)	2.64 (0.92)
5-year-olds	3.00 (1.11)	3.64 (0.84)
6-year-olds	3.50 (0.91)	3.58 (0.79)
adults	1.67 (1.00)	4.78 (0.44)

Table 1: Mean choice of epistemic pictures by age group and sentence type. Maximum = 5. Standard Deviation in parentheses.

We first assess the **INPUT FREQUENCY HYPOTHESIS** that children will select fewer epistemic pictures for *morati* sentences relative to adult controls and English-learning peers because, unlike *must, morati* is used primarily as deontic in the BCS input. We used the glmer function in the statistical package lme4 (Bates et al. 2014) in R (R Core Team 2013). The data were fitted into a generalized linear-mixed (logit) model using the maximum likelihood method (Laplace Approximation) (Baayen 2008; Dixon 2008; Matuschek et al. 2017). The model had selection of the epistemic picture as the reference for the dependent variable. We first compared children to adults for choice of epistemic pictures, including participant and item as random effects, giving the model: (EPISTEMIC ~ GROUP + (1|PARTICIPANT) +(1|ITEM)). We found no significant difference between groups in overall likelihood of epistemic picture selection (GroupChild, ß = –0.20, Z = –0.772, p = 0.44). We ran another model looking only at the child group, to test the effect of age in months (continuous) on choice of epistemic pictures (EPISTEMIC ~ AGEMOS + (1|PARTICIPANT) + (1|ITEM)). We found a significant positive effect of child's age on choice of epistemic pictures, such that the older the child the more likely they were to select epistemic pictures (AgeMos, ß = 0.027, Z = 3.334, p = 0.0009***). Percentages of epistemic picture choices by age group descriptively illustrate this effect: 3-year-olds: 51%; 4-year-olds: 54%; 5-year-olds: 65%; 6-year-olds: 72%), compared to the adult 64%. We can therefore reject the input frequency hypothesis, as BCS children do not show a significant preference for deontic picture selections relative to adults, and increasingly prefer to select epistemic pictures with age.

We fit further similar models to assess the SYNTACTIC BOOTSTRAPPING HYPOTHESIS that BCS children will be adult-like for structure-to-meaning mapping for *morati* earlier than English-learning peers because *morati* has categorical syntactic cues for flavour interpretation. We expect adults to pick significantly fewer epistemic pictures for MONOCLAUSAL constructions than for BICLAUSAL; if child groups distinguish interpretation by structure, they should show this same contrast. To test this hypothesis, we ran a model testing the likelihood of epistemic picture choice by sentence type (biclausal vs. monoclausal) and age group (with child groups binned by year), and their interactions. We included random slopes for participant by sentence and random effects for item, giving the model: (EPISTEMIC ~ SENTENCE * AGEGROUP + (1 + PARTICIPANT|SENTENCE) + (1|ITEM)). We set adults as the reference level. Adults show the expected highly significant effect of sentence type, with a significantly lower likelihood of epistemic picture selection for monoclausal sentences (Monoclausal, ß = –4.00, Z = –4.95, $p < 0.001$***). Compared to adults, all child groups were significantly less likely to pick epistemic pictures for the reference biclausal sentences (this effect weakens a little from ages 3 and 4 to ages 5 and 6, which is the adultlike direction for development) (**Table 2**). Child groups were all significantly more likely than adults to pick epistemic pictures for monoclausal sentences, showing significant interactions (**Table 2**). These overall effects show adults distinguish by sentence type, and child groups show both more unexpected epistemic picture selections for monoclausal sentences and fewer expected epistemic picture selections for biclausal sentences than adults.

	ß	Z	*p*-value
Monoclausal	–4.00	–4.95	<0.001***
3-year-olds	–2.79	–3.60	<0.001***
4-year-olds	–3.17	–4.11	<0.001***
5-year-olds	–2.25	–2.88	<0.004**
6-year-olds	–2.28	–2.88	<0.004**
Monoclausal:3yos	3.22	3.64	<0.001***
Monoclausal:4yos	4.21	4.79	<0.001***
Monoclausal:5yos	3.44	3.86	<0.001***
Monoclausal:6yos	4.13	4.51	<0.001***

Table 2: Model results for the generalized linear-mixed (logit) model using the maximum likelihood method (Laplace Approximation): EPISTEMIC ~ SENTENCE * AGEGROUP + (1 + PARTICIPANT|SENTENCE) + (1|ITEM). Biclausal sentences are the reference level for SENTENCE and Adults are the reference level for AGEGROUP.

However, this model does not show whether each child group differentiates picture selections by sentence type, as adults do. To see that effect, we re-leveled the same model for each age group, so that the main effect of sentence type would be reported for the reference level. Three-year-olds weakly significantly differ by sentence type, in the adult-like direction (Monoclausal, ß = –0.78, Z = –2.15, $p < 0.03$*).[14] No other child group significantly differs by sentence type. We thus find weak support for the syntactic bootstrapping hypothesis for 3-year-olds only (note English 3-year-olds had a significant overall deontic preference, and no child group differentiated by sentence type). While 3-year-olds show a distinction in the adult-like direction, their accuracy and the strength of the distinction is by no means adult-like: 3-year-olds also show significantly fewer epistemic picture selections for biclausal sentences than do adults and significantly more epistemic picture selections for monoclausal sentences than do adults.

We fit further similar models to assess the **Pragmatic Inference Hypothesis** that children will over-select epistemic pictures for MONOCLAUSAL constructions relative to adult controls, but in line with English-learning peers, because both *must* and *morati* invite the same inferences in their deontic uses. To assess this hypothesis, we limit the analysis to monoclausal sentences. Adults were set as the reference level for age group (EPISTEMIC ~ AGEGROUP + (1|PARTICIPANT) + (1|ITEM)). For Monoclausal sentences, all child groups except 3-year-olds differed from the adult baseline, showing the predicted increasing likelihood of epistemic responses with increasing strength of effect by age group (**Table 3**).

	ß	Z	*p*-value
3-year-olds	0.42	0.99	0.32
4-year-olds	1.01	2.40	0.02*
5-year-olds	1.19	2.78	<0.01**
6-year-olds	1.86	4.03	<0.001***

Table 3: Model results for the generalized linear-mixed (logit) model using the maximum likelihood method (Laplace Approximation) on the Monoclausal sentence data: EPISTEMIC ~ AGEGROUP + (1|PARTICIPANT) + (1|ITEM). Adults are the reference level for AGEGROUP.

Looking only within the child group, we looked at whether age in months (continuous) and type of sentence affected likelihood of epistemic picture selection over developmental time

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[14] Throughout we report nominal p-values (uncorrected for multiple comparisons). This effect is weak and becomes marginal if we correct at the count of three main hypotheses, using a Bonferroni Correction (p = 0.016). That said, we run more than 3 models with varying numbers of factors, so correcting for a higher number of comparisons would be warranted. Thus, this effect will require replication to be confirmed (to help rule out a Type I error – a "false positive") and should be taken as merely suggestive of this child population's possible knowledge rather than fact.

(EPISTEMIC $\sim$ AGEMOS + (1|PARTICIPANT)), first fitting only monocausal sentences and then only biclausal sentences. Children choose significantly more epistemic pictures as they age for both biclausal (AGEMOS, ß = 0.02, Z = 2.32, p = 0.02*)[15] and monoclausal sentences (AGEMOS, ß = 0.03, Z = 3.22, p = 0.001**) sentence types, with a more significant effect for monoclausal sentences.[16]

These results support the pragmatic inference hypothesis, as children choose increasingly more epistemic pictures, away from the adult rate for monoclausal sentences and towards the adult rate for biclausal (where adults are at ceiling for choosing epistemic pictures). This pattern is fully parallel to the English results.

To show individual data and developmental shifts by age groupings we used a series of scatterplots, with each age group represented in a separate panel, shown in **Figure 5** (as in Cournane & Pérez-Leroux 2020[17]). Each participant was plotted according to how many epistemic pictures they chose for biclausal sentences (x-axis, range = 0 – 5), and how many epistemic pictures they chose for monoclausal sentences (y-axis, range = 0 – 5). Participants were classified as 'epistemic avoidant' if they gave less than half of their total responses to both conditions as epistemic (Quadrant c), 'epistemic dominant' if they gave more than half epistemic responses overall (Quadrant b), 'target-oriented' if they chose the epistemic picture more often

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[15] This effect is weak, and significance would not survive multiple comparisons (see fn14).

[16] To further examine this effect for monoclausal sentences (whether they gain epistemic selections at a faster rate than biclausal sentences for children by age group), we looked again at the model testing the syntactic bootstrapping hypothesis ((EPISTEMIC $\sim$ SENTENCE * AGEGROUP + (1 + PARTICIPANT|SENTENCE) + (1|ITEM)), but setting 3-year-olds as the reference level and monoclausal as the sentence reference level. The effect of age is consistently positive for all older child groups, showing more epistemic selections for monoclausal (4YOS, ß = 0.62, Z = 1.72, p = 0.09; 5YOS, ß = 0.76, Z = 2.12, p = 0.03*; 6YOS, ß = 1.43, Z = 3.59, p < 0.001***) and the interaction between each child group and biclausal is always negative, indicating that the difference in epistemic selection rates by sentence type narrows (BICLAUSAL:4YOS, ß = –0.99, Z = –1.96, p = 0.05; BICLAUSAL:5YOS, ß = –0.22, Z = –0.42, p = 0.68; BICLAUSAL:6YOS, ß = –0.92, Z = –1.63, p < 0.10).

[17] For reference, here is the equivalent English results figure. Different from the BCS design, the axes both have Max = 8 items, and there was no 6-year-old group. Otherwise, this is like the BCS figure (the x-axis maps the sentences for which epistemic pictures were expected, and the y-axis the sentences for which epistemic pictures were not expected).
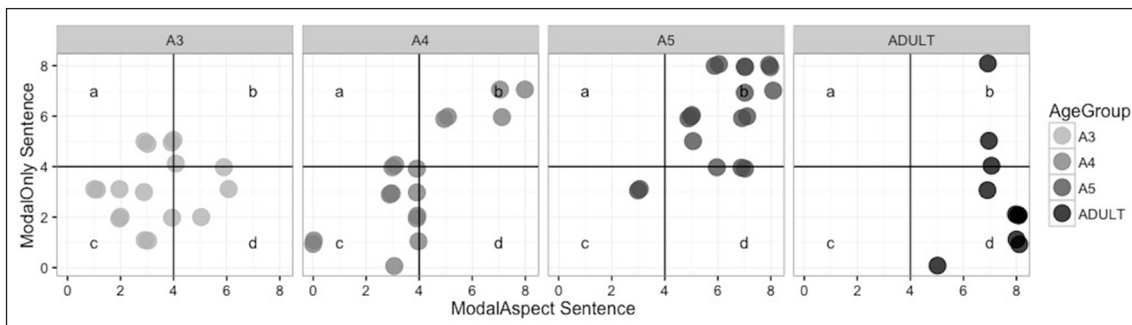
to the biclausal condition, than to the monoclausal condition (Quadrant d), and those who had the opposite pattern were labelled 'contrarian' (Quadrant a).

Most adults appear in the target-oriented quadrant d. They were at ceiling for biclausal sentences, but ranged in their selections of epistemic pictures for the monoclausal sentences (range = 0 – 3). Overall, children move from being off-centre in the adultlike direction along the x-axis at age 3, to preferring epistemic pictures for both sentence types at age 6. Among all children, only 1 fell into quadrant c ('epistemic avoidant'), and only 5 fell into quadrant a ('contrarian'). The youngest children fall primarily in the target-oriented (d) and epistemic-dominant (b) quadrants. Four-year-olds show mixed patterns (as in prior studies: Fond 2003; Heizmann 2006; Cournane & Pérez-Leroux 2020). By 5, most children fall into the epistemic dominant quadrant, and by 6-years-old, almost all do. The 6-year-olds are the only group with no overlap with adults.
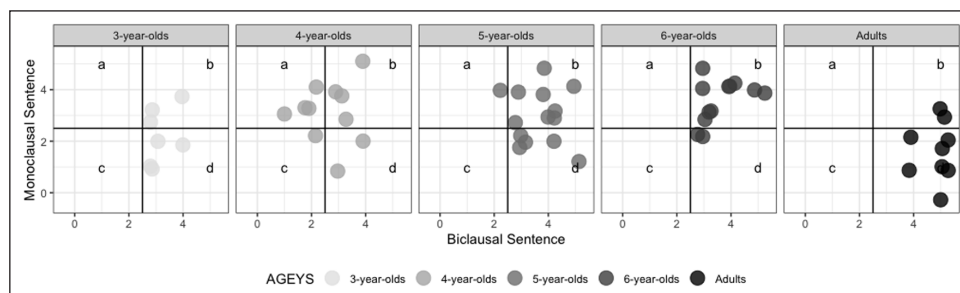

Figure 5: Individuals plotted by number of epistemic picture selections for BICLAUSAL (x-axis) and MONOCLAUSAL (y-axis) sentences, faceted by age group.

3.2.2 Qualitative Results

Children sometimes gave informative responses to our prompts for why they chose the pictures they did for individual trials. These results are intended to supplement and provide insights into our quantitative measures, bearing in mind that responses were inconsistent, with some children offering several informative responses and others none, variably over age groups.[18] Of the post-exclusion children: 2/7 of the 3-year-olds gave informative elaborations, 11/11 of the 4-year-olds, 13/14 of the 5-year-olds, and 9/12 of the 6-year-olds. What follows references these children only.

First, we got evidence that the children understood our pictures as intended. Many children, in various contexts, pointed to the source of necessity when explaining their choice of deontic pictures. For example, when asked what they see in the picture they chose after Penguin said

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[18] A task variation to consider would be having children listen to the sentences via headphones. This would make the experimenter's follow-up questions pragmatically more natural, and perhaps yield more consistent feedback.

Mede moraju da se okupaju 'The bear cubs must take a bath', one 3-year-old (3;09) said *Vidim kako su se isprljali* 'I see how/that they got dirty'. When Penguin said *Mede moraju da samelju orahe* 'The bear cubs must grind walnuts',[19] one 4-year-old (4;11) chose the deontic picture and responded by saying *Da im je mama donijela orahe. Moraju se orasi otvorit.* 'That Mama brought them walnuts. The walnuts must be opened' (impersonal, monoclausal, with embedded infinitive).

For epistemic pictures, most 6-year-olds pointed to indirect evidence as support for choosing epistemic pictures, for both biclausal (13) and monoclausal (14) sentences, even when they accurately repeated monoclausal sentences (15). Some described the pictures in a way compatible with having direct evidence (14), where the child says they see the bears bathing (**Figure 4**, Epistemic). In (13)–(15), children first respond to *Kako znaš?* 'How do you know?'.

(13) Child: Tako što ide voda i unutra su. i vidim odjeću.
thus that goes water and inside be.3PL. and see.1SG clothes
'Because the water is running and they're inside. And I see clothes.' (S56, 6;07)

(14) Child: Jer je Pingvin rekao mede se moraju okupat.
because is penguin said bear.cubs SE must.3PL.PRS bathe.INF
'Because Penguin said the bear cubs must take a bath.'

Exp.: I šta ti tu vidiš?
and what you there see.2SG.PRS
'And what do you see there?'

Child: Da se mede kupaju.
DA SE bear.cubs bathe.3PL.PRS
'That the bear cubs are taking a bath.' (S19, 6;07)

(15) Child: Tako što je torta u pećnici.
thus that is cake in oven
'Because the cake is in the oven.'

Exp.: A šta je rekao Pingvin?
and what is said penguin
'And what did Penguin say?'

Child: Reko je mede moraju da naprave tortu.
said is bear.cubs must.3PL.PRS DA make.3PL.PRS cake
'He said the bear cubs must make a cake.' (S56, 6;07)

Children sometimes recast biclausal test sentences as monoclausal in their follow-ups. We saw 6 instances of this by four different 4-year-olds. And one of the 3-year-olds also recast biclausal

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[19] Grinding walnuts is a common activity for Bosnian children, who help in dessert-making.

sentences as monoclausal a couple times, as in (16). This type of recasting was less common among older children – 0/13 of the 5-year-olds did this, and 2/9 of the 6-year-olds. Children did this in follow-ups both when they had selected the target epistemic picture and the non-target deontic picture, though the latter was less common and not true of the 6-year-olds.

(16) Exp.: Kaže   Pingvin: 'Mora   da   mede   prave   snješka.'
             says   penguin must.3SG.PRS DA   bear.cubs make.IPF.3SG.PRS snowman.
             Koja   je   to   slika?
             which is   that picture
             'Penguin says: "The bear cubs must be making a snowman." Which picture is that?'

      Child: Pingvin je   reko da   moraju   pravit   snješka.
             penguin is   said DA   must.3PL.PRS   make.INF snowman
             'Penguin said they must make a snowman.'   (3;06)

Older children sometimes recast biclausal sentences as non-modal (17). Among the 6-year-olds, 4/9 recast biclausal sentences as non-modal, including both who also recast them as monoclausal on different trials. Two of the 5-year-olds, and one of the 4-year-olds also recast biclausal sentences as non-modal. Neither 3-year-old did this. The 4-year-old recast two monoclausal sentences as non-modal as well, after choosing the epistemic picture for both.

(17) Peng.: Mora   da   se   mede   kupaju.
             must.3SG DA   SE   bear.cubs bathe.IPFV.3PL.PRS
             'The bear cubs must be taking a bath.'

      Exp.: Koju   je   sliku   vidio Pingvin? (…) Kako znaš?
             which is   picture saw   penguin   (…) how   know.2SG.PRS
             'Which picture did Penguin see? … How do you know?'

      Child: Zato što je   reko da   se   mede   kupaju.
             because   is   said DA   SE   bear.cubs bathe.IPFV.3PL.PRS
             'Because he said that the bear cubs are taking a bath.'   (6;03)

Summarizing our results, younger children chose fewer epistemic pictures than older children, and 3-year-olds are more adult-like than older children when hearing monoclausal sentences, showing weak discrimination by sentence type. Younger children sometimes recast biclausal sentences as monoclausal, but unlike the older child groups they rarely recast either biclausal or monoclausal sentences as non-modal. Older children chose mostly epistemic pictures when hearing both biclausal and monoclausal sentences, showing particularly non-adult patterns for picture selections for monoclausal sentences. When asked why they chose the epistemic picture, they refer to indirect evidence in the scene, and sometimes claim they see things not depicted in

epistemic pictures, by inferring from indirect evidence of an event to the event itself. When asked what they heard, they rarely recast biclausal sentences as monoclausal, but sometimes recast both biclausal and monoclausal sentences as their non-modal counterparts. Recasting results patterns are summarized in **Table 4**.

Recast Type	3-year-olds n = 2	4-year-olds n = 11	5-year-olds n = 13	6-year-olds n = 9
BiCl > MonoCl	1	4	0	2
Modal > Non-Modal	0	1	2	4

Table 4: Counts of individuals by age group (with number of individuals who contributed) and type of sentence recasting produced (sentence heard > sentence produced).

4 Discussion

This study has explored how preschool children learn and navigate interpretations of flavour-variable modal verbs. In particular, we have tested what factors influence child modal verb interpretation as deontic or epistemic: input biases towards one flavour, syntactic constraints on flavour, and pragmatic inferences in young children. We explored these questions using a picture preference task with BCS *morati* 'must' sentences with preschool children and adults. This BCS study builds on prior work using the same task with English *must* with similar age groups. BCS *morati* and English *must* are both flavour-variable necessity modals, but syntactic distributions by flavour and input flavour biases differ between the two languages. As such, BCS helps us better understand relative influences on modal flavour development, for BCS itself and more broadly in comparison to prior results for English (Cournane & Pérez-Leroux 2020).

First, our results allow us to reject the INPUT FREQUENCY HYPOTHESIS, that BCS children will undergenerate epistemic interpretations of *morati* relative to adult controls and English-learning peers because, unlike *must, morati* is used primarily as deontic (and other root sub-flavours) in their input. At no age in our 3-to-6-year-old sample do children prefer deontic interpretations over epistemic for *morati,* and children show an increasing likelihood to select epistemic pictures as they age. The failure of the input frequency hypothesis to explain non-adult child biases is underlined by the comparison of BCS and English results (Cournane & Pérez-Leroux 2020): English children hear *must* primarily with epistemic uses in their input, but there was a significant overall deontic preference in the English 3-year-old group. The older children in both our BCS study and in the English study showed a preference for epistemic pictures, especially notable for sentence types for which adults prefer deontic pictures (monoclausal in BCS, *must* + bare verb in English). For English, the older children's epistemic bias was possibly explained by input

frequency bias, as they may gain increased awareness that *must* is used primarily as epistemic in their speech community (Tagliamonte & D'Arcy 2007). For BCS, this explanation for the non-adult epistemic bias found in older preschool children does not hold, casting doubt on this explanation for English.

Second, we found weak support in the youngest child group for the SYNTACTIC BOOTSTRAPPING HYPOTHESIS, that children will be adult-like for structure-to-meaning mapping for *morati*: they will choose fewer epistemic pictures for MONOCLAUSAL constructions than for BICLAUSAL, because, unlike *must*, *morati* has categorical syntactic cues for flavour interpretation. Our 3-year-old group, though small after exclusions, showed discrimination by sentence type in the adult-like direction. The 4-, 5- and 6-year-old children showed no discrimination by sentence type. In the English study, no child group showed any distinction by sentence type (unlike adults). Thus, with respect to syntactic bootstrapping we see noteworthy differences among the youngest children: BCS 3-year-olds show some sensitivity to syntax, English 3-year-olds do not (deontic bias). Our effect with 3-year-olds is small and further work should aim to replicate or corroborate.

Finally, we find support in the older child groups for the PRAGMATIC INFERENCE HYPOTHESIS, that children will over-select epistemic pictures for MONOCLAUSAL constructions relative to adult controls. Our 5- and 6-year-old groups chose somewhat more epistemic pictures for biclausal sentences than younger children, thus becoming more adult-like. But, at the same time, older children also chose more epistemic pictures for monoclausal sentences than younger children, becoming less adult-like, and this growth appears to be at a somewhat faster and more significant rate. Given the results for the syntactic bootstrapping hypothesis, that greater change for epistemic selections for monoclausal sentences is expected – as children show some distinction by sentence type at age 3 (fewer epistemic selections for monoclausal sentence), then the trajectory to becoming epistemic-dominant regardless of sentence type involves a greater rate of change towards epistemic selections for the monoclausal sentences. To become adult-like, after age 6 we expect children to gradually fall less for the inference and show distinction by sentence-type.

Considering the qualitative results, older children often pointed to the indirect evidence in the pictures (e.g. clothes on the ground by the bathtub) to support their picture choices, including for when the sentence stimuli was monoclausal. And, older children sometimes recast both sentence types as non-modal equivalents.[20] This may relate to the felicity of both in inferential situations:

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[20] This begs the question, are the inferences we characterize as epistemic (likelihood) actually actuality inferences (*you are obliged, so you do*) (see Veselinović 2019: 211–212)? We set-out to test the epistemic proposal, and think the epistemic proposal is more in line with our modal story contexts (non-actuality), but this merits future consideration. Children prefer not to mark indirect evidence with *must* compared to adults (Cournane & Pérez-Leroux 2020, Experiment 2), so recasting as non-modal is consistent with prior studies. This problem – disentangling *must p* from *p* – is heavily debated (e.g. von Fintel & Gillies 2010; Lassiter 2016).

when one infers *It must be raining* on the basis of indirect evidence, one can mark that inference with *must*, or just say *It is raining* (assuming clear evidence) (von Fintel & Gillies 2010).

Most notably, the BCS results suggest that falling for pragmatic likelihood inferences is the most generalizable explanation for the older preschooler (age 5 and 6) epistemic picture-selection bias, observed previously in English. We see the same pattern in both languages: older preschoolers are more adult-like than younger children for the sentence-type that keys epistemic interpretations (English: *must* + aspect-marking, BCS: biclausal), but over-select epistemic pictures compared to adults and younger children for the sentence type that keys deontic interpretations (English: *must* + bare verb, BCS: monoclausal). This similarity obtains despite syntactic and input differences for *must* and *morati*. Unlike in English, where input biases, syntactic ambiguity, and pragmatic inferences all could contribute to increased epistemic picture selection, BCS allows us to tease these factors apart. We find the pragmatic story satisfying for the prior English results, as English-learning children command both flavours for modal verbs in production by age 3 for most children, much earlier than we find the epistemic bias (age 5 and 6).

How does this inferencing work in our task? An obligation normatively implies that the obligatory action is realized. This inference, that an event which is "necessarily obliged to happen in the future is also obliged to happen in the present" (Invited Inference: Traugott & Dasher 2001: 130), is available to adults speaking both English and BCS. Our epistemic pictures do not directly show the modal prejacent φ (i.e. *The bears take a bath*) occurring in the present, but they do show strong indirect evidence for φ. Indirect evidence scenarios nonetheless communicate that φ is true (von Fintel & Gillies 2010, i.a.; see also Lassiter 2016; Mandelkern 2019 for further discussion about how and why these scenarios support both epistemic *must* φ and plain φ). Thus, from the deontic 'X *must* φ', the reasoning path to our epistemic pictures is available, even if the modality in 'X *must* φ' is unambiguously interpreted as only deontic (as in our BCS monoclausal sentences). This work teaches us more about how pragmatic meanings associated with modals play out in development, adding to existing knowledge about modal pragmatics (i.e. scalar implicatures, Noveck 2001, i.a.; speaker meanings, Hacquard & Lidz 2016, i.a.).

Cournane & Pérez-Leroux (2020) argued that their results for the older child group may mask preschoolers learning from the syntax, as English shows modal auxiliaries overtly above grammatical aspect in the surface order (*must* > progressive/perfect marking), potentially feeding a bias for the higher (epistemic) interpretation of *must* (as in (4b,c)): Learning that *must* is higher than aspect may carry over to sentences where the syntax provides no overt cue (as with 4a).[21,22] Our BCS results for 3-year-olds lend some weight to this idea. BCS children

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[21] They further argue that this alignment may contribute to ongoing incrementation (Labov 2001) of epistemic uses over the more conservative root uses of modal auxiliaries, as part of the unidirectional language change of the modal cycle (Traugott 1989; Bybee et al. 1994).

[22] Cournane & Pérez-Leroux (2020) also ran control experiments on the same population (with distinct subjects), notably a deontic control to ensure that older children hadn't simply reanalysed *must* as lexically epistemic-only. They

were more adult-like at 3 than in the older groups. By age 5, and more so by age 6, children prefer epistemic pictures for both sentence types. We suggest that a plausible explanation for this change is that children never lose the sensitivity to distributional differences for *morati*, but that pragmatic changes gradually mask their adult-like, deontic, interpretations for monoclausal *morati* sentences. This continuity for deontic interpretations is in line with the corpus evidence that shows root modal verb uses occur from age 2 (in BCS, Veselinović & Cournane 2020; cross-linguistically, see Papafragou 1998; Hickmann & Bassano 2016).

We suggest that in both languages, the pragmatic layer obscures adult-like syntactic comprehension, as children overcommit (relative to adults) to the inference of the type *If they must p, they likely do p*. What causes this pragmatic change? One possibility is development in child understanding of normative behaviours (as outlined in §2.4). These social-conceptual changes develop in parallel to language and show some differences in facets of normative reasoning between younger and older preschoolers.[23] This inference-based explanation for our results makes it unsurprising that adults also sometimes chose epistemic pictures for monoclausal sentences, despite these not having epistemic interpretations in BCS (on acceptability tasks, Veselinović 2019). The child inferences are consistent with adult inferences in type, what differs is that children seem to either generate these inferences more than adults (deontic obligations generate likelihood inferences more for children than adults), or fall for them more easily than adults (deontic obligations generate likelihood inferences similarly for children and adults, but children are more likely to assume these inferences aren't cancellable).

If the above is true, why are the 3-year-old groups different in English and BCS? We suggest that English-learning children may take a little longer to appreciate the temporal-aspectual cues to modal verb flavour interpretation in comprehension than BCS-learning children. While BCS and English modal verbs are similarly flavour-variable, they differ in their syntactic types and the informativity of their complements for giving away modal flavor for input usage. The explicit, categorical, cues from syntax available to BCS children – agreement marking on the modal itself, structural word-order differences, verbal aspect class differences – may help them bootstrap into the syntactically-constrained interpretation differences for *morati* in comprehension. The syntactic signatures of root versus epistemic uses of *morati* are similar to those differentiating desire versus

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used a sentence preference task with sentences differing only in the presence of *must* (e.g. *The boys must wash their hands with soap* vs. *The boys wash their hands with soap*). Participants had to pick sentences for Actual (e.g. two boys washing their hands) or Deontic (e.g. two boys with muddy hands) images. All age groups significantly preferred *must*-sentences with deontic pictures, suggesting that 5-year-olds had not reanalyzed *must* as epistemic only.

[23] Another possibility is that children initially erroneously think *must* and *morati* are possibility modals (see Dieuleveut et al. 2022). If they learn that they are in fact necessity modals sometime around age 4, this may contribute to an appreciation of the increased likelihood of the prejacent. This would be akin to thinking deontic *morati* means 'permitted', then working out it actually means 'obliged'. In other words, 3-year-olds may also be inclined to overcommit to the implicature from an obligation, but unlike older kids they don't treat *morati* as meaning obligation, just permission. This may explain children's change from the 3-year-old pattern to the 5/6-year-old pattern.

belief attitude verbs (i.e. *want* vs. *think*) (Progovac 1993 for BCS), which have also been shown to help young children differentiate these modal meanings (Hacquard & Lidz 2016; Harrigan et al. 2016). In English, working out modal flavour from syntactic distribution may be more difficult as modal auxiliary verbs are invariant in form, occur in the same position regardless of flavour, and are usually followed by a bare verb. van Dooren et al. (2017; 2019) assessed English and Dutch input for whether, in principle, the tense and aspect semantics (Condoravdi 2002) in the clause could give away a modal verb's intended meaning, since root modals tend to be restricted to future-orientation (Werner 2006; Klecha 2016; Rullmann & Matthewson, 2018).

If BCS children have more robust cues to modal verb flavour, why then does the BCS corpus show no child epistemic uses of modal verbs before age 4 while English corpora do? There are a few viable reasons for this. One possibility is sampling. Epistemic uses of *morati* 'must' and *moći* 'can' are proportionally rarer in the input than for English modal verbs like *must* or *have to* (Veselinović & Cournane, 2020), suggesting that they are rarer in BCS speech in general (note, speakers have other grammatical means of expressing epistemic modality in both languages). Young children use fewer modals overall than adults (as seen in corpus studies), so the likelihood of sampling a child epistemic use of *morati* or *moći* in BCS may simply be exceedingly low (unlike English). Alternatively, the lack of epistemic *morati* or *moći* in the child corpus study may be due to production-specific demands. Considering the qualitative results here, younger children sometimes recast biclausal stimuli as monoclausal. Perhaps these young children have particular difficulty planning or producing these constructions. This may be linked to the broad observation that comprehension often precedes production, and to cross-linguistic patterns of increased productive ability with biclausal structures after age 4 (see de Villiers & Roeper 2016). Whatever the cause, the BCS 3-year-old results merit further exploration in future work, as prior work on modal verbs in corpus studies of children 3-years-old and younger (§2.2), and other experimental work on modal flavour comprehension looking at 3-year-olds all show root biases (§2.3).

We used filler accuracy as an exclusion criterion, which led to the exclusion of primarily younger participants, most notably half the 3-year-old group. This was not particularly surprising to us, as 3-year-olds are a difficult group to work with for explicit behavioural tasks like ours – the task is demanding for attention and working memory. We selected our fillers as predicates which were invariant in meaning (unlike modal verb *morati*) but syntactically similar, landing on the following verbs: *voljeti* 'love', *mrziti* 'hate' and *htjeti* 'want'. These are predicates of personal taste and desire, and their syntax is similar to the deontic construction for *morati* (1a). To succeed on these items the participant only had to attend to the emotional state of the bears in the picture. We acknowledge that it's possible that there is a confound here: the 3-year-olds excluded may have been precisely those who have difficulty comprehending complex clause constructions (A.S. White, pc). It would be more telling if the filler verbs patterned with the epistemic construction for *morati*, as that kind of biclausal construction is also rare in the input (for modals, not necessarily

for verbs in general) and children's speech (in general, with a complete absence for modal verbs) for 3-year-olds (Veselinović & Cournane 2020). However, even the root modal construction, like the *voljeti* 'love', *mrziti* 'hate' and *htjeti* 'want' constructions (e.g. *Mede vole da jedu čorbu* 'The bears want to eat stew'), involve a kind of sentential embedding (not of a CP, like in BCS epistemic constructions). Our exclusion may have thus filtered out those children who have general difficulty comprehending sentential embedding (TP or larger) as yet, rather than simply those who had difficulty with the task (e.g. attention or interpreting our images). This possibility further underscores the merit of future work on BCS-learning 3-year-olds (or children of other languages with similar modal verb patterns).

The 4-year-olds in our study show no discernable pattern: except perhaps that none of them are deontic-biased, many appear at chance and no effects pertaining specifically to this group are significant. This is consistent with prior studies looking at this age group in Spanish (Fond 2003); English and German (Heizmann 2006) and English (Cournane & Pérez-Leroux 2020). Our best guess is they are heterogenous for the phenomenon (some are like 3-year-olds, some like 5-year olds; note that in English, this pattern is more discernable, Figure in fn.17), and on top of that they are also, like the 3-year-olds, not yet very good at the task, so there is general inaccuracy in both directions.

Finally, the English work by Cournane & Pérez-Leroux (2020) and our PRAGMATIC INFERENCE HYPOTHESIS to explain both the English and BCS results, are both inspired from language change theory. Modal verbs are known to change from root flavours to epistemic in diachrony, as discussed in §2.4. To explain this repeated, unidirectional, modal change, Traugott and Dasher (2002)'s Invited Inferencing Theory of Semantic Change, argues that conventionalization of implicature (pragmatic inference becoming conventionalized, or semantically encoded) is a driving force which creates new meaning representations for modal verbs (for a similar idea with indefinites, see Aguilar-Guevara et al. 2010). This model aims to explain why and how root modals have gained additional epistemic meanings in diachrony.

Proponents of this approach argue that this Conventionalization of Implicature is enacted by adults (Traugott & Dasher 2002: 34). Children are not considered pragmatically sophisticated enough to be innovators (Traugott & Dasher 2002: 41), rather innovations are linked to "communicative-expressive need" (Nerlich & Clarke 1992: 127) and come from online adult usage via creative coinages.[24] However, our results and those from Cournane & Pérez-Leroux (2020) suggest that from age 5 children may be especially prone to generating or overcommitting to these inferences, though adults seem to do so too, to a lesser extent. An important way that children differ from adult native speakers is that children are still in the process of working out

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[24] Children also face communicative-expressive pressures, arguably greater pressure than adults, given their more limited grammars, other cognitive resources, and productive-communicative repertoires.

and refining the semantic representations for their input language modals. For modal words, semantic and pragmatic meaning are intertwined in the input situations in a way that may make learning what is semantically encoded, as opposed to only implied, especially challenging. In light of this, the semantic encoding process may well be imperfect, with implied meanings sometimes grammatically encoded as truth-conditional (contra the input grammar) as part of the normal learning process of abducting word meanings from usage in contexts.

Our child results are in line with theories of language change which argue that children learning their first language(s) are an intuitive place to look for the driving forces of regular language changes, since children must build their grammars on the basis of indirect evidence from their input (e.g. Lightfoot 1979, 1999; Roberts & Roussou 2003; van Gelderen 2004; Cournane 2017). Of note, Cournane (2017) argues that input-divergent representations that occur after age 4 are the best candidates for actually catching on as changes in a language, as this is when children begin to care more about how their peers talk (Labov 2001, i.a.) and may reinforce each other's input divergent grammars. Moreover, as discussed in §2.4, older preschool children may be especially prone to "falling for" the inference from obligation to likelihood due to differences in how these children reason about rules and normative behaviours, compared to younger preschool children and adults: older preschool children appear to be more categorical and deterministic than adults when it comes to reasoning associated with deontic modality. Our analysis is also consistent with this conceptual developmental pattern.

BCS and English child data on extant flavour-variable modals give only proof of concept – this inference occurs online, and more so in 5- and 6-year-old children than adults. What matters for the child-driven change approach is that children differ from adults in the direction of known patterns of change for grammatical elements of the relevant type. BCS, however, does not show us clear evidence for change as *morati* already has both modal interpretations (and as long as morphological cues remain clear the situation is probably quite stable). Further studies should look for this likelihood inference with modal verbs with only root meanings (i.e. root attitude verbs, see Lightfoot 1979; Traugott 2006; Hacquard 2013), to see if children show the same pattern.

5 Conclusion

Learning to interpret and use flavour-variable modal verbs like *morati* 'must' presents children with a challenging mapping task: they must assign more than one non-actual meaning to the same word. How do children learn and navigate modal flavour for these modal verbs in their input languages? How does modal verb interpretation develop over the preschool years? And, what factors most influence children's modal verb interpretations as deontic vs. epistemic? The BCS study we presented has helped address these questions, and adds to results known from the same task in English (Cournane & Pérez-Leroux 2020). While both languages have flavour-variable

necessity modals, *must* is primarily epistemic in the input, while *morati* is primarily deontic, and English morphosyntax only partially constrains interpretation, while BCS provides unambiguous morphosyntactic cues to both modal flavours. Our results showed that the youngest BCS children (age 3) were the most adult-like for distinguishing between modal interpretations by syntactic constructions, suggesting BCS's clear syntactic cues to modal flavour are helpful for early child comprehension. Older child groups in our BCS study showed a strong epistemic bias, including for *morati* sentences which are deontic for adults. The result for older children was the same as for the English study with *must*, despite differences in input-frequency and structural cues correlated with flavour (deontic vs. epistemic).

We have argued that pragmatic inferences from deontic to epistemic interpretations – *if they must p, they likely p* – play an essential role in children's behaviour in modal verb interpretation in the older preschool years. While these children understand deontic modal sentences, they infer that obligations hold and can select epistemic depictions to illustrate deontic sentences. The existence of this inference from deontic to epistemic was first proposed as an explanation for the commonly observed historical change in the meaning of modal verbs. Our results provide proof of concept that this mechanism for semantic change could be driven primarily by older preschool children.

Data accessibility statement

The full list of stimuli (test items and fillers) in BCS with English translations, anonymized data spreadsheets, and R scripts are available in the folder "BCS Experiment" at www.osf.io/v9ure/.

Abbreviations

BCS: Bosnian/Croatian/Serbian

NOM: nominative

PRS: present

IPF: imperfective

INF: infinitive

PFV: perfective

PL: plural singular

SG: singular

SUBJ: subject

Ethics and consent

All consenting and assenting processes adhered to university IRB protocol (NYU IRB-FY2017-594), and local daycare administrative approval in Sarajevo, Bosnia & Herzegovina.

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Competing interests

The authors have no competing interests to declare.

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