A hybrid model of auxiliary contraction: evidence in children's speech

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Abstract

The present study finds parallel patterns of auxiliary contraction in a corpus study of children's speech and an earlier corpus study of adults' speech (Bresnan 2021). The combination of probabilistic and near-categorical patterns is accounted for by the hybrid model of auxiliary contraction of Bresnan (2021). These findings show that children's language, like that of adults, depends on both the usage probabilities of multiword sequences and their prosodic and rhythmic patterns reflecting the syntactic context.

The hybrid formal and usage-based model of auxiliary contraction of Bresnan (2021) combines the formal grammar of LFG including lexical sharing, and a dynamic, exemplar-based lexicon.[†] It accounts for contraction phenomena unexplained by either of the component theories alone: (1) the usage-based lexicalization of contractions, (2) the probability of cooccurrence of word and auxiliary predicting the probability of their contraction, (3) the prosodic wordhood of contractions, and (4) the rightward metrical dependence of unstressed auxiliaries in weak positions. The present study finds similar patterns of auxiliary contraction in a corpus study of children's speech, showing that children's language, like that of adults, depends on both the usage probabilities of multiword sequences and their prosodic and rhythmic patterns reflecting the syntactic context.

Section 1 briefly sketches the hybrid model and Section 2 exemplifies the probabilistic and near-categorical patterns in adult speech that follow from the model, summarizing highlights of Bresnan (2021). The new contribution of the present study, Section 3, presents evidence from a corpus study showing that similar patterns occur in children's speech.

1 The hybrid model

To grasp the hybrid model of auxiliary contraction quickly from the point of view of an LFG grammarian, take a standard LFG grammar, add lexical sharing and connect it to prosodic and metrical structures; then swap out the LFG lexicon for an exemplar-based lexicon, and visualize the resulting LFG lexical schemata as labeling clouds of lexical exemplars. These steps, described in more detail in Bresnan (2021), are briefly illustrated here as background.

In the lexical sharing theory of auxiliary contraction illustrated in Figure 1, adjacent terminal category nodes D, I are mapped to the same lexical exponent *you're*.[1] Unlike the dominance relations in c-structure trees, which are indicated by straight lines connecting nodes, the mapping from terminal syntactic

[†]I thank Ida Toivonen and an anonymous reviewer for suggested revisions. For the analyses and graphics I used R (R Core Team 2020) with contributed packages lme4 (Bates et al. 2015), lattice (Sarkar 2008), and rms (Harrell Jr 2021). This open-source software can be downloaded at no cost from https://cran.r-project.org/.

[1]Here the category labels D, I and C are used for convenience and explicitness, in order

categories to lexical exponents is many-to-one and is indicated by the arrows pointing from the terminal c-structure categories (D, I, V, and the like) to the lexical exponents *you're* and *going* in Figure 1. The adjacent nodes D and I in Figure 1 are pointing to the same exponent *you're*, and are said to "share" it. For formal details of the instantiation of lexical schemata of the atomic units *you* and *'re* as D and I and of the joint constraints on the entire contraction *you're*, see Wescoat (2005).

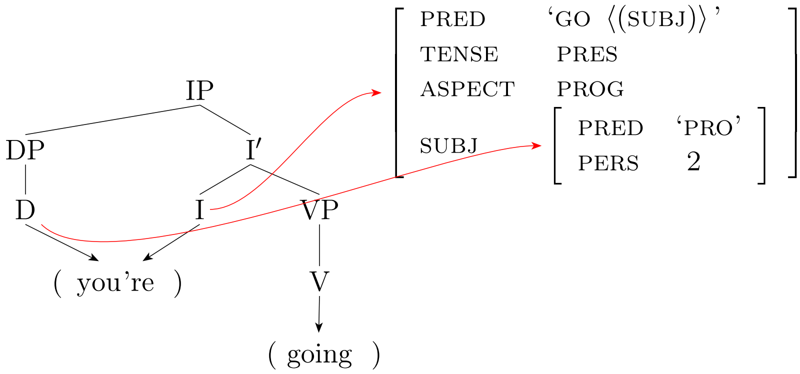

Figure 1: Lexical sharing

To Wescoat's 2005 formal theory of English auxiliary contraction, Bresnan (2021) adds prosodic and metrical connections. First, lexical sharing implies prosodic wordhood of the lexical exponent as illustrated in Figure 2, because all lexical words are prosodic words (Inkelas 1991, Inkelas and Zec 1993, Selkirk 1996).[2]

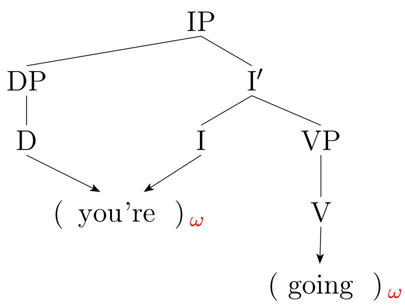

Figure 2: Lexical sharing implies prosodic wordhood

Second, in the lexical sharing analysis the contracted and uncontracted forms of the auxiliary *are, 're* have the same c-structure position. See Figure 3.

to represent respectively pronouns and the uninverted and inverted positions of the tensed auxiliaries. The specific choices and granularity of the c-structure category labels are not crucial to the model (Bresnan 2021, n. 25, p. 123).

[2]See Bresnan (2021, n. 27, p. 125) on apparent exceptions.

For unstressed auxiliaries the I in Figure 3 (and likewise C) is a metrically weak position requiring a strong—that is, stressed—complement (Bresnan 2021, pp. 117–119, 125).

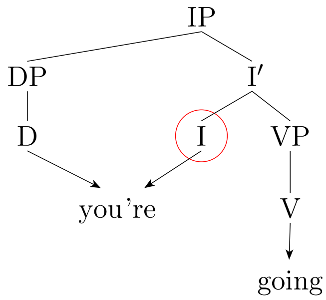

Figure 3: Contracted *'re* has the same c-structure position as uncontracted *are*, a metrically weak position for unstressed auxiliaries.

Arguing against affixed-word analyses of contraction and in favor of simple cliticization, Wescoat (2005) motivates the syntactic position of the auxiliary in Figure 3 with evidence from coordination, where parallel I′ nodes can be conjoined despite the head of the first being lexically shared with the subject (1a,b), and where subject-auxiliary contractions cannot be conjoined, because they are nonconstituent D I sequences (1c).[3]

(1) a. ***I***[***'m*** *looking forward to seeing you*] *and* [*will be there on Sunday*]

b. ***You***[***'ll*** *do what I say*] *or* [*will suffer the consequences*]

c. *[***They're*** *and* ***you're***] *going.*

An alternative analysis of (1)a,b that does not involve I′ coordination is left peripheral ellipsis of the rightward subject of conjoined IPs (Bresnan and Thráinsson 1990):

(2) [***You'll*** *do what I say*] *or* [*(**you**) will suffer the consequences*]

However, this alternative is inapplicable to cases like (3a), where the operator *who* has scope over coordinated complement I′ (or C′). Here a left-peripheral source is not semantically equivalent to (3a). The question in (3a) is about the ones that will both forget and suffer the consequences, while in (3b), the ones that will forget are not necessarily the same as the ones that will suffer the consequences. Thus despite the availability of left peripheral ellipsis, I′/C′ coordination still provides evidence for Wescoat's theory of lexical sharing.

[3]As a reviewer notes, non-constituent D I sequences can appear in the conjoined clause residue of right node raising (RNR), as in *They might and you will do it*, where a VP is extracted from both sentential conjuncts. RNR is prosodically marked by accents on the right edges of the residue conjuncts and does not bear on the absence of ordinary NP conjunction for examples like (1c) expected under affixed-word analyses (Wescoat 2005).

(3) a. ***Who***[***'ll*** *forget*] *and* [*will suffer the consequences*] *?*

b. ≠ [***Who****'ll forget*] *and* [***who*** *will suffer the consequences*] *?*

In the hybrid model, these LFG components are linked to a dynamic exemplar-based lexicon (Bybee 2001, 2006, Bybee and Hopper 2001) as mathematically modelled by Pierrehumbert (2001, 2002, 2006) at the level of word phonetics. Figure 4 provides a simplified visualization of tensed auxiliary contractions in this model. The labels *you, you're,* and *are* with their varying pronunciations stand for (partial) 'lexical entries' in traditional linguistic terminology and correspond to structural descriptions at several levels. Each entry maps onto a matching set of remembered instances of its utterance—the memory traces, or exemplars, structured into 'clouds' by similarity.[4] The visualization is simplified to show only varying pronunciations of remembered instances; it omits links to further grammatical, pragmatic, semantic, and social information. Fresh experiences and memory decay lead to continual updating of the entries in the mental lexicon, so that frequent, recent instances are more highly activated than infrequent, temporally remote ones.

labels: *you* [juː/jə] *you're* [juːɹ/jʊɹ/jɔɹ] *are* [ɑɹ/əɹ]

memory traces:
[jə] [jʊɹ] [əɹ]
[jə] [jə] [jʊɹ] [əɹ] [əɹ]
[jə] [jɔɹ] [jɔɹ] [juːɹ]
[juː] [jʊɹ] [jʊɹ] [jʊɹ] [ɑɹ] [əɹ][ɑɹ]
[juːɹ] [jɔɹ] [jʊɹ]
[juː] [jʊɹ] [jʊɹ]
[juː] [jə] [jʊɹ] [ɑɹ]
[juːɹ] [juːɹ] [əɹ]
[jɔɹ] [ɑɹ]

Figure 4: Exemplar-based lexicon

The hybrid lexicon replaces the 'lexical entries' in Figure 4 with LFG lexical schemata within the lexical sharing theory, so that LFG structures serve to label or index the clouds of memory traces. The result is visualized in Figure 5 with extensional depictions of the lexical schemata for contractions (Bresnan 2021).

[4]The similarity within exemplar clouds is symbolised here by their matching color, viewable in the online version of this paper.

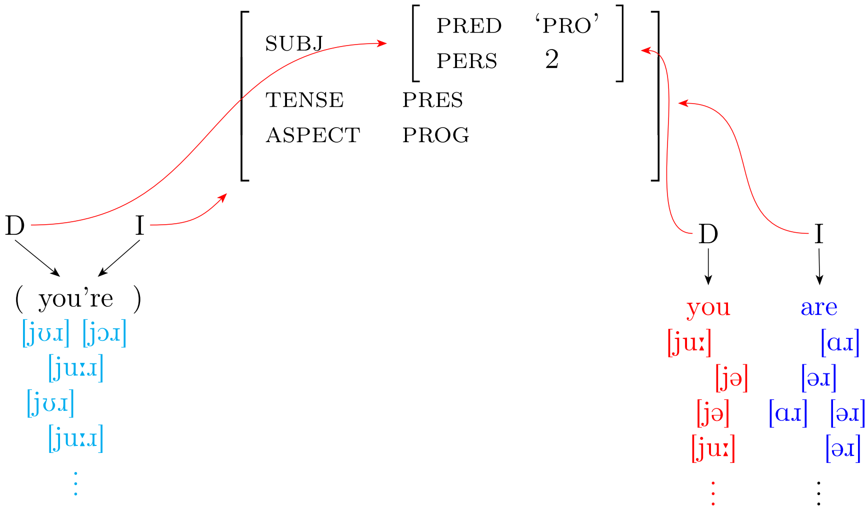

Figure 5: LFG functional schemata label lexical exemplar clouds

2 Consequences of the model

The hybrid model has broader explanatory scope than either of its usage-based or formal-grammar-based components alone. The main consequences are briefly reviewed here; see Bresnan (2021) for detailed discussion of evidence and analyses of data.

Lexicalized contractions On the usage-based theory of the lexicon, more frequently used words and multiword expressions are phonetically more reduced and become lexically stored (e.g. Bybee 2001, 2006, Bybee and Hopper 2001, Pierrehumbert 2001, 2002, 2006, Seyfarth 2014, Sóskuthy and Hay 2017). Table 1 shows some examples of this phenomenon in auxiliary contractions collected by Wescoat (2005, 471–2). Arguing for a lexical source for these and other nonsyllabic auxiliary contractions, he observes that the laxed vowels occur *even in slow or emphatic speech*, unlike on-line contextual adjustments in the phonology of rapid connected speech.

Table 1: Wescoat's (2005, 471) "morphological idiosyncracies" in auxiliary contractions cited as evidence for their lexical source. Unlike fast-speech phenomena, "*I'll* [ɑl] and *you're* [jɔɹ] may be heavily stressed and elongated".

I'll	[aɪl/ɑl]	*I'm*	[aɪm/*ɑm]	*I've*	[aɪv/*ɑv]
you'll	[juːl/*jɔl]	*you're*	[juːɹ/jɔɹ]	*you've*	[juːv/*jɔv]

Probability of contraction Recent work on English auxiliary contraction has found that probabilistic measures derived from frequencies of use of hosts and auxiliaries correlate with the likelihood of contraction (Frank and Jaeger 2008, Spencer 2014, Barth and Kapatsinski 2017, Barth 2019, Bresnan 2021). These results are expected in the exemplar-based lexicon: given production biases toward lenition and shortening, contractions of hosts and auxiliaries tend to increase with their production.

For example, in Bresnan's (2021) study of auxiliary contraction in New Zealand English the nouns having the highest share of cooccurrences with *is/'s* are *one, mum, dad*, and *thing*: 83.7% are contracted with the auxiliary, compared to the average of 56.5% for all nouns.

Prosodic wordhood of contractions The prosodic wordhood of tensed auxiliary contractions is supported by the word-level phonological processes in contractions and by the absence of pausing and interruptions between the host and the contracted auxiliary (Bresnan 2021), as shown in (4a,b).

(4) a. **(we... um... 've)*$_\omega$ *all done it*
(cf. *we've all done it*)

b. **(he ... uh... 's)*$_\omega$ *odd*
(cf. *he's odd*)

Rightward metrical dependence Unstressed auxiliaries occurring in I/C are in a metrically weak position which must be followed by a strong sister phrase (bearing stress), as Figure 6 illustrates.

Figure 6: Rightward metrical dependence of weak I/C

When unstressed auxiliaries in the weak I position lack a following strong sister phrase, the result is ungrammatical, as exemplified in (5a,b).

(5) a. *You're* [ɹ] *going.*
**You're* [ɹ].

b. *You are* [əɹ] *going.*
**You are* [əɹ].

And the same holds for weak C position. For example, in (6a,b), the IP or S complement to the inverted auxiliary in C must contain a strong (stressed) element.[5] Stressless *it* is followed by stressed *doing* in the (6a), but not in (6b), where contraction is ill-formed.[6]

(6) a. *That bird, what's it doing?*

b. **That bird, what's it?*

This shared metrical behavior of contracted and uncontracted auxiliaries in metrically weak positions is called the "central generalization of contraction" by Selkirk (1984, 405): "only auxiliaries that would be realized as stressless in their surface context may appear in contracted form" and it is also the core generalization of Labov's (1969) analysis, which phonologically derives the contracted forms from the uncontracted in the same phrase structure position. In contrast to previous morphological analyses of some contractions (e.g. Sadler 1998; Spencer 1991; Bender and Sag 2001; Börjars et al. 2019, pp. 87–88), it follows from the present lexical sharing analysis in which the contracted and the unstressed uncontracted auxiliary forms occupy the same syntactic position where the shared metrical requirement of a strong sister constituent in c-structure applies.

Natural speech is full of dysfluencies and incomplete utterances, including what appear to be violations of rightward metrical dependence (e.g. *I'm . . . Oh never mind.*) However, these are usually marked either by conventional discourse fillers signalling a planned delay (Clark and Tree 2002) (e.g. *I'm um . . .*) or by the absence of utterance-final intonation. Hence they do not undermine rightward metrical dependence as a property of fluent, complete utterances.

3 In children's speech

Similar patterns in auxiliary contractions appear in children's speech: lexical contractions, the probability of cooccurrence of host and auxiliary predicting probability of contraction, and the prosodic wordhood and rightward metrical dependence of contractions.

3.1 Lexical contractions in the previous literature

Early work on auxiliary contractions in children's speech investigates the order of acquisition of the alternative forms, with conflicting conclusions.[7] Much of

[5]See Wescoat (2005) and Bresnan (2021) on the analysis of inverted auxiliary contractions within the lexical sharing theory.

[6]See Bresnan (2021, p. 118 and n. 17) for further discussion concerning stressed and stressless *it* in relation to auxiliary contraction.

[7]Brown (1973) and de Villiers & de Villiers (1973) each give evidence for the opposite order of acquisition of uncontracted and contracted *be* forms. Kuczaj (1979) attributes the conflicting conclusions of the earlier work to sampling differences.

the subsequent literature on the development of auxiliaries is concerned with the debate between constructivist and generativist approaches to the development of the tense/aspect and agreement/inflection systems, and generally disregards the topic of auxiliary contraction itself (e.g. Wexler 1994, 1998, Rice et al. 1998, Wilson 2003, Theakston and Lieven 2005, 2008, Theakston et al. 2005, Rowland and Theakston 2009, Theakston and Rowland 2009, Rispoli et al. 2009, Rissman et al. 2013, Rispoli 2016).

The constructivist line of research on auxiliaries, although not focused on contraction *per se*, has shown that contractions of auxiliaries with their hosts are acquired as lexically stored units in children's speech. For example, in a longitudinal corpus study of the acquisition of three exponents of the category of 'inflection' in English—the copula *be*, the auxiliary *be*, and 3sg present agreement—Wilson (2003, 75) shows that ***children learn lexically specific host-auxiliary chunks***—sequences such as *he's, that's*—independently of learning general subject-auxiliary combinations.[8] Pine et al. (2008) replicate Wilson's findings in a different longitudinal dataset of children's speech with additional controls.[9] Wilson (2003, 84) further observes that because they constitute ***prosodic words***, lexically specific chunks like *he's, that's* may be "more readily extractable units than other recurring sequences such as *is* V-*ing*, which does not constitute a single prosodic word."

Regarding children's acquisition of such contractions as units, (Wilson 2003, 85) makes an important point:

> The position that items like *he's* and *I'm* may be unanalysed in child grammar has been held by many researchers. However, an important point needs to made. Although we will argue that *he's* and *I'm* are often unsegmented in child grammars, this does not imply that they are simply equivalent to *he* and *I*, as some researchers have seemed to suggest (e.g. Pinker 1996, 261). Empirically it is clear that they are not, because it is very rare that children say things like *I'm want it*, which would be expected if they did not distinguish between *I'm* and *I*. In terms of the present account, *I* and *I'm* are claimed to be represented very

[8] Wilson (2003, 88) counts both contracted and uncontracted copulas and auxiliaries, excluding contexts in which *be* cannot be contracted, such as before VP ellipsis. He does not report separate counts for contracted vs. uncontracted forms, and notes that where contraction could be orthographically indicated, the children "almost always" used it. His transcripts, selected from five longitudinal corpora in CHILDES, spann the ages 1;6–2;3, 1;11–2;5, 1;8–2;7, 2;8–3;5, and 2;3–3;5. The transcripts of the present study (Section 3.2) are a superset of Wilson's (2003, 87), drawn from the same five corpora together with three additional longitudinal corpora, and including a wider range of children's ages.

[9] Note that the term "auxiliary" in the present study includes the copula, following Bresnan (2021, n. 1, p. 109). In contrast, both Wilson (2003) and Pine et al. (2008) refer to the same verb forms as "auxiliary" or "copula" depending on the construction they occur in. In the present framework, copular and auxiliary constructions are otherwise distinguished (cf. Bresnan 2021, pp. 134–135).

> differently in the child's grammar: the unit *I'm* exists only as part of the construction in (6c) [*I'm* V-*ing*], and other construction(s) for copula sentences. It has no independent existence as a lexical item which would allow it to be used to construct a sentence like *I'm want it.*

In the present framework, *I'm* is represented as a shared lexical exponent of adjacent pronoun and auxiliary categories, which affects its meaning and syntactic distribution. Even if children's very early usage of such contractions may treat them as a single fused word rather than a composite of morphemes, their contexts of distribution indicate that they generally carry some version of the functional information expected under lexical sharing (cf. Figure 5). Recent corpus and experimental work has argued that the inventory of words and chunks gradually developed with statistical learning during language acquisition is used during children's comprehension and production and persists into adulthood (e.g. Arnon et al. 2017, McCauley and Christiansen 2019, Isbilen et al. 2020).

It is thus reasonable to infer from the previous literature that contractions of auxiliaries with their hosts are acquired as lexically stored chunks in children's speech.

3.2 Data of the present study

The questions the present study of children's speech addresses are parallel to those in Bresnan's (2021) study of adult speech: Does the probability of cooccurrence of host-auxiliary sequences predict their probability of contraction? Do contractions behave like prosodic words? Are weak (unstressed) I/C auxiliaries rightward metrically dependent?

Data to answer these questions comes from a joint project with Arto Anttila and Research Assistant Gwynn Lyons at Stanford in the Summer of 2015. The project selected eight longitudinal corpora consisting of 386,155 utterances from conversational interactions children between $1\frac{1}{2}$ and over 5 years of age and their caretakers, contributed to the CHILDES database of North American English (MacWhinney 2000a) by Brown (1973), Clark (1978), Demetras (1986), Kuczaj (1979), Sachs (1983), and Suppes (1974). From these corpora the project team extracted 87,318 utterances of both child and child-directed speech by means of Python scripts using the morphological parsing tier provided with these corpora in CHILDES (MacWhinney 2000b). The extracted utterances contained any of the six tensed auxiliary verbs *is, are, am, will, have, has*, orthographically transcribed as full or contracted (*'s, 're, 'm, 'll, 've, 's*). Python scripts also collected **ngrams** from a broader set of North American English child corpora with longitudinal samples, consisting of 584,941 utterances, including child-directed speech, from both the eight selected corpora and ten additional corpora.

After manual inspection and exclusion of misparses and dysfluencies, unintelligible or incomplete hosts of the auxiliaries, main verb uses of *have* and *has*, infinitive forms, and possessives and plurals mistaken for the auxiliary *'s*, the "cleaned" dataset consists of 79,683 utterances, or 0.913 of the original data. From this dataset the target children's utterances were extracted and further inspected, removing 79 instances of main verb *have*, unsegmented expressions containing contractions (e.g. *suh* for *it's a*), unintelligible contexts, and possessive *'s* mistagged in the morphological tier as contractions of *is*. This children's dataset contains 25,270 utterances and is the source of the statistics in Sections 3.4 and 3.5.

To examine whether usage probabilities affect contraction in children's speech, it is necessary to focus on the portion of data where contractions are not already ruled out by the grammar itself. Therefore cases where contraction is prohibited for reasons of grammar (cf. MacKenzie 2012) were all excluded: where the auxiliary occurs in utterance final position, is directly preceded by a pause, lacks a leftward host altogether, is stressed by a preceding or following intensifying adverb (*too, really, probably*, is preceded by a non-noun (*hey, yeah, okay, uhhuh, away, hi, either, maybe, hurry, together*) or a host having a final sibilant when the auxiliary verb is *is* or *has*. The resulting subset of data contains 21,385 utterances, and is the source of the statistics in Section 3.3.

How reliably do the transcriptions indicate contraction? For Bresnan's (2021) corpus studies of adult speech, the researchers verified that samples of the transcribed contractions matched the acoustic files or phonetic transcriptions. For the data collection used in the present study the researchers did not have recordings for most of the CHILDES corpora used, so in principle the adult transcriptions of children's speech might reflect the adult transcribers' knowledge of grammar.[10] However, the manual for the CHAT transcription format used in these corpora (MacWhinney 2000b) provides cautions and training for the issues and problems that arise when transcribing children's speech, including the many divergences between speech and writing and many ways of transcribing and coding divergences between child and adult speech, and for marking unclarities. Transcribers were instructed to adhere as closely as possible to the child's actual output utterances regardless of deviations from the adult language. The transcriptions include many child pronunciations of words (e.g. "gween" for "green" and "dat" for "that") and there are multiple instances of transcriptions of utterances which would be ungrammatical in the adult child-directed speech, such as omitted, doubled, and superfluous auxiliaries: *it horsie, what is he's doing?, it's makes loud noise*. These show that the transcribers focused on distinctive properties of children's speech and did not generally assimilate it to adult knowledge of language.

[10]This possible objection was provided to the author by Chit-Fung Lam in personal communication dated July 17, 2021.

3.3 Probability of contraction

For Wilson (2003, 86), "The constructivist account predicts that on the whole, copula and auxiliary *be* should occur more frequently with closed-class (or highly frequent) subjects with which *be* can be learned as a chunk." His study and that of Pine et al. (2008) find that in children's speech the cooccurrence frequencies of subjects with 3rd singular inflections on main verbs, copulas, and auxiliaries (both contracted and uncontracted) are generally higher with pronoun subjects.

In what follows the **conditional probability** of a word in the context before an adjacent auxiliary in contracted or uncontracted form is used (cf. Bresnan 2021):

(7) $$\boldsymbol{P(host|aux)}$$

The probability in (7) is estimated from corpora by the ngram calculation shown in (8):

(8) $$\frac{\boldsymbol{count(host\ aux)}}{\boldsymbol{count(aux)}}$$

The natural logarithm is used to compress extreme values. For example, in the ngram collection (Section 3.2) there were 7 bigrams of *Agra is* or *Agra 's* and 103,457 unigrams of *is* or *'s*. So log P(*Agra*|*is/'s*) is calculated as log(7/103,457) = −9.601001. And log P(*Mommy*|*is/'s*) = log(533/103,457) = −5.26839, while log P(*Mommy*|*will/'ll*) = log(70/10,139) =−4.975649.

On the choice of "backward" rather than forward conditional probability—measuring the probability of the potential host given the following auxiliary, rather than the probability of the auxiliary given the potential host—see Bresnan (2021, 113–114) and references. McCauley and Christiansen (2019) argue for the same "backward" condition in their model of chunking in child language learning.

In our dataset, 686 different pre-auxiliary nouns (from the letter *a* to *Zorro*) were identified, along with 43 different types of pre-auxiliary pronouns and pro-forms.[11] (9) shows these pronouns as transcribed in the corpora:

(9) Pre-auxiliary pronouns:
anybody, dat, de, everybody, everyone, everything, he, her, here, him, how, I, it, me, mine, nobody, none, nothing, now, she, so, some, somebody, someone, something, that, them, there, these, they, this, those, we, wha, what, when, where, who, why, you, yours, em, then

The pronouns cooccur with following auxiliaries far more often in our dataset than lexical nouns do:

[11] The term 'pronoun' is used henceforth to include pro-forms such as pro-adjectives and pro-adverbs.

(10) Instances of pre-auxiliary use (tokens):

pronouns	nouns
19,549	1,836

Figure 7 shows how the mean log conditional probability of potential hosts given the target auxiliaries differs by host type in each of the 8 selected corpora of children's speech. An ANOVA test comparing two linear mixed-effect models of $logP(host|aux)$, both including a random effect of child and differing only in the presence of a fixed effect of host type (pronoun vs. noun), yielded a significant effect of host type: $\chi^2(1) = 20{,}630$, $p = 2.2 \times 10^{-16}$.

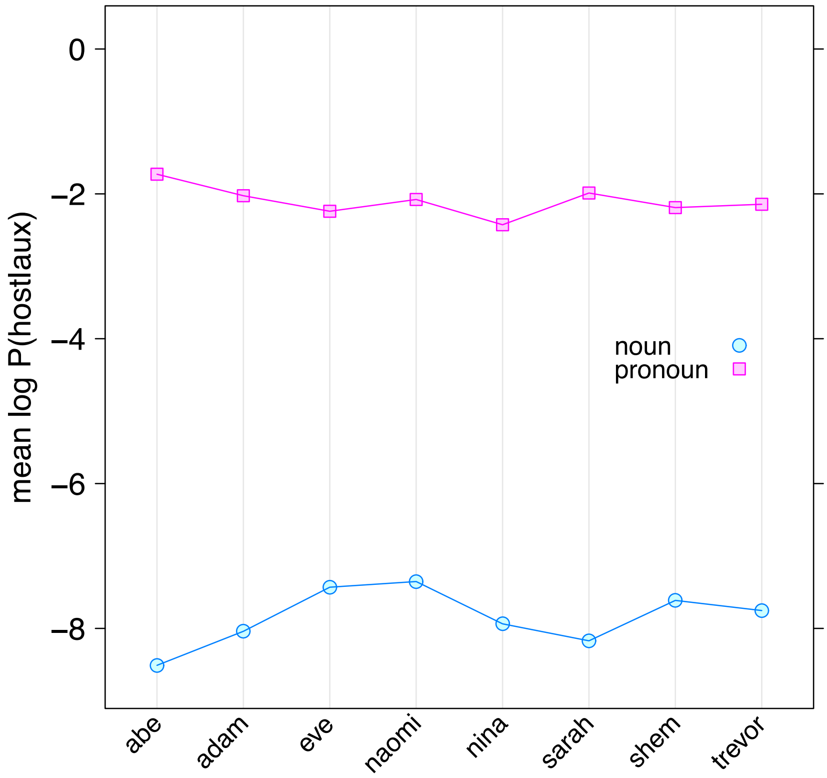

Figure 7: Mean log conditional probability of pre-auxiliary nouns and pronouns produced by children in 8 selected corpora

Given this substantial difference in cooccurrence probabilities, we would expect from the hybrid auxiliary model to find more contractions with the proform and pronoun subjects than with lexical noun subjects. Figure 8 bears this prediction out for each target child, showing again that the proportion contracted differs by host type. An ANOVA test comparing two logistic mixed-effect models of proportion contracted weighted by the numbers of total observations, both including a random effect of child and differing only in the presence of a fixed effect of host type (pronoun vs. noun), yielded a significant effect of host type on contraction: $\chi^2(1) = 2{,}338.1$, $p = 2.2 \times 10^{-16}$.

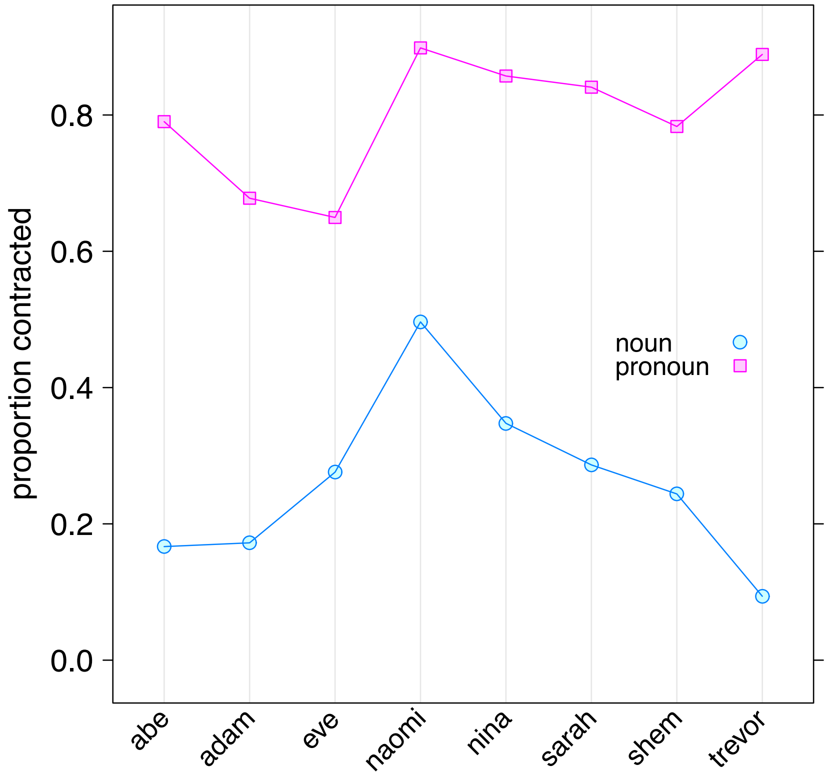

Figure 8: Proportions of contractions with pre-auxiliary nouns and pronouns produced by children in 8 selected corpora

Noun hosts, words for mother and father and *one* Among non-pronoun hosts, words for mother and father (*Mommy, Daddy, mommy, daddy, Papa, Mama, Mom, Dad*) and *one* have the highest conditional probabilities of occurring before *is/'s*. Of these, 43.1% are contracted, compared to the average of 21.1% of all other nouns in the dataset.

These findings support Wilson's (2003, 84) remarks on "chunking with *be*":

> Any particular open-class subject, such as *the pony*, presumably occurs much less frequently than any closed-class subject, so it is proposed that it is much less feasible for the child to abstract constructions such as *the pony's* V-*ing*. However it is plausible that some high-frequency lexical subjects such as *Mommy* and

Daddy might also be learned as units along with *be*. Therefore, to be precise, the claim is not that there is an inherent difference between open- and closed-class subjects in terms of whether they can be chunked with *be*, but rather, chunking should occur much more often with closed-class subjects than it does with open-class subjects.

What is the evidence from other nouns in our dataset? We should not expect a direct mapping from the conditional probabilities of individual pre-auxiliary nouns to their proportions contracted in our data. The reason is that there are so few instances of pre-auxiliary nouns in our dataset; recall (10). While their cooccurrence statistics—the log P(host|aux) values—were derived from the much larger collection of ngrams (Section 3.2), over 57% of the nouns preceding third person singular present tense forms of *be* (*is/'s*) in our 8 selected corpora have a frequency of 1.

Any low-frequency noun host in this dataset might occur once or a few times with contraction, resulting in a higher proportion of contractions than words for *Mommy, Daddy* and *one*. For example, the proper name *Agra* occurs only once, in the utterance *Agra's tired*, making *Agra* 100% contracted before *is/'s* in the data, more than *Mommy* at 51.3%. Yet their cooccurrence probabilities are the reverse: log P(*Agra*|*is/'s*) is less than log P(*Mommy*|*is/'s*), as we saw in the discussion of (8.)

To see the effects of conditional probability of cooccurrence of host and auxiliary on contraction, we must step back from individual data points and look at larger trends in the data. *Agra* falls in the second lowest 25% of the nouns in the dataset in log P(noun|*is/'s*) value. Many of the other nouns in this quartile occur uncontracted. *Mommy*, meanwhile, is in the top 25%. If all the nouns had an equal chance of contracting with *is*, the proportion of contractions would be expected (all else being equal) to be constant across the quartiles of conditional usage probabilities.[12] But if contraction is a function of usage probabilities, we would expect the rate of contraction to rise as the quartiles of log P(noun|*is/'s*) rise.

Therefore if we simply divide the set of unique nouns into quartiles by their log P(noun|*is/'s*) values and examine the overall proportion of contractions in each quartile, we can get a rough picture of the data trend, as shown in Figure 9. The figure shows that as the log P(noun|*is/'s*) values increase, the overall proportion contracted of the nouns within each quartile also increases. Table 2 gives the numbers from which Figure 9 is constructed.

[12] All else is never equal. Bresnan (2021, 132–137) shows by means of a multiple regression model of *is* contraction in adult speech that there is an effect of conditional probability of cooccurrence on contraction after adjusting for multiple other effects. A similar regression analysis of child speech is beyond the space and data limitations of the present study, however.

Table 2: log P(noun|*is*/*'s*) quartiles

quartile ranges:	[−11.6,-10.2)	[−10.2,-9.60)	[−9.60,-8.71)	[−8.71,-4.67)
total types:	191	62	106	110
total instances:	222	116	225	743
total contractions	46	25	64	291
proportion contracted:	0.207	0.216	0.284	0.392

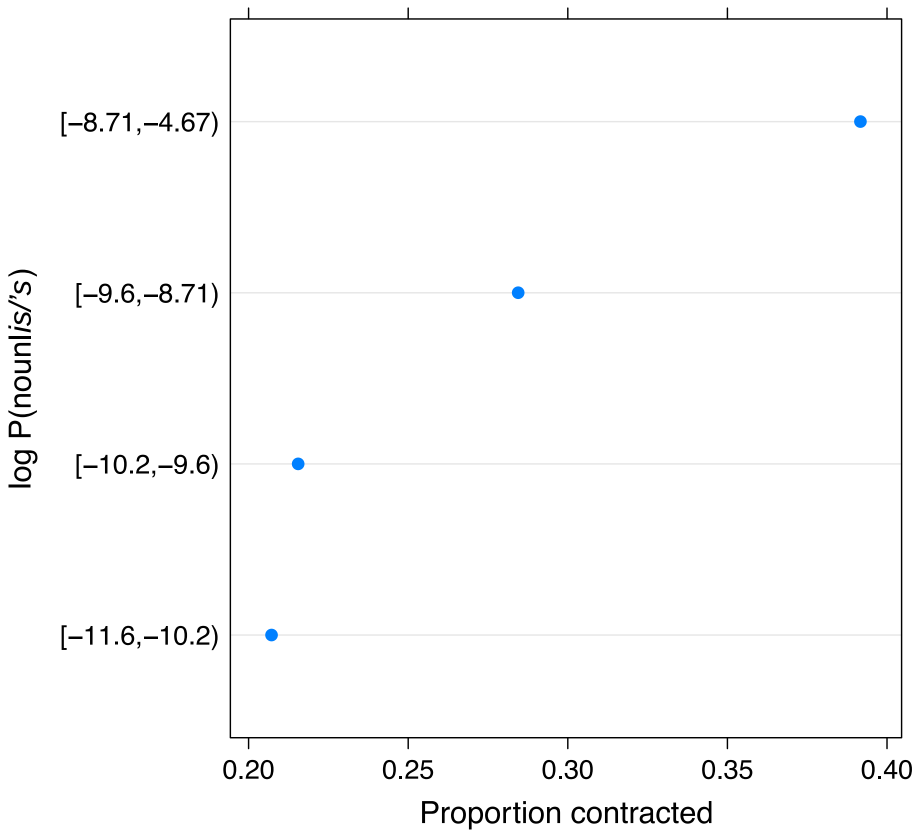

Figure 9: Overall proportions of nouns contracted with *is* by quartiles of log P(noun|*is*/*'s*) in 8 selected corpora

An ANOVA test comparing two logistic mixed-effect models of proportion contracted weighted by the numbers of observations, both including a random effect of child and differing only in the presence of the fixed effects of the quartiles of conditional probability of cooccurrence with *is*/*'s* shown in Table 2, yielded a significant effect of the quartiles on proportion contracted, compared to the hypothesized equality of proportions as the grand mean: $\chi^2(3) = 26.946$,

$p = 6.04 \times 10^{-06}$.

The visually rising trend in proportions contracted shown in Figure 9 was verified by the quartile model itself, the fixed effects of which are given in Table 3. Here the intercept is the mean proportion contracted of the lowest quartile, and for each higher quartile the model contrasts its mean proportion contracted to the mean proportion contracted of all of the previous quartiles. As in Figure 9, the proportion contracted of the second quartile did not reliably differ from that of the first quartile, but each of the higher quartiles differed reliably from those lower than it. Thus, there is a significant overall rise in proportions contracted with the rise in quartiles.

Table 3: Model estimates showing a significant effect of rising quartiles of log P(noun|*is/'s*) on proportion contracted.

	estimate	standard error	Z value	Pr(>|Z|)
intercept	-0.914	0.259	-3.532	0.000
quartile$(-10.2, -9.6]$	-0.007	0.144	-0.048	0.962
quartile$(-9.6, -8.71]$	0.161	0.070	2.316	0.021
quartile$(-8.71, -4.67]$	0.161	0.034	4.733	2.21×10^{-06}

From these results it is reasonable to conclude that in children's speech, as in the adult speech studied by Bresnan (2021), the conditional probability of cooccurrence of sequences of host and auxiliary in usage affects their contraction. This conclusion holds true both for pronouns compared with nouns and within the lexical nouns themselves.

3.4 Contractions as prosodic words

The preceding section showed that where contraction is grammatically possible in the children's data, the proportion contracted is affected by the conditional probability of cooccurrence of the host and auxiliary. In contrast, this and the following section examine where contraction should not be grammatically possible because of the constraints imposed by prosodic words and rightward metrical dependence.

In our dataset all contracted auxiliaries have a leftward host. There are numerous instances like (10a) and none like (10b):

(11) a. *am I a lady ?*
am I going tell Daddy where dis [: this] ball came from ?
has pooped her diaper .
are eating grass .

b. **'m I a lady ?*
**'m I going tell Daddy where dis [: this] ball came from ?*
**'s pooped her diaper .*
**'re eating grass .*

The table in (12) shows the counts of each type:

(12)

	unContracted	Contracted
Host:	7,681	16,089
noHost:	1,500	0

A two-sided exact Fisher test to determine whether the odds of contraction with no host differ from chance yielded a p-value $< 2.2 \times 10^{-16}$ (95% confidence interval = 0.00, 0.00; odds ratio = 0).

Furthermore, unfilled pauses, transcribed as "(.)", appear before and after contractions (13a), but they never break up contractions (13b):

(13) a. *I'm (.) no one .*
it's (.) a house .
they're (.) they're at the beach .

b. **Adam (.) 'll fix the clothesline.*
**the pie (.) 's in the oven .*
**what number (.) 's the hands on ?*

All pre-auxiliary pauses occur with a full auxiliary (14):

(14) *Adam (.) will fix de [: the] clothes+line .*
the pie (.) is in the oven .
what number (.) is the hands on ?

The table in (15) shows the counts of each type:

(15)

	unContracted	Contracted
no preAuxPause:	9,012	16,095
preAuxPause	169	0

A two-sided exact Fisher test to determine whether the odds of contraction with a pre-auxiliary pause differ from chance yielded a p-value $< 2.2 \times 10^{-16}$ (95% confidence interval = 0.00, 0.01; odds ratio = 0).

The required presence of a host of the contracted auxiliary and the absence of pauses or interruptions between them are properties of prosodic wordhood. As these data indicate, the same patterns appear in the children's speech dataset of the present study as in adult speech Bresnan (2021).

3.5 Rightward metrical dependence

Rightward metrical dependence implies that a contracted auxiliary should never occur in the final position of an utterance. Overall, about 93% of utterance-final auxiliaries in the dataset are uncontracted. Counts are shown in (16).

(16)

	unContracted	Contracted
not utteranceFinal:	8,462	16,035
utteranceFinal:	719	54

A two-sided exact Fisher test to determine whether the odds of contraction in utterance-final position differ from chance yielded a p-value $< 2.2 \times 10^{-16}$ (95% confidence interval = 0.03, 0.05; odds ratio = 0.04). Some examples of the expected uncontracted final instances are given in (18).

(17) *dere [: there] it is .*
I don't know where caboose is .
here you is .
so we can know where de [: the] mailman is ?
Dad (.) see how strong I am ?
I will .
I am .
I finded where the swing is .
can you tell what these are ?
this baby is gonna go to the beach like this girl is .

An examination of the relatively small number of exceptional contractions in final position suggests that they may arise from younger speakers who have not fully learned the metrical properties of complete utterances and from incomplete utterances transcribed as complete, arising from the inherent difficulties in defining where a child's utterance ends. See (18a,b) for two examples that violate the rightward metrical dependence of contracted auxiliaries at younger ages.

(18) a. Nina at 1;11.6
MOT: *do you want to find the cow ?*
*CHI: ***here's*** *.*
*MOT: *where's the cow ?*
*CHI: ***here's cow*** *.*
*MOT: *no (.) that's a horse .*
*CHI: *horse .*

b. Nina at 2;5.26
act: nina starts hugging her rubber doll .
*CHI: *he's hugging me .*
*MOT: *who's hugging you ?*
*CHI: ***he's*** *.*
*MOT: *that funny doll ?*
act: nina twists the rubber doll in many shapes .
*CHI: *he [/] he bend .*

Nevertheless, the data sample of exceptions is too small to yield a reliable inferential test of an age effect.

Exceptions to rightward metrical dependence could also arise from incomplete utterances transcribed as complete. The ***utterance*** is the basic syntactic unit in the CHILDES corpora, but the CHAT transcription manual states that it is not always clear where the child's utterance ends. MacWhinney (2000b) observes that whether words the children utter are transcribed as a complete utterance depends on the transcriber's knowledge of their possible constraints on utterance length, their difficulties in saying a word, and the level of syntactic integration they have achieved, among other factors.

For example, in (19) the first line, ending in *I'm*, is transcribed as a complete utterance with the utterance terminator '.'; yet the sentence appears to continue on the next line with the verb *gonna*, which provides a rightward stressed context that allows the contraction.

(19) Adam at 4;5.11
*CHI: *if I finish dese [: these] cutting dese [: these] noodles* ***I'm*** *.*
*CHI: ***gonna*** *have_to +...*

Likewise, in (20) and (21) the final contraction is repeated in the next line, which completes the preceding line marked as a complete utterance:

(20) Sarah at 3;5.07
*CHI: *yeah because* ***I'll*** *.*
*CHI: ***I'll show*** *you how to do it now (.) okay ?*

(21) Trevor at 3;10.2
*CHI: ***or I'll*** *.*
*FAT: *what ?*
*CHI: ***or I'll shoot*** *.*

An extreme example of repetition of a part until completion is (22), where the first four consecutive occurrences of *where's?* are transcribed as complete utterances, violating rightward metrical dependence, although the fifth occurrence of *where's* provides a rightward stressed context that allows the contraction.

(22) Naomi at 3;8.19
*CHI: ***where's ?***
*CHI: ***where's ?***
*CHI: ***where's ?***
*CHI: ***where's ?***
*CHI: ***where's the other truck ?***

In sum, exceptions to rightward metrical dependence of auxiliary contractions might reflect either immature or incomplete utterances, the latter arising from unclarities in determining where a child's utterance ends, but the sample is too small to provide reliable quantitative estimates.

What is that?* vs. *What is it? Apart from the occurrence of a relatively few utterance-final contractions there is further support for the rightward metrical dependence of contraction. Consider children's utterances of two common questions in the dataset: *what is that?* and *what is it?* In the former, contractions are optional, but in the latter, contractions do not occur, as shown in (23).

(23)

	unContracted	Contracted
what is that ?	113	372
what is it ?	189	0

A two-sided exact Fisher test to determine whether the odds of contraction with *what is that?* vs. *what is it?* differ from chance yielded a p-value $< 2.2 \times 10^{-16}$ (95% confidence interval = 0.00, 0.01; odds ratio = 0).

Why is contraction disallowed before *it* but allowed before *that*, when neither is utterance final? The words *that, doing* in *What's that? And what's it doing?* provide rightward stressed elements in a metrically strong complement for *what's* contractions; the subject *it* alone does not, because it is unstressed. In other words, contraction does require a metrically strong complement in these cases of inverted auxiliaries. Bresnan (2021) discusses similar cases in adult speech.

4 Conclusion

In sum, the hybrid model of auxiliary contraction combining LFG and a dynamic exemplar-based lexicon (Bresnan 2021) accounts for four patterns in children's speech—both probabilistic and near-categorical—that closely match those of adults. Pattern 1 is the **usage-based lexicalization** of contractions: the evidence that contractions of auxiliaries with their hosts are acquired as lexically stored chunks in children's speech (Wilson 2003, Pine et al. 2008). Pattern 2 is the positive correlation between host-auxiliary **contractions and their conditional probability of cooccurrence in usage**. This pattern is manifest in the dataset in two ways: first in the contrasts between a large set of 43 closed-class pronouns/pro-forms and lexical nouns; and second, within the lexical nouns themselves, where their quartiles of conditional probabilities before an auxiliary—including words for *Mommy, Daddy* and *one*—correspond positively to the proportions of contractions. Pattern 3 is the requirement that contraction have a host to the left of the auxiliary and no pauses or interruptions between them—properties of **prosodic wordhood** which characterize lexical words. And Pattern 4 is the maturing pattern of host-auxiliary **contractions requiring a metrically strong complement in complete ut-**

terances. The last two patterns follow from connecting the theory of lexical sharing (Wescoat 2005) to prosodic and metrical properties (Bresnan 2021), as outlined in Section 2.

The evidence of the present study shows that children's language, like that of adults, depends on both the usage probabilities of multiword sequences and their prosodic and rhythmic patterns reflecting the syntactic context.

In terms of the developmental debate between constructivists and generativists referenced in Section 3.1, the present framework does not require one to choose sides between the acquisition of lexically specific multiword items and early abstract knowledge of the tense/agreement system. It is a design feature of LFG as a theory of lexical syntax to encode abstract functional information (f-structure) in lexically specific fragments. This design accounts for both the range of syntactic variation across languages and for the ease of breaking linguistic streams into syntactic chunks, referred to as the "fragmentability of language" by Bresnan (2001), Bresnan et al. (2015). What is new in the present hybrid model of LFG is lexical sharing, which allows a single lexical exponent of multiple adjacent syntactic terminal categories, and the usage-based model of the lexicon, which explains the formation and storage of these shared lexical exponents as a function of their conditional probabilities of cooccurrence.

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