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Acquiring *wanna*: Beyond Universal Grammar

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ABSTRACT

The *wanna* facts are a classic Poverty of Stimulus (PoS) problem: *Wanna* is grammatical in certain contexts (*Who do you want PRO to play with?*) but not others (*Who do you want ~~who~~ to play with you?*). On a standard analysis, "contraction" to *wanna* is blocked by some empty constituents (WH-copies) but not others (PRO). All empty constituents are inaudible, so it has been unclear how restrictions on them could be learned. Children's reported knowledge of the *wanna* facts (Crain & Thornton, 1998) has therefore been attributed to a principle of Universal Grammar (UG). In two experiments, we demonstrate that children's use of *wanna* is not in fact adultlike and that error rates are modulated by the frequency of the embedded verb (*play*). These results suggest that if there is a UG principle, children appear not to know that it is relevant, raising important questions about what learning mechanisms enable children to circumvent the input's apparent poverty.

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1. Introduction

1.1. *The Poverty of Stimulus*

The famous *wanna* facts (1) are a classic illustration of the problem of the Poverty of Stimulus (PoS). In American English, the word sequence *want to* may be pronounced *wanna* in (1a), but the form is ungrammatical in (1b). The traditional analysis of these facts—first noticed by Lakoff (1970)—attributes the distinction to the differing properties of empty constituents. The WH-word copy (1b), unlike PRO[1] (1a), appears to "block" a phonological operation of contraction.

(1) The *wanna* facts
  a. [Who$_i$ do [you want [PRO to meet ~~who$_i$~~]]] ? (✓*wanna*)[2]
  b. [Who$_i$ do [you want [~~who$_i$~~ to meet the president]]] ? (**wanna*)

Debate over the precise syntactic analysis of (1) raged within the pages of *Linguistic Inquiry* for nearly a decade (Lightfoot 1976; Postal & Pullum 1978, 1982, 1986; Jaeggli 1980; Chomsky & Lasnik 1977, Aoun & Lightfoot 1984), until the editor declared a moratorium on further discussion of *wanna* in that journal (see footnote in Bouchard 1986).[3] Nevertheless, the facts continue to draw interest (Lightfoot 2006; Falk 2007; Goodall 2017; Boeckx & Hornstein 2004; Rezaeian et al. 2017; Sato 2012) and are regularly invoked in introductory textbooks (e.g., Carnie 2013) and for non-linguist audiences (e.g., Everaert et al. 2015).

[1]The status of PRO is controversial, and some have argued that the empty constituent in (1a) is actually a movement trace (e.g., Boeckx & Hornstein 2004). Our use of the label should be taken as a notational convenience, not a commitment to any particular syntactic view.

[2]In previous research, the contexts in which *wanna* is grammatical and ungrammatical have been referred to in ways that center a particular view of the restriction on *wanna* (e.g., "object extraction" for (1a) and "subject extraction" for (1b) reflect a movement-based analysis). Here we adopt the theory-neutral notation ✓*wanna* and **wanna* to refer to the form when it is used in a grammatical or ungrammatical context respectively. We also differentiate between the phonological form *wanna* and the lexeme WANT.

[3]I thank David Lightfoot for bringing this illustrative fact to my attention.

Syntacticians' enduring interest in the *wanna* facts reflects the momentous role they have played in shaping modern linguistic theory. A central idea of that theory is that there exist different kinds of empty constituents with different abstract properties—as illustrated, for example, by their differential "visibility" to presumed phonological operations such as *wanna* contraction. Because these constituents are by definition absent from the sentences that children hear, a fundamental puzzle is how children could ever learn restrictions on them. By positing innate knowledge of linguistic principles, such as a prohibition against contraction over a WH-word copy, the theory of Universal Grammar (UG) explains how children acquire syntax.

One might wonder whether there is some way to learn the *wanna* facts without UG. For example, perhaps a learner could track all instances of adjacent *want* and *to* and note that there is a context in which *wanna* never occurs. Two studies have investigated this possibility (Hsu & Chater 2010; Zukowski & Larsen 2011). Both came to the same conclusion: Strings where *want* and *to* are adjacent but *wanna* is ungrammatical (primarily WH-questions such as (1b)) occur far too infrequently to support the correct generalization. Zukowski & Larsen (2011) found only 12 instances of the crucial ungrammatical context in a CHILDES corpus of 700,000 adult utterances, of which three actually contained the ungrammatical form **wanna* (and would therefore constitute direct counterevidence to a learner relying on this information). Hsu & Chater (2010) estimated that learning the *wanna* facts would take between 320 and 38,442 years, depending on the corpus used and the number of symbols in the model's grammar. The context that the researchers assumed to be crucial (1b) is simply too infrequent.

1.2. *The status of* wanna *in child language*

If the *wanna* facts cannot be learned from WH-questions like (1b), where does the knowledge come from? One influential hypothesis, of course, is UG: specifically, a principle that prohibits phonological reduction over a WH-copy. This hypothesis makes a testable prediction. If children are born knowing a principle ruling out **wanna*, they should obey that constraint from the earliest point at which they can be tested.

In a landmark study, Stephen Crain and Rosalind Thornton (C&T; Thornton 1990; Crain & Thornton 1998) asked whether this is true. Using the prompts in (2), C&T guided children age 3;06 to 5;05 to produce utterances in which *wanna* was either grammatical or ungrammatical. Target questions directed to a puppet (Ratty) were elicited under the pretext that Ratty was too shy to answer the experimenter's questions directly.

(2) Prompts eliciting target questions (Crain & Thornton 1998)

a. Target questions where *wanna* is grammatical (✓*wanna*)

Grown-up	The rat looks kind of hungry. I bet he wants to eat something. Ask him what.
Child	What do you wanna eat?
Ratty	Is that pepperoni pizza over there? I'll have some of that.

b. Target questions where *wanna* is ungrammatical (**wanna*)

Grown-up	I bet the rat wants someone to brush his teeth for him. Ask him who.
Child	Who do you want to brush your teeth?
Ratty	Cookie Monster!

C&T's results were striking. While the rate of ✓*wanna* neared 88%—children clearly preferred *wanna* to *want to* when the reduced form was grammatical—they avoided **wanna* almost categorically (i.e., they produced it in only 8% of all opportunities). These results were interpreted, and have since been widely cited, as crucial empirical evidence that knowledge of the *wanna* facts is provided by a principle of UG.

More recently, however, new evidence raised doubts about this conclusion. Zukowski and Larsen (2011; henceforth Z&L) set out to ask whether individuals with Williams syndrome know the *wanna* facts. They found, unexpectedly, that their typically developing control children did not. When *wanna* was ungrammatical, children age 4;00–7;03 produced it nearly 50% of the time. The discrepancy with C&T's results was partially due to prompt structure. Many of C&T's prompts ended after the word "wants" ("Ask him who he wants"), potentially introducing a pause in sentence planning between *want* and *to*. When Z&L reintroduced this confound, children's use of **wanna* dropped but remained quite a bit higher than what C&T reported (32% vs. 8%). Z&L conclude that their results "cast doubt on the claim that children have innate knowledge of a categorical constraint" against **wanna* and suggest that the facts may somehow be learned.

1.3. *The current study*

In two experiments, we aimed to clarify exactly what children do and do not know about the *wanna* facts. Our work was motivated by the conflicting findings in the literature (C&T, Z&L), which have only been partially explained.

1.4. *A methodological note: Introducing a frequency control*

In grammatical contexts, phonological reduction of both lexical and functional words is more likely preceding high-frequency words (Jurafsky et al. 2000). The restriction on *wanna* is purely structural; if children know this, the frequency of the following word (i.e., the embedded verb) should not influence their use of **wanna*. However, if children don't know the structural restriction on *wanna* (as Z&L's results suggest), it is crucial to ensure that the embedded verbs in **wanna* and ✓*wanna* sentences are of equal frequency in order to avoid introducing any asymmetries in use of the reduced form. In our experiments, we therefore matched our target questions carefully for the relevant lexical variables. In Experiment 1, we also elected not to use embedded verbs of extremely high frequency (e.g., DO, EAT, MAKE) to mitigate the possibility that children could retrieve high-frequency chunks when producing target questions. These higher-frequency verbs were later included in Experiment 2, after we discovered an effect of frequency in Experiment 1. Specifically, we found that frequency did affect use of *wanna*, but not in the direction we anticipated: The reduced form**wanna* was used less, not more, with higher-frequency embedded verbs. Furthermore, the effect was grammatically conditioned (i.e., held for *wanna but not ✓wanna). In the Discussion (section 4.3), we consider what mechanisms could be responsible for this effect.

2. Experiment 1

2.1. *Methodology*

2.1.1. *Participants*

Two groups of children participated in Experiment 1: a "younger" group corresponding to the age range tested by C&T, age 3;09–4;10 (mean age 4;04, n = 12) and an "older" group, age 5;03–7;03 (mean age 6;02, n = 14). All children spoke American English at home. Most participated at summer camps in the Washington, DC, area; a smaller number of children from the same region, recruited at community events, participated at the lab. One group of Georgetown University undergraduates (n = 15) also participated as a point of comparison. All adults reported being native speakers of American English and denied ever having taken a class in linguistics or language acquisition.

2.1.2. *Design*

Using a modified version of C&T's paradigm, we elicited target questions in which syntactic structure was unconfounded from lexical properties of the embedded verb (Table 1). Most

Table 1. Embedded verbs in target questions were matched for variables that affect phonological reduction in adult speech. Most crucial was frequency (CHILDES Parental Corpus: Li & Shirai 2000; MacWhinney 2000).

	Frequency		Phoneme count		Syllable count	
	✓*Wanna*	**Wanna*	✓*Wanna*	**Wanna*	✓*Wanna*	**Wanna*
Experiment 1						
mean	573.3	576.7	3.7	3.7	1.3	1.3
median	411.5	338.5	3.0	3.0	1.0	1.0
Experiment 2						
mean	10641.8	12539.0	2.8	2.3	1.0	1.0
median	9425.0	8937.0	3.0	2.0	1.0	1.0

importantly, embedded verbs were matched for word frequency in the CHILDES Parental Corpus (Li & Shirai 2000; MacWhinney 2000), in addition to length (in phonemes and syllables) and estimated age of acquisition (Kuperman, Stadthagen-Gonzalez & Brysbaert 2012).

Following Z&L, our design crossed syntactic context (grammatical/ungrammatical) and WH-word (who/what/which) in a 2 x 3 design. Twenty-four target questions were distributed across four experimental blocks such that each block contained one target question from each cell in the design table. Targets were intermixed with eight fillers (two per block) that did not involve the verb WANT. See Appendices A and B for all prompts and target questions in Experiment 1.

2.1.3. *Paradigm*

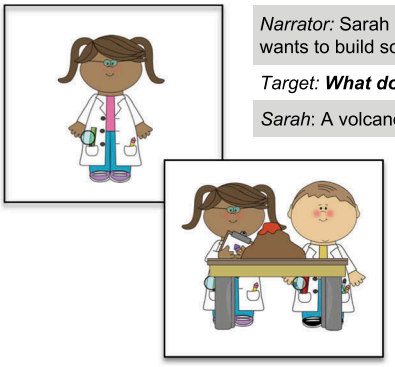
We elicited target questions in a story narrative accompanied by images from the clip art database http://www.mycutegraphics.com/. The experiment was programmed in PsychoPy (Peirce 2017). Each block depicted the characters participating in an activity: a party at school, outer space exploration, science class, and detective work. At the beginning of the experiment, participants were introduced to one of the characters, the "new kid in school," who wanted to meet the other students but was too shy to talk to them. The child was asked to help by asking the other characters questions about what was going on.

The story display (Figure 1) was designed to provide maximum contextual support for the target questions. On each trial, a narrator described what the characters were doing and then prompted the child to ask a question. All prompts followed the same structure. For each target question (e.g., *Who do you want to talk to the alien*?), the lead-in included a corresponding imperative (e.g., *Ask Zoe who she wants to talk to the alien*), such that the argument structure of all embedded verbs was modeled immediately before the target question was elicited.

Participants directed their questions at the "questionee" (who always appeared in the center of the screen), often adding the character's name as a tag at the beginning or end of their question (e.g., "Who do you want to talk to the alien, Zoe?"). Children regularly volunteered guesses as to who or what the "questionee" would pick. After asking an appropriate question, participants heard the "questionee" character state his/her choice, then observed the outcome on the following frame. Children engaged readily with this paradigm, and many asked to continue after the 20-minute experiment ended. Most children asked the target question with minimal prompting. When prompting was required, it was usually because children answered the (unstated) target question, out loud and/or by pointing at one of the "choices." In these cases, the experimenter reminded the child that it was the "questionee" character who got to decide. Explanation of this kind was rarely necessary after the first trial (which we intentionally made a filler trial).

2.1.4. *Materials*

Narration (including prompts) was prerecorded by the author, a native speaker of American English. As in previous work, prompts used the third person singular form *wants to* in order to avoid modeling adjacent *want to*. The child characters' responses were synthesized in Macintalk using three "genuine" child voices from Infovox Ivox (Ella, Josh, and Scott; http://www.assistiveware.com/product/infovox-ivox). The Macintalk voices Heather and Nelly were used for a teacher and an alien respectively.



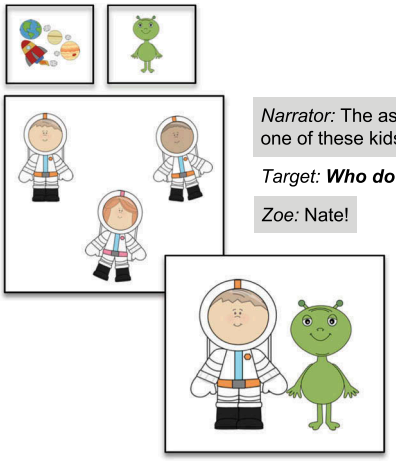
Narrator: Sarah is ready to work on her science project. I think Sarah wants to build something. Ask Sarah what she wants to build.

Target: ***What do you want to build?***

Sarah: A volcano!

Narrator: Look at the volcano that Sarah and Nate built!

a. Example trial eliciting ✓*wanna.*



Narrator: The astronauts will pick one person to talk to the alien. I think Zoe wants one of these kids to talk to the alien. Ask Zoe who she wants to talk to the alien.

Target: ***Who do you want to talk to the alien?***

Zoe: Nate!

Narrator: There's Nate, talking to the alien!

b. Example trial eliciting **wanna.*

Figure 1. Procedure for eliciting target questions.

2.2. *Results*

2.2.1. *Analysis*

Children were included in our analyses if they produced at least one question of each type (i.e., one question where *wanna* would be grammatical and one where it would not be, regardless of whether the child actually used the form *wanna*) and completed at least two of the four blocks of the experiment. One child (C017) asked to stop after the third block but nevertheless produced enough questions to be included. Four children failed to produce any target questions and were not considered further (similar to previous experiments).

We classified children's responses as "target" and "nontarget." "Target" responses were those that could be scored with respect to the pronunciation of adjacent *want* and *to* and retained the critical syntactic properties of the target question. For example, we accepted minor changes such as "which kid" for "who" but not major changes that altered the question's structure.[4]

[4]Major changes included omitting the object in a transitive construction ("Who do you want to kick the football?" → "Who do you want to kick?"), appending a preposition ("Which one do you want to ride to space?" → "Which one do you want to ride to space with?"), or changing the main and/or embedded verb ("Who do you want to put on the chest?" → "Who do you wanna protect the treasure?").

The "want to" sequence in target responses was categorized as *want to* or *wanna* based on audio recordings. Tokens were coded as *want to* if the [t] was audible and followed by a vowel (responses where the final vowel was a schwa as in "wanta" were coded as "want to"). Group averages were obtained by calculating the rate of *wanna* in target questions for each subject, then averaging across the individuals in each group.

2.2.2. *Main effect*

Children use **wanna* nearly half the time (47%)—far more than adults (2%). In contrast, both groups produce the reduced form when it is grammatical, though children far more so (adults: 35%, children: 65%). The results by age group are plotted in Figure 2. The older children use **wanna* less than ✓*wanna* (42% vs. 70%) despite our frequency control, evidencing some structural knowledge. In the younger children, however, use of *wanna* does not differ by structural context (53% **wanna* and 59% ✓*wanna*). Clearly, neither group's performance is adultlike.

The high rate of **wanna* was not due to any particular child, as one can see from the individual results in Table 2. Adultlike avoidance of **wanna* (generously defined as ≤2 instances of **wanna*) was achieved by only 11/26 children in Experiment 1, three of whom never used *wanna* in any context (and one of whom, C004, managed to produce only one target question with the **wanna* context). Although children varied in the extent to which they avoided **wanna*, every child who produced at least one instance of *wanna* in either context had at least one instance of **wanna*. A subset of children (n = 9) used almost exclusively *wanna*, regardless of syntactic context, while a much smaller number of children produced exclusively *want to* (n = 3).

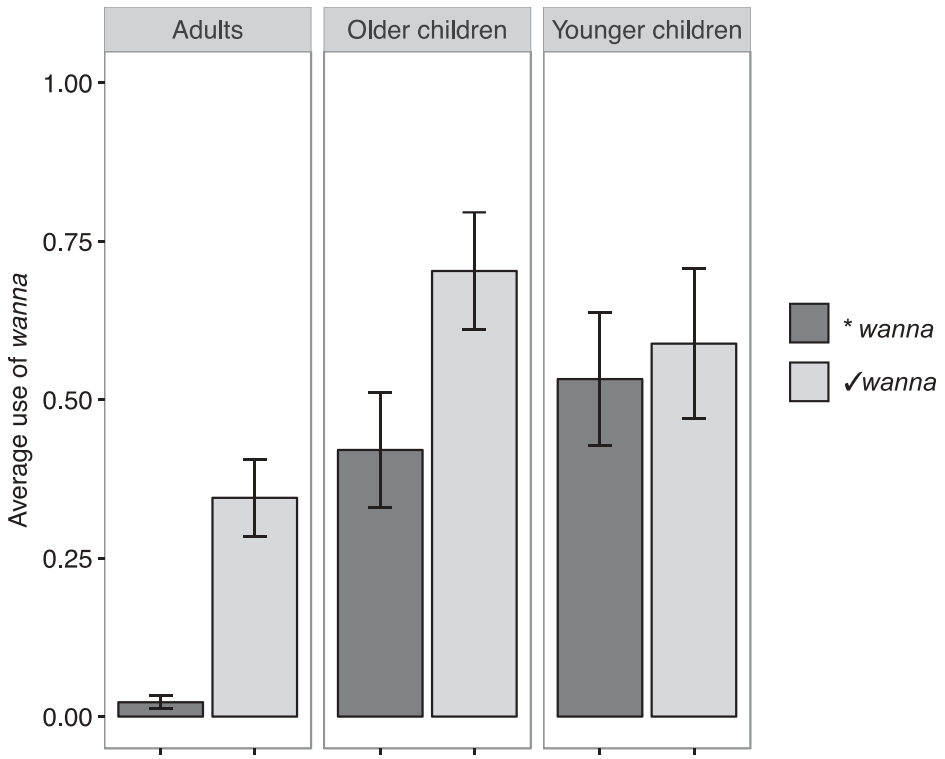


Figure 2. Average use of *wanna* in Experiment 1 in contexts where the reduced form is grammatical (✓*wanna*) or ungrammatical (**wanna*).

Table 2. Individual children's use of *wanna* and *want to* in contexts where the reduced form is grammatical (✓*wanna*) or ungrammatical (**wanna*), Experiment 1.

		✓*Wanna*		**Wanna*	
Subject	Age	*Wanna*	*Want to*	*Wanna*	*Want to*
C004	3;09	7	0	1	0
C027	3;09	0	11	0	11
C028	3;09	1	11	3	8
C036	4;04	0	10	0	11
C025	4;05	6	0	3	1
C006	4;06	3	6	2	4
C017	4;07	2	3	3	6
C011	4;08	10	1	9	1
C014	4;08	5	2	4	0
C002	4;09	12	0	3	4
C005	4;10	11	0	7	1
C008	4;10	5	3	3	3
C021	5;03	10	1	2	10
C032	5;03	7	5	1	10
C019	5;04	10	0	7	0
C033	5;06	11	1	2	7
C001	6;01	7	2	1	5
C034	6;01	1	11	5	7
C024	6;02	12	0	8	2
C013	6;05	5	7	2	7
C015	6;06	0	11	0	11
C003	6;07	7	0	4	0
C010	6;09	10	1	3	9
C031	6;09	12	0	3	1
C018	7;03	5	7	2	6
C029	7;03	10	2	5	4
		169	95	83	129

2.2.3. *Embedded verb frequency*

One explanation for our child participants' high rate of **wanna* is that, unlike in prior studies, we excluded extremely high-frequency embedded verbs (to mitigate retrieval of "chunks"). To explore whether this variable affected use of *wanna*, we split target questions into two groups according to the embedded verb's frequency in the CHILDES Parental Corpus: "low" (< 360) and "medium" (> 360, < 1500).[5] We found a clear frequency effect (Figure 3). For both groups of children combined, the rate of **wanna* was higher for lower-frequency (57%) relative to medium-frequency (34%) embedded verbs, while the rate of ✓*wanna* was equivalent across the two frequency bins (low frequency: 65%, medium frequency: 66%). The effect held within each age subgroup. For the older children, use of **wanna* decreased from 54% with low-frequency embedded verbs to 29% with medium-frequency verbs, while use of ✓*wanna* did not differ by frequency (low frequency: 69%, medium frequency: 73%). Similarly, for the younger children, use of **wanna* decreased from 60% with low-frequency embedded verbs to 41% with medium-frequency verbs, while use of ✓*wanna* remained the same (low frequency: 61%, medium frequency: 59%).[6]

[5]Embedded verbs in the two conditions were matched overall for mean and median frequency; however, we did not *a priori* divide them into "lower" and "medium" frequency. A *post hoc* cutoff of 360 resulted in even numbers of verbs in each group (six in each category for each condition).

[6]Several reviewers wonder if the frequency effect is actually an item effect (e.g., because several lower-frequency embedded verbs were intransitive, and the sentences could have been misparsed). It is not. Use of **wanna* was attested for every single embedded verb, regardless of argument structure. The rate of **wanna* for individual items ranged from 14% (*catch*) to 67% (*fly*); see section 4.3.1 for further discussion.

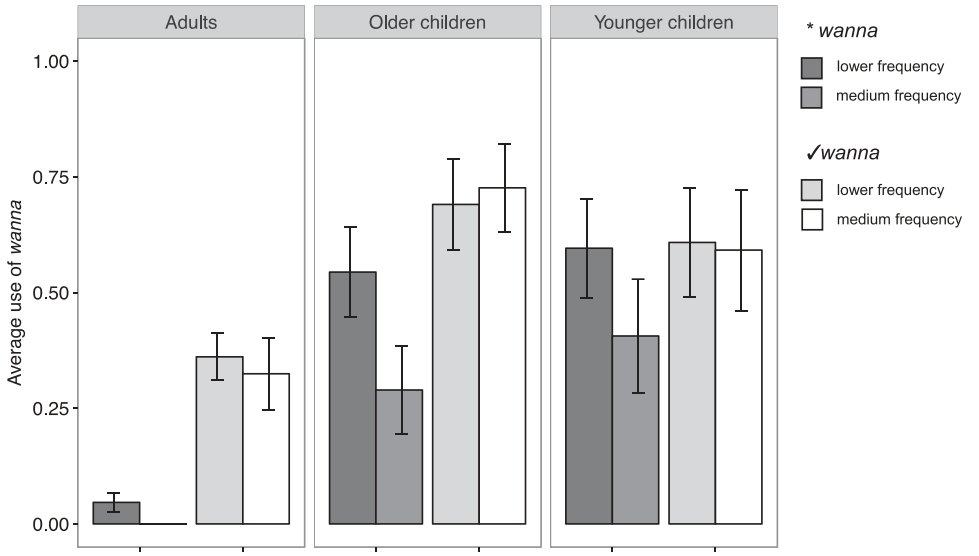


Figure 3. Use of **wanna*, but not ✓*wanna*, decreases with medium-frequency relative to lower-frequency embedded verbs.

This finding, that use of **wanna* decreases before high-frequency verbs, contrasts with the *increase* in the use of grammatical reduced forms such as ✓*wanna* in adult speech (Jurafsky et al. 2000). We will argue in the Discussion that these opposing findings have distinct sources.

The impression from Figure 3 was confirmed statistically with a mixed ANOVA on the child data (with syntactic context and frequency as within-subject variables and age bin (younger vs. older children) as a between-subject variable).[7] A main effect of syntax confirmed that children used ✓*wanna* more than **wanna* ($F = 9.978$, $p = .005$), while a main effect of frequency reflected greater use of *wanna* with low-frequency relative to medium-frequency embedded verbs ($F = 6.377$, $p = .020$). Crucially, this factor interacted with syntactic context ($F = 10.943$, $p = .003$), reflecting the specific influence of embedded verb frequency on the **wanna* context. There were no significant effects of age. Older children used ✓*wanna* slightly more and **wanna* slightly less than the younger children did, producing a marginal syntax * age interaction ($F = 3.461$, $p = .078$). None of the remaining interactions reached significance or marginal significance (all Fs < 2.5, ps > .1). In particular, there was no three-way interaction between syntax, frequency, and age ($F = 2.123$, $p = .159$), indicating that the syntax-frequency interaction is similar across the developmental trajectory: No matter what age they are, children use less **wanna*, but not ✓*wanna*, with higher-frequency embedded verbs.

In what way does frequency influence use of **wanna*? Understanding the frequency effect requires looking beyond the group mean. Figure 3 includes children who exclusively use *wanna* or exclusively *want to*, who cannot inform our understanding of how frequency influences individual children's use of the two forms. Instead, it is the subgroup of children who use both *wanna* and *want to* ($n = 14$) in whom the effect of frequency is most interesting. Figure 4 illustrates that children who use both forms modulate their use of **wanna*, but not of ✓*wanna*, in accordance with embedded verb frequency.

[7]One child (C004) produced only one target question in the **wanna* condition (with a low-frequency embedded verb) and therefore had zero observations for medium-frequency embedded verbs. He is excluded from the statistical analysis reported in this paragraph, but we include him in Table 2 and Figure 3.

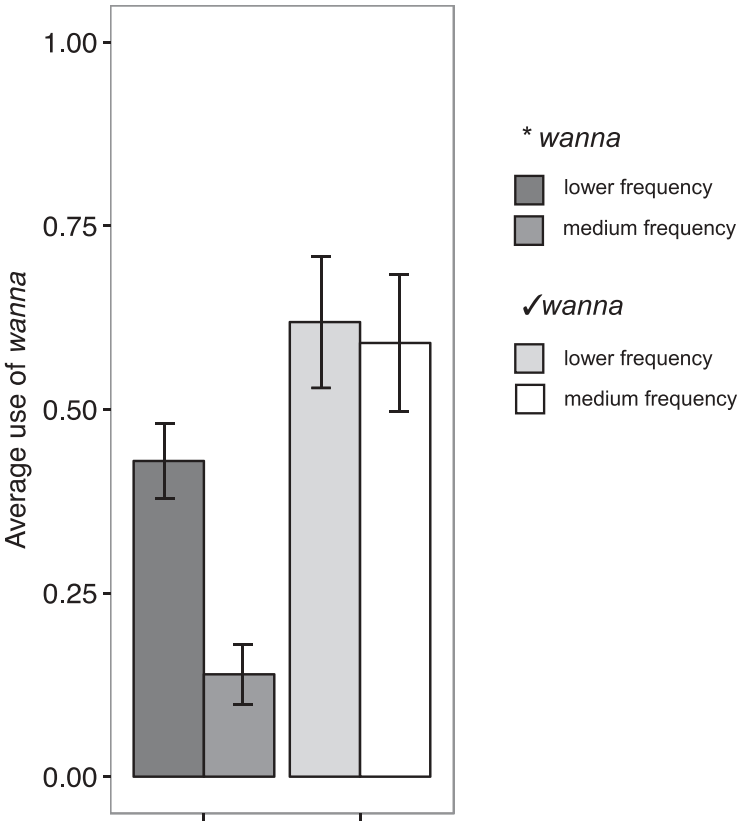


Figure 4. For children who alternate between *wanna* and *want to* (n = 14), use of **wanna* (but not ✓*wanna*) is lower when the following verb is higher frequency.

2.3. *Experiment 1 summary*

Experiment 1 demonstrated that children's use of *wanna* is not adultlike: Children age 3;09 through 7;03 use **wanna* nearly 50% of the time. With somewhat higher frequency embedded verbs, use of **wanna* drops somewhat but remains quite high (34%). The frequency effect is specific to the structural context where *wanna* is ungrammatical.

Our unexpected discovery of an interaction between structural context and lexical frequency motivated us to reconsider the very high-frequency embedded verbs that we excluded in Experiment 1. In Experiment 2, we asked how much children would use *wanna* when it precedes those forms: the highest-frequency verbs in child-directed speech. Based on the results of Experiment 1, we predicted that use of **wanna*, but not ✓*wanna*, would be further reduced in Experiment 2. This finding would confirm a role of frequency in children's grammars, revealing knowledge of a significantly different character than what has previously been assumed.

3. Experiment 2

3.1. *Methodology*

In Experiment 2, we elicited target questions in which the embedded verbs were among the highest-frequency verbs in child-directed speech (e.g., DO, HAVE, GO, SEE, etc.). We suspect that extremely high-frequency verbs like these were used in the experiment that produced apparently adultlike performance in young children (C&T).

3.1.1. *Participants*

As in Experiment 1, two groups of children participated: a "younger" group, age 3;09–4;09 (mean age 4;03, n = 10) and an "older" group, 5;00–7;03 (mean age 6;02, n = 14). We recruited children from the same participant sources as in Experiment 1 using the same inclusion criteria.

3.1.2. *Materials*

Twelve new target questions (six eliciting *wanna* in each structural context) were created with embedded verbs chosen from the highest-frequency verbs in child-directed speech (excluding mental verbs such as THINK and KNOW as well as, of course, WANT). Verbs in the two structural contexts were matched on lexical properties as closely as possible (see Table 1). All questions used the WH-word WHO. Prompts and target questions appear in Appendices C and D. The prompt structure, methods used to create auditory stimuli, experimental procedure, response coding criteria, and analyses were identical to that used in Experiment 1.

3.2. *Results*

Results for individual children are reported in Table 3. As with Experiment 1, four children were excluded for failing to produce enough target questions. The group means are displayed in Figure 5. With the highest-frequency verbs in child-directed speech, the rate of **wanna* declined to 29% (versus 47% in Experiment 1) but remains far from adultlike. The rate of ✓*wanna* was exactly the same as in Experiment 1 (65%). Structural context now matters for the younger children (23% **wanna*, 63% ✓*wanna*), as well as the older ones (34% **wanna*, 66% ✓*wanna*): A main effect of syntax occurred in the absence of any interaction with age ($F < .1$, $p > .75$). (That interaction was marginal in Experiment 1).

Figure 6 presents the results for children who used both *wanna* and *want to*, analagous to Figure 4 for Experiment 1. With these very high-frequency verbs, these children use **wanna* 16% of the time (vs. 76% ✓wanna). This is the lowest rate of **wanna* by any group in either experiment: It is half the

Table 3. Individual children's use of *wanna* and *want to* in contexts where the reduced form is grammatical (✓*wanna*) or ungrammatical (**wanna*), Experiment 2.

		✓*Wanna*		**Wanna*	
Subject	Age	*Wanna*	*Want to*	*Wanna*	*Want to*
C124	3;09	2		1	1
C134	3;10	6	0	3	2
C101	3;11	4	2	0	5
C132	3;11	2	1	0	1
C115	4;00	0	6	0	3
C113	4;01	4	0	2	2
C121	4;09	1	5	0	6
C125	4;09	5	0	2	1
C130	4;09	4	1	0	4
C131	4;09	0	6	0	6
C114	5;00	2	4	0	5
C107	5;05	0	5	0	5
C133	5;06	3	1	0	5
C119	5;08	6	0	4	1
C129	5;11	6	0	5	1
C103	6;00	2	3	1	3
C105	6;01	4	1	0	6
C122	6;06	4	0	2	1
C104	6;07	6	0	0	5
C100	6;08	5	0	4	1
C106	6;08	6	0	2	3
C109	6;08	0	5	0	3
C111	7;00	6	0	5	0
C120	7;03	0	6	0	5
		78	46	31	75

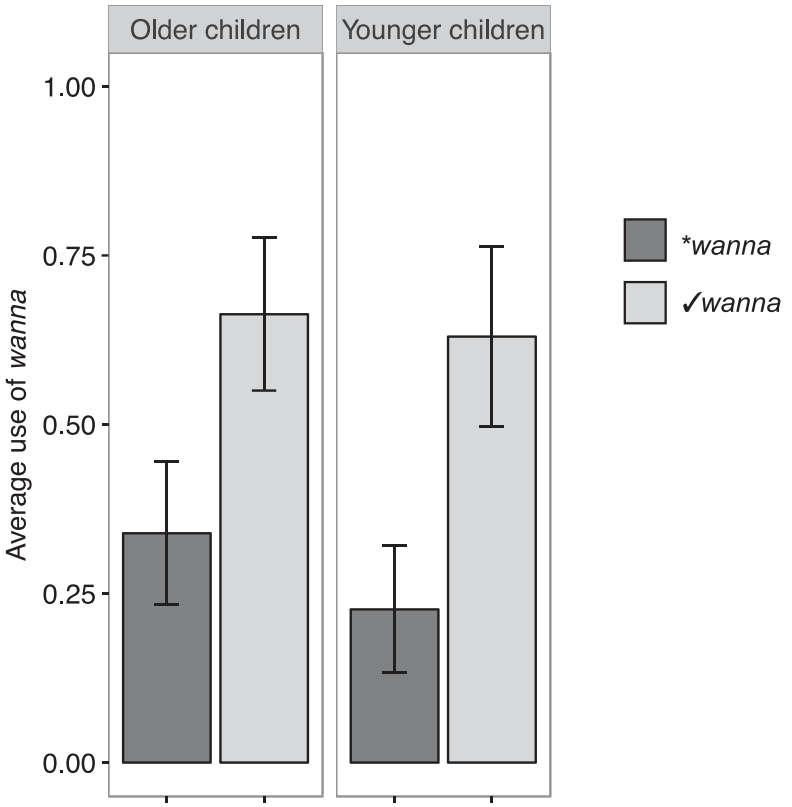


Figure 5. Average use of *wanna* in Experiment 2 in contexts where the reduced form is grammatical (✓*wanna*) or ungrammatical (**wanna*).

corresponding mean for Experiment 1 (30%). Nevertheless, it is still higher than one would expect if knowledge were provided by a UG principle.

3.3. *Experiment 2 summary*

Experiment 2 revealed that even with the highest-frequency verbs in child-directed speech, children's use of *wanna* is still not adultlike. Unlike in Experiment 1, however, the younger children made a structural distinction. The results further confirm that children use **wanna* where it is ungrammatical and that error rates are lower with higher-frequency embedded verbs.

4. General discussion

4.1. *Summary of results*

In two experiments with children age 3;09–7;03, we demonstrated that children's use of **wanna* is not adultlike, even with the highest-frequency verbs in child-directed speech. Contrary to the predictions of the UG account, children do *not* avoid **wanna* from the earliest age at which they can be tested—nor even for several years afterwards. We also found that use of **wanna* (but not ✓*wanna*) decreases with higher frequency embedded verbs. Neither of these results is accounted for by the standard UG analysis, raising important questions about the learning mechanisms that enable children to circumvent the Poverty of Stimulus and about the role of frequency in children's developing grammars.

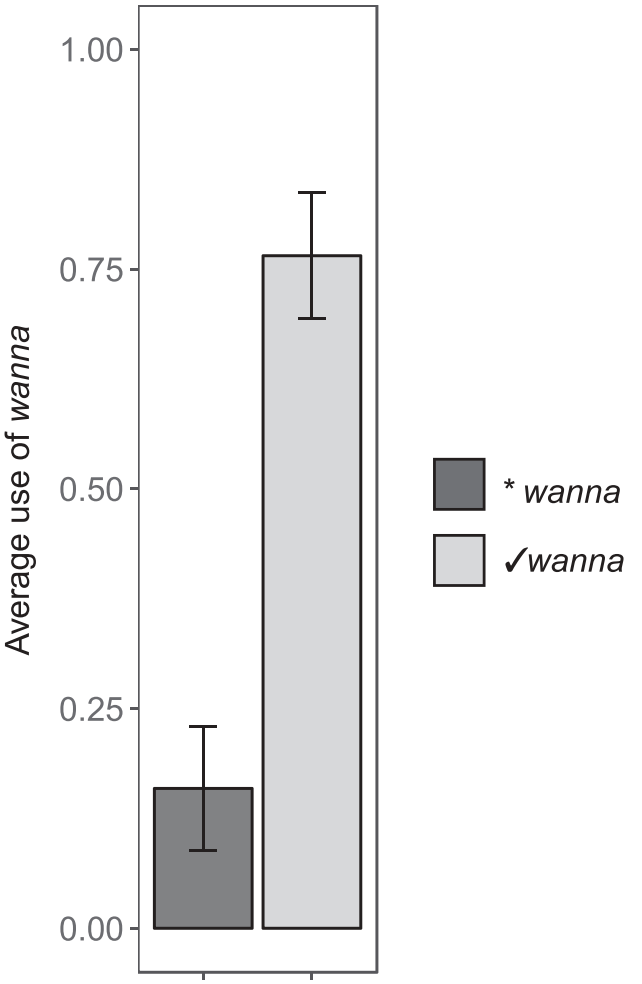


Figure 6. For children who alternate between *wanna* and *want to* (n = 11), use of **wanna* is 16% with very high-frequency verbs.

4.2. *The role of UG*

On the traditional UG analysis of *wanna*, certain unpronounced constituents—"traces"—play a significant role in syntax, leading them to block phonological operations such as contraction (Lightfoot 1976). Learnability concerns were a central motivation for this analysis: It was thought that children could not possibly learn subtle distinctions among constituents that they could not hear, hence this knowledge must be innate. Our experiments and those of Z&L have failed to provide any evidence from language acquisition for this account. Some readers may nevertheless wish to maintain the UG analysis on descriptive grounds (e.g., because a single abstract principle provides a unified account of a number of reduction phenomena, including the *wanna* facts; Lightfoot 2006). This position is consistent with the acquisition evidence as long as one concedes that this UG principle is not doing any work when it comes to helping children acquire the *wanna* facts. If the principle exists, children appear not to know that it is relevant here. In other words, learning restrictions on *wanna* is a problem where—as Ambridge, Pine, and Lieven (2014) put it—UG does not help.

4.3. *Frequency effect*

Use of **wanna* was observed through age 7 and even with the highest-frequency verbs in child-directed speech. Children's use of *wanna* is clearly not adultlike. We did find relatively less **wanna* (but not ✓*wanna*) for higher-frequency embedded verbs. This result is important because it could explain why C&T observed apparently adultlike knowledge of *wanna*: Perhaps they used extremely high-frequency embedded verbs. Our results show that C&T's widely cited finding does not generalize beyond these verbs.

The frequency effect also has theoretical interest. Why would children use **wanna* less with higher-frequency embedded verbs? Typically, frequency effects work in the other direction: Phonological reduction tends to increase, not decrease, in high-frequency contexts (Jurafsky et al. 2000). However, in typical studies of phonological reduction, the target forms are grammatical, and their reduction in high-frequency contexts is attributable to low-level variables (e.g., predictability). In contrast, our frequency effect concerns a form that is ungrammatical, and the effect cannot be explained by low-level, structure-insensitive variables because it held only in a particular grammatical context (i.e., for **wanna* but not ✓*wanna*). The explanation for our frequency effect must have something to do with the particular structural context in which *wanna* is ungrammatical. In this section, we consider three possible explanations.

4.3.1. *Misanalyzed target sentences*

One possibility is that children occasionally misparsed our target sentences and that this was more common with lower-frequency embedded verbs. When the WH-word is analyzed as the embedded verb's object, rather than as its subject, *wanna* is grammatical. Perhaps children mistakenly analyzed some of the WH-words on the **wanna* trials as objects rather than subjects. When designing our materials, we took several measures to guard against this type of misanalysis. First, each target question had only one grammatical parse in the adult grammar. Adults' categorical avoidance of **wanna* but not ✓*wanna* confirms that our materials were indeed unambiguous, at least concerning the grammaticality of *wanna*. Second, since different WH-words may invite different parses, we ensured that the WH-word was not confounded with grammatical context. Rate of **wanna* was equivalent across the three WH-items in Experiment 1 (only *who* questions were used in Experiment 2).[8] Third, we took care to provide linguistic and pragmatic support for the target parse in the prerecorded prompts (see Appendices A and C: Each structure was first modeled as a declarative sentence, then as an indirect question, while the experimenter pointed to the characters on the screen: *I think Nate* [point] *wants one of these guys* [point] *to kick the football* [pictured]. *Ask Nate who he wants to kick the football.*).

These controls all ensured that each target sentence had a single grammatical parse: On **wanna* trials the WH-word was always the subject, and on ✓*wanna* trials the WH-word was the object. However, children may have allowed different parses than adults if they did not know the argument structure of the embedded verbs. While plausible in theory, this explanation does not appear to be consistent with the evidence. The majority of **wanna* items (7/12)—including three of the five items where the rate of **wanna* surpassed 40%—had transitive embedded verbs with overt objects (e.g., *Who do you want to explore outer space?*). Children did occasionally omit the object or otherwise alter the structure of these sentences, but those responses were excluded from further analysis, as detailed in section 2.2.1, and they do not contribute toward the rates of **wanna* reported in this article. For the transitive verb trials that were included in our analysis, it is still possible that children parsed the WH-word as a second (extracted) object, treating the embedded verb as a double-object verb. Although we cannot rule this out, we note that the verb *kick*—which actually does allow a double-object

[8]It was not possible to include WH-item as a term in the repeated measures ANOVA in Section 2.2.3 because there were too few observations per cell. However, we performed a separate repeated measures ANOVA with WH-item and syntactic context (but not frequency or age group) as within-subjects variables and confirmed that the rate of **wanna* did not differ significantly by WH-item ($p > .4$).

interpretation—had the lowest rate of *wanna* out of all of the lower-frequency verbs (27%). Finally, if children are systematically misanalyzing the argument structure of embedded verbs, use of *wanna* should be particularly high for the five intransitive verbs in Experiment 1 (all verbs in Experiment 2 were transitive). However, removing all five intransitive items does not change the main result or the frequency effect. The overall rate of *wanna* in Experiment 1 remains high (46% for the seven transitive trials vs. 47% for transitive and intransitive trials combined), and the frequency effect remains, in the full group of children (use of *wanna* with low-frequency verbs = 34%, medium frequency = 14%) and in the subgroup of children who used both *wanna* and *want to* (use of *wanna* with low-frequency verbs = 38%, medium frequency = 13%).

Certainly it is plausible that children occasionally misanalyzed our target sentences and that this was more common with lower-frequency embedded verbs.[9] This may well have contributed to the increased rates of *wanna* with lower-frequency embedded verbs. We emphasize, however, that there is no evidence to suggest that children misanalyzed our target sentences systematically. Children use *wanna* with a wide range of transitive and intransitive verbs, even when the form is clearly ungrammatical in context and when there is ample contextual support for the correct parse. Misanalysis may help explain the frequency effect we observed, but it cannot explain children's use of *wanna* in general.

4.3.2. *Increased processing burden*

Another possible explanation for the frequency effect is that the lower-frequency embedded verbs increased the cognitive burden of producing target questions, which in turn led children to mistakenly produce *wanna* instead of *want to*. There is evidence that cognitive limitations do in some cases lead to systematic errors (e.g., leading children to omit subjects where they are obligatory: Bloom 1990; Valian & Aubry 2005). An account based on processing difficulty seems difficult to reconcile with the claim that knowledge of *wanna* comes from UG. It is not clear why frequency-imposed processing demands would prevent children from conforming to an innate grammatical principle without impairing their ability to construct an embedded-clause WH-question. One might have expected the opposite—that is, violations of learned knowledge but not innate principles. The story is somewhat simpler if knowledge of *wanna* is learned. In that case, children would know that *wanna* is grammatical in one context but not another, but the difficulty of the task—which is exacerbated by lower-frequency verbs—leads them to make mistakes.

It does seem plausible that processing difficulty, like occasional misparsing, may have contributed to the increased use of *wanna* with lower-frequency verbs. Again, however, this does not provide a satisfying explanation for the use of *wanna* in general. The children in our experiments were relatively old (up to age 7;03), and *wanna* was used even with the highest-frequency verbs in child-directed speech. Processing difficulty is a plausible explanation for the frequency effect, but it seems unmotivated as an explanation for the broader pattern.

4.3.3. *Nonadultlike grammatical knowledge*

Finally, there is the possibility that increased use of *wanna* with lower-frequency embedded verbs reflects some aspect of the learning process. For example, perhaps children store information about embedded verbs alongside information about the structural context in which *wanna* occurs. This is consistent with the lexically driven learning procedure that we outline in the following section. However, as argued previously, the frequency effect could alternatively reflect misanalysis, processing difficulty, or some other factor and may not have anything to do with the learning procedure. A full understanding of how and why frequency matters for children's use of *wanna* awaits further investigation. Whatever the

[9]Argument structure errors are not the only possible source of misanalysis. It is also possible that children misanalyzed the sentences in some other way. For example, a reviewer suggests that a child might misanalyze *to* as a complementizer and the WH-copy in canonical embedded subject position, such that the WH-copy does not intervene between *want* and *to*. This story, while not implausible, illustrates the puzzles that remain even for a child with substantial innate knowledge. She must not only determine whether it is PRO or a WH-copy that intervenes between any given sequence of *want* and *to*; she must also know the precise position that each empty constituent occupies in the sentence.

explanation, it is clear that embedded verb frequency *does* matter and that C&T's widely cited finding of adultlike use of *wanna* does not generalize to lower-frequency verbs.

4.4. *A potential procedure for learning the distribution of* wanna

We have argued that the UG account of *wanna* finds no support in the acquisition data, suggesting that children must somehow learn the *wanna* facts from exposure. The problem, of course, is that the information that researchers have presumed to be essential—specifically, sentences in which *want* and *to* are adjacent and *wanna* is ungrammatical—is not available in children's input. In this section, we suggest that children could circumvent the input's apparent poverty by approaching the learning problem differently. In spelling out this particular proposal, we do not mean to suggest that it is the only possible path children might take. Indeed, determining the exact learning procedure that children actually use to acquire *wanna* will require developing additional, contrasting hypotheses that can then be tested experimentally. Our goal in this section is only to spell out one possible account, showing how new ideas about learning might help to solve this classic PoS problem.

4.4.1. Wanna *and* want *as separate verbs*

Under the classic framing, children know that *wanna* is a reduced form of *want to* and that *wanna* is ungrammatical when there is a specific empty constituent between *want* and *to* (a deleted WH-copy). However, there is a different way of thinking about the restriction. Suppose instead that children initially analyze *wanna* as a frozen form, leading them to track its distribution separately from the verb *want*. This approach would reveal that *wanna* occurs almost exclusively in control constructions (3) (it may also occur as the combination of *want* and the indefinite determiner *a* as in "I wanna puppy"). The form *want* has a different, wider distribution, as it also occurs in subject infinitival constructions (4) and in transitive constructions with determiners (see Sag & Fodor 1995; Roberts 1997; and Pullum 1997 for related ideas; examples come from child-directed speech in the Valian corpus (Valian 1991), available on CHILDES [MacWhiney 2000]).

(3) Control construction (✓*want to*, ✓*wanna)*

a. Did you wanna read a book?
b. How many jumps do you wanna do?
c. I wanna eat your nose.

(4) Subject infinitival construction (✓want to, *wanna)

a. Do you want me to open it?
b. Where do you want him to go now?
c. I don't want you to get hurt.

This approach is consistent with evidence that children produce contracted forms such as *wanna* and *gonna* before they productively use the infinitival marker *to* (Bloom, Tackeff & Lahey 1984). This suggests that children cannot initially analyze *wanna* as consisting of *want* and *to* because they do not yet represent the morpheme *to*. Representing *wanna* as a single lexical item would lead children to track this form separately from *want*. The restricted distribution of *wanna* would be readily apparent, since it occurs only in constructions like (3). Children apparently do eventually recognize that *wanna* and *want to* are related; otherwise we would not have observed so much use of **wanna* in constructions like (4) in our experiments (the prompts eliciting these questions included the verb *want*, not *wanna*). However, as long as children continue to represent these separately, children can eventually learn their different distributions from exposure to sentences like (3) and (4).

Table 4. Different verbs are licensed in different constructions; these lexical restrictions are late-acquired (Chomsky, 1969).

	Promise	Appear	Ask	Tell	Want	Wanna
(5) a. Mari wants to talk to the alien	✓	*	✓	*	✓	✓
b. Mari appears to talk to the alien	*	✓	*	*	*	*
(6) a. Mari told Lee to talk to the alien	*	*	✓	✓	✓	*
b. Mari promised Lee to talk to the alien	✓	*	✓	*	*	*

If children do represent *wanna* as a separate verb, acquiring its restrictions is part of a larger learning task: sorting out which lexical items occur in different infinitival constructions in English. Some of these restrictions are listed in Table 4. The sentences in (5) are similar on the surface but have quite different structural representations. (5a) is a subject control construction (the subject of the embedded verb is "controlled" by—shares an identity with—the matrix subject) whereas (5b) is a raising construction (the subject of the embedded verb is the matrix verb's subject, which has "raised" out of its original position; cf. *It appears Mari is talking to the alien*). Similarly, the apparently identical sentences in (6) have different underlying structures: The subject of the embedded verb in (6a) is Lee, whereas the subject of the embedded verb in (6b) is Mari. Each construction in Table 4 also has a distinct set of lexical restrictions. For example, (5a) and (6b) license PROMISE but not TELL, (6a) licenses TELL but not PROMISE, and (5b) licenses neither.

The lexical restrictions in Table 4 must be learned distributionally, through exposure to constructions containing these individual verbs. Importantly, we know from Carol Chomsky's seminal work that children correctly use and interpret subject infinitival constructions only after a protracted, multistage learning period extending as late as age 9 (Chomsky 1969). Acquisition of the constructions is strikingly independent of age, a fact Chomsky attributed to the lexical nature of the learning required (i.e., the need for exposure to specific words in specific constructions, which may by chance happen for one child by age 4 and another not until age 8).[10] In view of this, it is not so surprising that the acquisition of **wanna* is not well predicted by age, since learning it may require the same kind of lexical exposure.

4.4.2. *The learning procedure*

Through distributional learning children might learn that different verbs occur in different surface sequences. But how might children learn to associate WANNA and WANT—and PROMISE, TELL, and the other exceptional verbs in Table 4—with different constructions? One possible hypothesis draws on ideas of "cue-based acquisition" (Lightfoot 1991, 2017; Fodor 1998). The idea is that the child stores pieces of analyzed sentences, including their lexical content, and later generalizes over them to form abstract representations.[11] Figure 7 illustrates the procedure. First, the hierarchical structure of an input sentence must be parsed using knowledge of categories and phrase structure. Second, select pieces of the analyzed sentence (i.e., of the parse) are stored in memory. These pieces of structure are similar to the "elements of I-language" that Lightfoot's (2017) learner accumulates to form a grammar. In Lightfoot's theory, parses encode information about the hierarchical arrangements of innate categories. For a learner to acquire the restrictions in Table 4, these stored parses must also list the matrix verbs that have been encountered, making them similar to the lexically specified "micro-cues" posited by Westergaard (2009). The representations must also include information that disambiguates sentences that are superficially similar but structurally distinct in order to distinguish

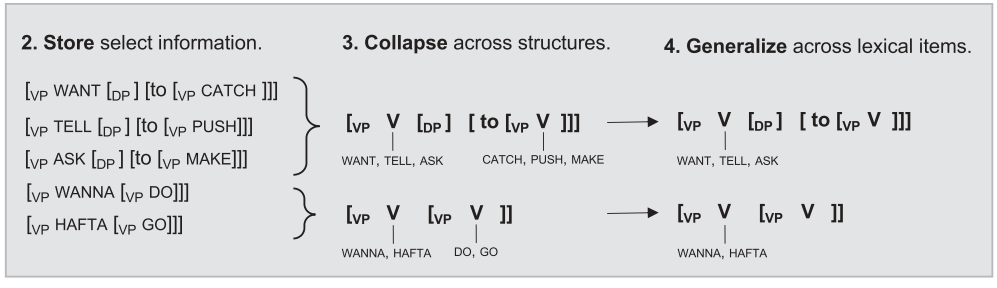
[10] A reviewer points out recent work suggesting that older children's difficulty with *promise* has to do with structural intervention effects (Mateu Martin, 2016). This may be true, but it does not change the nature of the learning required. Children must learn that the word *promise* but not the word *tell* is licensed in a particular structural configuration. The only way to do this is by analyzing the distribution of the form *promise*.

[11] The term "abstract" is used differently in UG and non-UG approaches, so it is worthwhile to be explicit about what we mean here. The representations in Figure 7 are "abstract" in that they reflect generalizations over experience (specific words and sentences). In UG approaches, "abstract" is sometimes used to refer to representations that exist independently of any experience, as innate mental representations. The representations in Figure 7 are not abstract in that sense, though their components (e.g., grammatical categories) could be.

a. Learning Procedure

1. Parse input.

[$_{TP}$ [$_{VP}$ Want [$_{TP}$ [$_{DP}$ me] [to [$_{VP}$ catch it]]]]]?
[$_{TP}$ [$_{VP}$ Tell [$_{TP}$ [$_{DP}$ him] [to [$_{VP}$ push]]]]].
[$_{TP}$ You[$_{VP}$ asked [$_{TP}$ [$_{DP}$ me] [to [$_{VP}$ make it]]]]].
[$_{TP}$ Wanna [$_{VP}$ read [$_{DP}$ a book]]]]?
[$_{TP}$ You [$_{VP}$ hafta [$_{VP}$ go to bed now]]].



To learn exceptional verbs like *promise* and—we argue—*wanna*, the learner must track which verbs occur in different constructions. It is only necessary to store main verbs, but if a learner does not know this, she may store embedded verbs as well, ultimately generalizing across them to acquire fully adultlike representations.

b. Structural Representations

Children

[Who$_i$ [do [$_{TP}$ you [$_{VP}$ want [$_{DP}$ ~~who$_i$~~] [to [$_{VP}$ catch [$_{DP}$ the ball]]]]]]]

[Who$_i$ [do [$_{TP}$ you [$_{VP}$ wanna [$_{DP}$ ~~who$_i$~~] [$_{VP}$ fly [$_{DP}$ the airplane]]

Stored parses (grey background) link embedded and main verbs to a construction. Embedded verbs that are stored with the WANT construction (*catch*) are more likely to be produced with the correct main verb (*want*) than verbs that are not stored with that structure (*fly*; see above). Both *wanna* and *want* are correct main verbs in the WANNA construction.

Adults

[Who$_i$ [do [$_{TP}$ you [$_{VP}$ want [$_{DP}$ ~~who$_i$~~] [to [$_{VP}$ catch [$_{DP}$ the ball]]]]]]]

For adults, the embedded verb position is not lexically specific, so the correct main verb is always produced no matter what the embedded verb is.

Figure 7. (a) One possible learning procedure for the acquisition of lexical restrictions on infinitival constructions. (b) Representations of the relevant knowledge in children and adults. Stored content is highlighted in gray.

(for example) PROMISE from WANT. Third, the learner compares the individual lexically specific parses, collapsing those with the same structure into a single representation. These collapsed representations are annotated with the specific lexical items that have occurred in that configuration. In this way the representations encode structural information as well as lexical information, capturing adults' knowledge of the lexical restrictions on infinitival constructions.

4.4.3. *Storage of embedded verbs*

The previous procedure assumes storage of structural configurations and of main verbs (WANNA, PROMISE, and so on). This is the information that must be stored to account for adults' knowledge. Other pieces of the structure, for example the identity of embedded verbs, need not be encoded. But how do children know which pieces of a parse are important to store? Perhaps they do not know, and so they store the identity of embedded verbs as well. This would link embedded verbs to main verbs via particular constructions. Higher-frequency verbs will be more likely to be encountered (hence represented) in a particular construction, so these verbs will be correctly acquired earlier: They will be associated with either WANT or WANNA for the control construction and WANT but not WANNA for the subject infinitival construction. Thus, assuming storage of embedded verbs provides yet another possible explanation for the frequency effect we observed in our experiments. Of course, adults avoid **wanna* regardless of the frequency of the embedded verb. This means that if children do restict the embedded verb position to a specific set of lexical items, they eventually generalize it to allow all verbs in the language. Furthermore, there are a variety of other explanations for the frequency effect, and it may turn out to be unrelated to the learning process. It is clear that a learning procedure is necessary (because children apparently do not have access to a UG principle telling them where to use *wanna*), but it is not yet clear whether this learning procedure has anything to do with the frequency effect.

4.4.4. *The availability of input*

The proposal here for acquiring the *wanna* facts is that—as is necessary for other aspects of verb acquisition, in UG-based as well as others approaches—children store information about the lexical items that they have encountered in particular structural configurations (constructions). On this account, knowledge of the *wanna* facts emerges as children encounter the verb *want*, but not the separate verb *wanna*, in the subject infinitival construction (4). The necessary information for this learning process comes from exposure to any and all forms of that construction, including *yes*/*no* questions (*Do you want me to open it?*), WH-questions (*Where do you want him to go now?*), and declaratives (*I don't want you to get hurt.*). Children do not need to encounter the complicated (and vanishingly rare; Z&L) variants of those structures in which *want* and *to* are actually adjacent.

To determine whether the necessary information for this process exists in children's input, we searched the "English-North America" corpora of CHILDES (MacWhinney 2000) for the string V N/pro Inf V.[12] Matching strings were hand-sorted to exclude children's speech and utterances in which the NP was not the subject of the embedded verb (e.g., "want something to eat"). As described regarding Table 4, not all subject infinitival constructions are the same, and this procedure did not differentiate the *want* construction from other superficially similar ones (e.g., raising-to-object constructions with *expect*). However, our learning procedure for *wanna* does not require children to make this distinction. Children may well use information from all these sentences to group verbs into those that participate in subject infinitival constructions (*want, expect, promise*, and so on) and those that do not (*wanna*). That is all they need to do to avoid using *wanna* in subject infinitival constructions. Learners do need to make finer distinctions eventually, but how they do this is outside the scope of this article.

[12]This included the following corpora: Bates, Bernstein, Bliss, Bloom70, Bloom73, Bohannon, Brent, Brown, Clark, Cornell, Demetras1, Demetras2, ErvinTripp, EllisWeismer, Feldman, Gleason, Kuczaj, MacWhinney, McCune, Morisset, Nelson, NewEngland, NH, Normal, Peters, Post, Providence, Rollins, Sachs, Snow, Soderstrom, Trdif, Valian, Vanhouten, Vankleeck, Warren, and Weist.

Our search returned a total of 6,449 instances of subject infinitival constructions with a total of 48 main and 323 embedded verbs. Notably, the main verb was WANT in 5,237 (81%) of sentences. It combined with only four other verbs (LIKE, TELL, GET, and NEED) to account for 95% of all subject infinitival sentences in the corpus. This highly skewed distribution—particularly the overwhelming dominance of WANT—certainly seems like it might lead children to form a representation that is tightly bound to certain lexical items, supporting the plausibility of the learning procedure we have suggested. At any rate, there is clearly evidence that the main verb in this construction is restricted. (Incidentally, there were zero instances of subject infinitival constructions with the main verb PROMISE. That verb did appear in the corpus, but only in control constructions ("I promise not to . . . "). In light of this, it is unsurprising that it takes so long to learn the restrictions on the use of verb in subject infinitival constructions [Chomsky 1969]).

In contrast to the main verb position, the embedded verb position had a much higher type frequency, with the frequency of individual lexical items generally reflecting frequency patterns in the language as a whole (e.g., the most-frequent embedded verb was DO, occurring in 10% of the sentences). All 18 embedded verbs from the **wanna* trials in our experiments were attested as embedded verbs in the corpora. As expected, our highest-frequency verbs (defined as such based on their frequency of occurrence in the language as a whole) were well represented in the embedded verb position, medium frequency less so, and lower frequency least of all (median frequencies of occurrence were 247, 17.5, and 4.5 respectively).

4.4.5. *Summary of the learning proposal*

We have argued that UG does not appear to help children learn the *wanna* facts. Instead, we suggested, children might learn *wanna* as an exceptional verb, using the same type of construction-based distributional analysis that is necessary for learning verbs like *promise*. Although a UG principle does not appear to be relevant to this learning, there is nothing incompatible about adopting a construction-based analysis of the *wanna* facts and also maintaining a strongly generativist framework for acquisition more generally. This proposal simply acknowledges that some linguistic phenomena are lexically specific, and *wanna*—like *promise*—is among them. Of course, this is only one possible approach, and one can imagine others that are equally compatible with our data. Refining our field's theories of learning—in general, not only with regard to *wanna*—may well lead to a different approach. We would welcome such progress.

5. Conclusion

The *wanna* facts are a famous Poverty of Stimulus puzzle: A restriction that requires distinguishing among classes of inaudible constituents seems inherently unlearnable. Yet children's use of *wanna* is not adultlike, challenging us to generate new ideas that go beyond Universal Grammar and show how learning could operate given the input available.

We conclude with a broader point regarding the use of PoS puzzles as evidence that humans have innate knowledge of abstract linguistic principles. There is a pairing between one's theory of what the child is learning and one's notion of the input required for learning to succeed. Poverty of Stimulus argues that there is insufficient input for a specific learning approach to work, but one must always consider the possibility that there is another view of the learning process for which input actually is adequate. Our notions of learning and analysis of input ought therefore to be developed in tandem with—not independently of—our theories about what innate content the child brings to the task of language acquisition.

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Appendix A: Experiment 1 protocol

"School" block

1. These are the kids in Nate's class. Now he needs to meet his teacher. I think one of these people is Nate's teacher. Ask Zoe which one is their teacher. (Answer: The girl teacher.) There's the teacher helping Josh.
2. There's Sarah. It looks like she wants to surprise someone. I think Sarah wants to surprise one of these people. Ask Sarah who she wants to surprise. (Answer: Nate.) Look, the kids surprised Nate with a welcome party.
3. There's a magical creature at the party. It can change the size of anything. I think Nate wants something to grow really big. Ask Nate what he wants to grow bigger. (Answer: My pencil.) Wow, that pencil got really big.
4. There's an airplane at the party too. I think Josh wants one of these kids to fly the airplane. Ask Josh which kid he wants to fly an airplane. (Answer: Nate.) Look, there's Nate flying the airplane.
5. The party is over, and now the kids are lined up again. I wonder where they are going. Ask Kyle where they are going. (Answer: Outside.) There they are at recess.
6. There's Sarah in art class. I think Sarah wants to paint something. Ask Sarah what she wants to paint. (Answer: The sun.) Look at the sun that Josh and Sarah painted.
7. Looks like Kyle is holding a puppet. I wonder if he's going to do a puppet show. Ask Kyle if he is going to do a puppet show. (Answer: Yes.) Look at Kyle and Zoe's puppet show.
8. Now it's time for a book. I think Zoe wants to read one of these books. Ask Zoe which book she wants to read. (Answer: This one.) There's Zoe reading to Nate and Kyle.
9. The boys are at football practice. There's the goal post. I think Nate wants one of these guys to kick the football. Ask Nate who he wants to kick the football. (Answer: Me.) Look, Nate is kicking the football.

"Aliens" block

10. Now it's time for an outer space adventure. I think the teacher wants three kids to explore outer space. Ask the teacher who she wants to explore outer space. (Answer: Nate, Zoe, and Kyle.) Here are the kids who get to explore outer space.
11. Before they go into outer space, the kids need the right outfits. I wonder if they have outfits for space. Ask Kyle if they have outfits for space. (Answer: Yes.) Look at the kids in their astronaut suits.
12. The kids need to decide how they will get to outer space. I think Kyle wants to ride one of these things to space. Ask Kyle what he wants to ride to space. (Answer: The rocket.) There they go in the rocket, flying through space.
13. The kids are going to visit another planet. I think Zoe wants to visit one of these planets. Ask Zoe which planet she wants to visit. (Answer: The blue one.) OK, we'll go to the blue planet.
14. Many different things happen in outer space. I think Nate wants one of these things to happen. Ask Nate what he wants to happen. (Answer: See some aliens.) Yeah, that would be really cool.
15. Here we are at the blue planet. I wonder if there are any aliens on this planet. Ask Kyle if aliens live on this planet. (Answer: Yes.) Looks like Kyle's right—here are two aliens.
16. Both these aliens look cool, but we only have time to meet one alien. I think Nate wants to meet one of these aliens. Ask Nate who he wants to meet. (Answer: The green one.) OK, we'll meet the green alien then.

17. The astronauts will pick one person to go talk to the alien. I think Zoe wants one of these kids to talk to the alien. Ask Zoe which kid she wants to talk to the alien. (Answer: Nate.) There's Nate talking to the alien.
18. Look at this yellow moon. It goes with this alien planet. I wonder if the alien knows how to get there. Ask the alien if he knows how to get to the moon. (Answer: Yes, I'll take you there.) Looks like the kids got there.

"Science" block

19. Now the kids are working on their science projects. I wonder if Nate could work with Sarah. Ask Sarah if Nate can work with her. (Answer: Sure.) Here's Nate and Sarah working together.
20. Sarah's project is to build a science experiment. I think Sarah wants to build something. Ask Sarah what she wants to build. (Answer: A volcano.) Look at the volcano that Sarah and Nate built.
21. The kids are looking for bugs to put in this jar. I think Josh wants one of these kids to hold the jar. Ask Josh which kid he wants to hold the jar. (Answer: Emily.) There's Emily holding the jar while Josh looks for bugs.
22. The kids outside are still working on bugs. I think Kyle's got something in his jar. Ask Kyle what he has in his jar. (Answer: Bees.) Wow, better keep that jar shut.
23. Look, there's a frog. Someone should catch it. I think Josh wants one of these kids to catch the frog. Ask Josh who he wants to catch the frog. (Answer: Zoe.) Look, Zoe caught the frog.
24. Now the kids will use the magnifying class to look at plants. I think Josh wants to share the magnifying glass with someone. Ask Josh who he wants to share with. (Answer: Emily.) There's Emily using the magnifying glass.
25. There's Kyle with all the bugs they caught. I wonder if he's having fun. Ask Kyle if he is having fun. (Answer: Yes, science is awesome.) Those bugs must be really cool.
26. Josh looks pretty scared about those bugs. I think Josh wants one of those bugs to stay in the jar. Ask Josh what he wants to stay in the jar. (Answer: Those bees. I'm allergic.) Don't worry. Emily will make sure they stay in the jar.
27. Science class is over, and the kids get to keep the bugs and plants. I think Sarah wants to keep one of these things. Ask Sarah which one she wants to keep. (Answer: The grasshopper.) Here's Sarah with the grasshopper.

"Detective" block

28. There's Zoe. She's carrying a magnifying glass. I wonder if she's looking for something. Ask Zoe if she is looking for something. (Answer: Yes, I can't find my dog.) Oh no. Let's all help Zoe find her dog.
29. It's cold out, so the kids will need something to cover their heads. I think Nate wants one of these things to cover his head. Ask Nate what he wants to cover his head. (Answer: The brown hat.) Here's Nate in his hat.
30. The kids also need to wear the right outfits. I think Sarah wants to wear one of these outfits. Ask Sarah what she wants to wear. (Answer: The detective outfit.) Here are the kids in their detective outfits.
31. Sometimes detectives ask animals for help finding things. I think Sarah wants to ask one of these animals for help. Ask Sarah who she wants to ask for help. (Answer: The cat.) Here's the cat helping Sarah.
32. Now they're ready to go look for Zoe's dog. I wonder if the dog is close or far. Ask Zoe if she thinks her dog is close. (Answer: No, probably far away.) Then let's use these binoculars to look for him.
33. The binoculars will help the kids search far away. I think Nate wants one of these kids to use the binoculars Ask Nate which kid he wants to use the binoculars. (Answer: Sarah.) Sarah will use the binoculars.

34. Somebody needs to hide in the bushes and look for clues. I think Zoe wants one of these kids to hide in the bushes. Ask Zoe who she wants to hide in the bushes. (Answer: Sarah.) Look, there's Sarah and the cat hiding in the bushes.
35. Sarah still couldn't see Zoe's dog. Let's try something different. I think Nate wants to carry one of these tools. Ask Nate which one he wants to carry. (Answer: The magnifying glass.) There's Nate carrying the magnifying glass.
36. Wait, I think I see something next to Nate's foot. I think that's a clue. Ask Nate what we should do. (Answer: We should follow these tracks.) Look what they found.

Appendix B: Experiment 1 target questions

Target questions where *wanna* is grammatical (✓*wanna*)

Low-frequency embedded verbs

1. Who do you want to meet?
2. Who do you want to surprise?
3. Which planet do you want to visit?
4. Who do you want to share with?
5. Which one do you want to carry?
6. What do you want to paint?

Medium-frequency embedded verbs

7. What do you want to build?
8. What do you want to wear?
9. What do you want to ride to space?
10. Which one do you want to keep?
11. Who do you want to ask for help?
12. Which book do you want to read?

Target questions where *wanna* is ungrammatical (**wanna*)

Low-frequency embedded verbs

1. Who do you want to explore outer space?
2. Who do you want to kick the football?
3. Who do you want to hide in the bushes?
4. What do you want to grow bigger?
5. What do you want to cover your head?
6. Which kid do you want to fly an airplane?

Medium-frequency embedded verbs

7. What do you want to happen?
8. Who do you want to catch the frog?
9. What do you want to stay in the jar?
10. Which one do you want to use the binoculars?
11. Which kid do you want to hold the jar?
12. Which kid do you want to talk to the alien?

Filler questions

1. Which one is your teacher?
2. Where are you going?
3. Are you going to do a puppet show?

4. Do you have outfits for space?
5. Are there aliens on this planet?
6. Do you know how to get to the moon?
7. Can Nate work with you?
8. What's in your jar?
9. Are you having fun?
10. Are you looking for something?
11. Do you think your dog is close?
12. What should we do?

Appendix C: Experiment 2 protocol

"Beach" block

1. Sarah wants to play outside with the kids. I hope the weather is nice. I wonder if it's sunny or cloudy. Ask Zoe if it's sunny or cloudy. Zoe (Answer: Sunny) Great. That means the kids can play outside.
2. Now the kids are going to the beach. There's something they need to do first. I wonder what they need to do. Ask Nate what they need to do. Nate (Answer: Put on some sun screen.) Good idea. There's the sunscreen.
3. Zoe looks like she's ready to play with someone. I think she wants to play with one of these kids. Ask Zoe who she wants to play with. Zoe (Answer: Sarah) There's Zoe and Sarah playing in the sand.
4. Now Sarah is ready to go in the water. I think Sarah wants one of these kids to go with her. Ask Sarah who she wants to go in the water. Sarah (Answer: Josh) There's Josh and Sarah swimming in the water.
5. The other kids are going to play beach ball. They get to pick their teams. I think Kyle wants to have one of these kids on his team. Ask Kyle who he wants to have on his team. Kyle (Answer: Zoe) There's the kids playing beach ball.
6. There's Sarah and Josh. They just came back from swimming. I wonder if they found anything interesting. Ask Sarah if they found anything. Sarah (Answer: Yeah, a fish) Look at the fish that Sarah and Josh found.
7. Fish are good to eat. Animals especially like eating fish. I think Josh wants one of these guys to eat the fish. Ask Josh who he wants to eat the fish. Josh (Answer: The pelican) There's the pelican eating the fish.

"Movie" block

8. The kids are making a movie. I bet they have a director who is in charge. I wonder who the director is. Ask Zoe who the director is. Zoe (Answer: Sarah) There's Sarah in the director's chair.
9. Here's the camera. Someone needs to be in charge of the camera. I think Sarah wants one of these guys to do the camera. Ask Sarah who she wants to do the camera. Sarah (Answer: Kyle) There's Kyle doing the camera.
10. Sarah and Kyle are almost done making the movie. It's time for the audience to come. I think Kyle wants to see one of these kids in the audience. Ask Kyle who he wants to see in the audience. Kyle (Answer: Zoe) There's Zoe in the audience.
11. Zoe's going to the movies. She gets to pick some kids to take with her. I think Zoe wants to take some of these kids to the movies. Ask Zoe who she wants to take to the movies. Zoe (Answer: Nate and Josh) There's Zoe, Josh, and Nate in the audience.
12. Everyone in the audience is eating popcorn. I wonder if they are thirsty. Ask Josh if they're thirsty. Josh (Answer: Yes) Josh got some soda. There he is drinking it.
13. The movie is over. Sarah did a great job as director. I think Zoe wants one of these kids to say good job to Sarah. Ask Zoe who she wants to say good job. Zoe (Answer: Josh) There's Josh saying good job to Sarah.

"Pirates" block

14. Earlier, Sarah and Josh went swimming in the ocean. I think they found something when they were swimming. Ask Sarah what they found in the ocean. Sarah (Answer: Treasure) Whoa, cool.
15. Sarah and Josh are going to get the treasure and bring it back. That means they're pirates. I think Josh wants one of these kids to get the treasure. Ask Josh who he wants to get the treasure. Josh (Answer: Kyle) There's Kyle with the treasure.
16. Finding buried treasure is really exciting. I think Kyle wants to tell someone about the treasure. Ask Kyle who he wants to tell about the treasure. Kyle (Answer: Emily) There's Emily with the other pirates.
17. The kids are going to hide the treasure somewhere. I wonder where they're going to hide it. Ask Sarah where they're going to hide the treasure. Sarah (Answer: On this island) There they are on the island.
18. Now the pirates need to make a map showing where the treasure is. I think Zoe wants one of these kids to make the map. Ask Zoe who she wants to make the map. Zoe (Answer: Kyle) There's Kyle with the map he made. Now they can find it again later.
19. The kids have to go home. Someone needs to make sure nobody steals the treasure. I think Nate wants to put one of these guys on the treasure chest. Ask Nate who he wants to put on the chest. Nate (Answer: The parrot) There's the parrot on the treasure chest. It will make sure nobody steals the treasure.

Appendix D: Experiment 2 target questions

Target questions where *wanna* is grammatical *(✓wanna)*

1. Who do you want to play with?
2. Who do you want to tell about the treasure?
3. Who do you want to take to the movie?
4. Who do you want to put on the chest?
5. Who do you want to see in the audience?
6. Who do you want to have on your team?

Target questions where *wanna* is ungrammatical *(*wanna)*

1. Who do you want to eat the fish?
2. Who do you want to make the map?
3. Who do you want to say good job?
4. Who do you want to get the treasure?
5. Who do you want to go in the water?
6. Who do you want to do the camera?

Filler questions

1. Is it sunny or cloudy?
2. What do you need to do?
3. Did you find anything?
4. Who's the director?
5. Are you thirsty?
6. Where are you going to hide the treasure?