Learning argument structure generalizations*

ADELE E. GOLDBERG, DEVIN M. CASENHISER,
and NITYA SETHURAMAN

Abstract

General correlations between form and meaning at the level of argument structure patterns have often been assumed to be innate. Claims of innateness typically rest on the idea that the input is not rich enough for general learning strategies to yield the required representations. The present work demonstrates that the semantics associated with argument structure generalizations can indeed be learned, given the nature of the input and an understanding of general categorization strategies. Examination of an extensive corpus study of children's and mothers' speech shows that tokens of one particular verb are found to account for the lion's share of instances of each argument frame considered. Experimental results are reported that demonstrate that high token frequency of a single prototypical exemplar facilitates the learning of constructional meaning.

Keywords: *learning; constructions; frequency; categorization.*

1. Introduction

For some time, linguists have observed that, within a given language, there exist certain formal patterns that correlate strongly with the meaning of the utterance in which they appear. Such correlations between form and meaning have been variously described as linking rules projected from the main verb's specifications (e.g., Bresnan and Kanerva 1989; Davis 1996; Dowty 1991; Grimshaw 1990; Jackendoff 1983), as lexical templates overlain on specific verbs (Hovav and Levin 1998), or as phrasal form and meaning correspondences (*constructions*) that exist independently of particular verbs (Goldberg 1995; Jackendoff 2002).

One way to account for the association of meanings with particular forms is to claim that the association is innate (Baker 1988; Chomsky

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1982). This claim generally rests on the idea that the input is not rich enough for the relevant generalizations to be learned; this is the well-known "poverty of the stimulus" argument (Chomsky 1980, 1988; Pinker 1994). On the predominant nativist view, learning a grammar can be likened to customizing a software package: everything is there, and the learner simply selects the parameters that are appropriate for his environment (Jackendoff 2002: chapter 7). Many have criticized this approach for its biological implausibility (Bates and Goodman 1998; Deacon 1997; Elman et al. 1996; Sampson 1997). Moreover, there have been virtually no successful proposals for what any specific aspect of the parameters might look like. (For acknowledgments of this failure see, e.g., Ackerman and Webelhuth 1998; Culicover 1999; Jackendoff 2002; Newmeyer 1998.)

This article joins the growing body of literature that detracts from the poverty of the stimulus argument by presenting evidence that the nature and properties of at least certain patterns in language are learnable on the basis of general categorization strategies (see also, e.g., Bybee and Moder 1983; Bybee and Slobin 1982; Jackendoff 2002; Lakoff 1987; Taylor 1995). In this article we argue that language input provides more than adequate means by which learners can induce the association of meaning with certain argument structure patterns insofar as well-established categorization principles apply straightforwardly to this domain. Throughout this article, we adopt constructional terminology, but the ideas we present are not exclusive to a constructionist account. Those who favor one of the other terminologies mentioned above need only construe this account as a proposal for how children can learn linking rules or learn the semantics associated with various lexical templates on the basis of the input. What *is* crucial is the uncontroversial notion that there do in fact exist correlations between formal linguistic patterns and meaning.

In Table 1, we provide a partial list of such form and meaning correspondences (lexical templates, combination of linking rules, constructions) along with the labels we use as mnemonics throughout the article to refer to them.

Before we discuss our corpus and experimental findings, we review evidence that children store the associations of meanings with forms on two levels. The first involves the acquisition of verb-centered categories whereby children conservatively produce syntactic patterns on a verb-by-verb basis (Akhtar and Tomasello 1997; Baker 1979; Bates and MacWhinney 1987; Bowerman 1982; Braine 1976; Brooks and Tomasello 1999; Gropen et al. 1989; Ingram and Thompson 1996; Lieven et al. 1997; MacWhinney 1982; Olguin and Tomasello 1993; Schlesinger 1982; Tomasello 1992). Ultimately, however, generalizations over specific verbs are made, forming speakers' knowledge of argument structure patterns

Table 1. *Examples of correlations between form and meaning*

Form	Meaning	Construction label
1. Subj V $Obl_{path/loc}$	X moves $Y_{path/loc}$	Intransitive motion (VL)
Example: *The fly buzzed into the room.*		
2. Subj V Obj $Obl_{path/loc}$	X causes Y to move $Z_{path/loc}$	Caused motion (VOL)
Example: *Pat sneezed the foam off the cappuccino.*		
4. Subj V Obj Obj2	X causes Y to receive Z	Ditransitive (VOO)
Example: *She faxed him a letter.*		
3. Subj V Obj RP	X causes Y to become Z_{state}	Resultative (VOR)
Example: *She kissed him unconscious.*		

(Akhtar 1999; Bowerman 1982; Brooks and Tomasello 1999; Pinker 1989).

We do not address the question of exactly *when* generalizations emerge in this study; that is, no specific time line is suggested (for a range of views on this issue see Fisher 2002; Tomasello 2000). Instead we address the more general question of how it is possible for children to go from specific knowledge of individual verb usage to knowledge of more general linking patterns, using general inductive strategies. That children do have both levels of generalization is fairly uncontroversial. Evidence is briefly reviewed in sections 2 and 3.

2. Verb-centered categories exist

Many studies have demonstrated that the initial production of argument structure patterns is very conservative in that children stick closely to the forms they have heard used with particular verbs (Akhtar and Tomasello 1997; Baker 1979; Bates and MacWhinney 1987; Bowerman 1982; Braine 1976; Brooks and Tomasello 1999; Gropen et al. 1989; Ingram and Thompson 1996; Lieven et al. 1997; MacWhinney 1982; Olguin and Tomasello 1993; Schlesinger 1982; Tomasello 1992). For example, Olguin and Tomasello (1993) taught 25-month-old children four novel transitive verbs, each in a different syntactic pattern: both participants expressed, agent only, patient only, or neither argument expressed. Children almost always reproduced the same exact pattern they had heard. Tomasello (1992) observed that by far the best predictor of his child's use of a given verb on a particular day was her use of the same verb on the previous few days, not, as might be expected, her use of other verbs on the same day. Tomasello and his colleagues have discussed this verb-centered conservatism under the rubric of *verb islands*, since children readily substitute new nominals into the frames (Akhtar and Tomasello 1997; Clark 1996; Gropen et al. 1997; Tomasello 1992; Tomasello et al. 1997).

There is evidence that adults retain much verb-specific knowledge as well. Verbs are occasionally quite idiosyncratic in the types of argument structure patterns they appear in (Bresnan and Kaplan 1982; Chomsky 1965; Pollard and Sag 1987). For example, the near synonyms *help* and *aid* differ in their distribution:

(1) a. Pat helped her grandmother walk up the stairs.
    b. * Pat aided her grandmother walk up the stairs.
(2) a. ??Pat helped her grandmother in walking up the stairs.
    b. Pat aided her grandmother in walking up the stairs.

Psycholinguistic studies have demonstrated that speakers are influenced by the relative frequencies with which they have heard particular verbs used in various argument structure constructions (Ford et al. 1982; MacDonald et al. 1993). For example, knowledge that *believed* is more likely to appear with a clausal complement than with an object complement influences speakers' on-line interpretation of potentially ambiguous sentences (Garnsey et al. 1997; Trueswell et al. 1993). The relative frequencies play a role despite the fact that both possibilities are fully grammatical, as in the examples (3a) and (3b):[1]

(3) a. Pat believed the speaker might cause a riot.
    b. Pat believed the speaker.

We are suggesting that the earliest argument structure knowledge is, for example, roughly of the form given in (4). The angled brackets are intended to capture the fact that children readily substitute arguments other than the verb early on, subject to semantic constraints.

(4) ⟨actor⟩ *put* ⟨thing⟩ ⟨location⟩

3. Generalizations over verbs exist

If generalizations were not necessarily made, we might expect to find languages whose argument structure patterns varied arbitrarily on a verb-by-verb basis. For example, we might expect to find one semantically transitive verb expressed by SVO (Subject Verb Object) word order, another expressed by SOV order, and a third verb expressed by VSO order:

(5) a. Pat saw Chris.
    b. Pat Chris kissed.
    c. Hate Pat Chris.

But in fact languages are much more regular. Although there are lexical exceptions to argument structure patterns (cf. the *help*/*aid* example

cited above), that does not mean that there is no generalization. In fact, there is typically considerable regularity to the syntactic-semantic patterns of verb arguments: verbs that are closely related semantically do generally appear in the same argument structure constructions (Fisher et al. 1991; Goldberg 1995; Levin 1993; Pinker 1989).

Further evidence that children generalize the patterns they use stems from the fact that they occasionally spontaneously overgeneralize. The following examples come from Bowerman (1982):

(6) a. Will you have me a lesson? (Christy 4;0) [VOO pattern]
b. She came it over there. (Christy 3;4) [VOL pattern]

It is also clear that adults continue to spontaneously generalize argument structures patterns (Aronoff 1976; Clark and Clark 1979; Pinker 1989). The attested examples in (7) provide examples of such adult overgeneralizations:

(7) a. "Once you resort to higher-level predicates, you can just lambda your way out of practically anything." (reported by John Moore, May 1995)
b. "He concentrated his hand steady." (reported by Georgia Green, found in Russell Atwood's *East of A*, New York: Ballentine Books 1999).
c. "I'll just croak my way through, I guess." (reported by Mike Tomasello, May 1996)

The successful manipulation and comprehension of nonsense verbs in experimental settings also demonstrates that speakers are in fact able to make generalizations (Akhtar and Tomasello 1997; Gropen et al. 1989; Maratsos et al. 1987; Naigles 1990).

In the following section we describe a corpus study designed to take a close look at children's and mothers' early uses of particular verbs in particular constructions.

4. Children's early use of verbs in the Bates corpus

Database

In order to examine more closely children's early uses of particular constructions, we investigated a corpus of children's early speech. The main language corpus used in this study is the Bates corpus (Bates et al. 1988) on the Child Language Data Exchange System (CHILDES) database (MacWhinney 1995). This corpus contains transcripts from the Bates/Bretherton Colorado longitudinal sample of 27 middle-class children, 13

boys and 14 girls at age 20 and 28 months. There are transcripts for 15 minutes, equally divided into three types of mother–infant interaction: free play, reading of the book *Miffy in the Snow*, and snack time.

Data collection and coding

The speech of all 27 children at 28 months and the speech of fifteen mothers to their children aged 28 months were extracted from the Bates, Bretherton, and Snyder transcripts. Utterances were hand-coded independently by the two coders and then combined into one full list. Disagreements were resolved through discussion with a third person.

The speech of fewer adults was analyzed because there were more data points for each adult; i.e., parents spoke more than the children. A second set of seven mothers was coded separately in order to determine whether there was any bias in our sample of fifteen mothers. Identical trends were noted in the second sample so we used the sample of fifteen mothers that had been coded independently by the two coders.

Word and sentence segmentation decisions were respected. All complete child and adult utterances containing a verb were included in the coding. Every utterance was coded for construction type, verb, and speaker + situation + age. We focused on three constructions, listed in Table 2.

After an initial sampling of sentences with overt subjects and sentences without overt subjects, we collapsed the results because the only major difference between the two sets of data was that sentences without subjects were predominantly commands. There did not seem to be other distinctions relevant to the current discussion.

Classifications were based primarily on form: categorizing an utterance as an instance of the VOO pattern required a verb and two NPs. Categorizing an utterance as an instance of the VL pattern required that there be a verb and some type of locative: a preposition phrase indicating location, a particle indicating location (e.g., *down*, *in*), a locative (*there*, *here*), or some combination. Thus, *She lived in Pennsylvania* and *She went there* would both be considered an instance of the VL formal pattern

Table 2. *Labels and forms for patterns investigated*

Label	Form
VL	(Subj) V $\text{Obl}_{\text{path/loc}}$
VOL	(Subj) V Obj $\text{Obl}_{\text{path/loc}}$
VOO	(Subj) V Obj Obj2

while *She lived with her sister* would not be because "with" is not a locational preposition. The VOL pattern required a verb with an object NP and some type of locative phrase. The emphasis on form in our coding scheme was intended to avoid presupposing that utterances had the intended meaning associated with the linking generalizations or constructions given in Table 1. The decision to code for locative phrases ("L"s) instead of a purely syntactic category such as PPs was based on the fact that ultimate linking generalizations are known to be sensitive to general semantic properties of the oblique argument such as the general type of preposition involved. Since at least certain prepositions and locative expressions (including *up*, *down*, *off*, *in*, *on*, and *here*) are often among the first words uttered (Clark 1996), we assume that children are able to identify phrases as locative or non-locative.

We ignored variable word orders correlated with questions, topicalizations, etc. Questions such as *What did she put in his eyes?*, for example, were considered instances of the VOL pattern. Utterances considered unacceptable or ungrammatical to adults were included in the coding. We did not attempt to distinguish arguments from adjuncts because we did not want to assume the 28-month-old children had mastered the distinction. A sample from the coded transcript is given as Table 3.

Results

In analyzing the children's speech we found a strong tendency for there to be one single verb occurring with very high frequency in comparison to other verbs used in each of the constructions analyzed. For example, for the VL construction, the verb *go* accounted for a full 54 percent (121/224) of the instances of that construction in the children's speech. Other

Table 3. *Sample from the Bates, Bretherton, and Snyder (1988) corpus*

Construction	Verb	Source file	Utterance
VOL:	pour:	*PAU-SN28:	pour some milk in it.
VOL:	throw:	*HAN-SN28:	throw diaper away!
VOL:	put:	*GEO-FR28	I put him in.
VOL:	put:	*KEI-FR28:	put another ball in here.
VOL:	want:	*WAN-ST28:	want you in the house.
VOO:	give:	*GLO-SN28:	Cory gave me my turtle.
VOO:	give:	*EDD-SN28:	give me some milk?
VL:	get:	*KEI-ST28:	she get in her bed.
VL:	go:	*CHU-FR28:	it went in here.
VL:	come:	*FRA-FR28:	people come outside.

verbs occur in the construction, but with much less frequency. *Go* and the next six most frequent verbs are provided below:

(8) (Subj) V Obl_{loc} [X MOVES $\text{Y}_{\text{path/loc}}$; e.g., *I went to the store*]
   a. *go* 54% (121/224)
   b. *get* 6%
   c. *fall, come* 5%
   d. *look, live, sit* 4% each

A similar pattern emerged in the case of the VOL construction, exemplified by the sentence, *I put the book on the table*. The verb *put* accounts for a full 31 percent (16/51) of the instances of the construction in the children's speech. Again, other verbs appear in the construction, but with markedly less frequency:

(9) (Subj) V Obj $\text{Obl}_{\text{path/loc}}$ [X CAUSES Y TO MOVE $\text{Z}_{\text{path/loc}}$; e.g., *Marty put the milk in the fridge*.]
   a. *put* 31% (16/51)
   b. *get* 16%
   c. *take* 10%
   d. *do, pick* 6%

The ditransitive or VOO construction, is represented below:

(10) (Subj) V Obj Obj2 [X causes Y to receive Z; e.g., *Pat gave Chris a book*.]

Only six instances of the VOO construction were found in the children's speech in the Bates, Bretherton, and Snyder corpus. These included two instances of *give*, two of *make*, and two of *bring*. This paucity of data is due to the fact that the VOO construction is only just beginning to be learned at 28 months. We therefore examined data collected by Gropen and her coauthors from longitudinal data in the Brown corpus of Adam, Eve, and Sarah together with MacWhinney's data on Ross and Mark. Adam was recorded in 55 two-our samples taken every two to four weeks between the ages of 2;3 and 4;10. Eve was recorded in 20 two-hour samples taken every two to three weeks between the ages of 1;6 and 2;3. Sarah's speech was recorded in 139 one-hour samples taken at two to nineteen-day intervals between the ages of 2;3 and 5;1. Ross and Mark were both recorded by their father in 62 samples of varying sizes at varying intervals, Ross between the ages of 2;6 and 8;0, and Mark between the ages of 0;7 and 5;6.

As seen in Table 4, *give* is the most frequent verb to appear in this construction for the majority of children. The numbers for *give* do not include uses that Gropen and her coauthors considered idiomatic. In the

Table 4. *The most frequent verb in ditransitive (VOO) construction, based on Gropen et al. (1989)*

Child	Most frequent verb in VOO	Percentage of tokens	Total number of verb types
Adam	*give*	53% (59/112)	13
Eve	*give*	36% (4/11)	5
Sarah	*give*	43% (29/67)	12
Ross	*give*	43% (69/160)	13
Mark	*tell*	32% (11/34)	8
	give	29% (10/34)	

case of one child, Mark, there is no statistical difference between *give* and *tell*; the data set is too small for this particular child to draw any clear inferences. The overall frequency of *give* in the ditransitive construction in this child's speech outnumbers *tell* if idiomatic uses were included.

To summarize the data so far, one verb accounts for the lion's share of tokens of each of the constructions analyzed. Zipf long ago noted that highly frequent words account for most linguistic tokens (1935). Although he did not claim that there should be a single most highly frequent word for each clause pattern, nor did his work prepare us for the fact that a single verb accounts for such a large percentage of the tokens, Zipf's observation nonetheless suggests that we may find a similar pattern in constructions other than argument structure constructions.

4.1. *Accounting for the high frequency of children's productions*

The question arises as to why these particular verbs are used more frequently in these constructions by children. One factor, of course, is that these verbs are among the most frequent verbs in the language at large (Carroll et al. 1971). But this does not in itself predict that these verbs should account for such a high proportion of tokens of any single construction, since most frequent verbs appear in multiple constructions.

More directly relevant is the fact that the same pattern described above in children's speech also holds in the input: mothers' speech to children. That is, the use of a particular construction is typically dominated by the use of that construction with one particular verb. For example, *go* accounts for a full 39 percent of the uses of the VL construction in the speech of mothers addressing 28-month-old children in the Bates, Bretherton, and Snyder (1988) corpus. This high percentage is remarkable since this construction is used with a total of 39 different verbs in the mother's speech in our corpus; the figures for the three constructions under discussion are given in Table 5.

Table 5. *Fifteen mothers' most frequent verb and number of verb types for three constructions in the Bates, Bretherton, and Snyder (1988) corpus*

Construction	Mothers	Total number of verb types
Subj V Obj	39% *go* (136/353)	39 verbs
Subj V Obj Obl	38% *put* (99/256)	43 verbs
Subj V Obj Obj2	20% *give* (11/54)[a]	13 verbs

[a] *Tell*, in our small sample of 54 appeared an equal number of times as *give*. We believe the high number of instances of *tell* is an artifact of the book-reading context, since only one instance occurred in a non-story context. The other ten occurrences are all directly related to the task of reading the story; in fact the second object in eight out of ten instances is *story*.

We know from previous studies that children's use of verbs is highly sensitive to their mothers' use of the verbs (Choi 1999; De Villiers 1985; Naigles and Hoff-Ginsberg 1998); thus it is not surprising that the high frequencies of the children's use reflects the high frequencies of the mothers' use.

4.2. *Accounting for the high frequency in the input*

The fact that *go*, *put*, and *give* are so frequent in the input raises the question as to why that should be so. There seem to be two reasons. First, if we compare for example, *go* with *amble*, or *put* with *shelve*, it is clear that *go* and *put* are more frequent because they apply to a wider range of arguments and therefore are relevant in a wider range of contexts (Bybee et al. 1992; Heine 1993; Zipf 1935).

In addition, each of the main uses of these verbs designates a basic pattern of experience, for example, someone causing someone to receive something (*give*), someone causing something to move (*put*), or someone acting on something (*do*). These meanings are readily accessible to the child, since they involve concrete actions. Thus the verb meanings need to be accessible as well as highly frequent in the input in order to be frequently produced in early child language (Slobin 1985).

5. General-purpose verbs and constructional meaning

As represented in Table 6, the meanings of the most frequent verbs used in particular argument structure constructions bear a striking resemblance to the meanings independently posited for those argument structure constructions (Goldberg 1995).

"General-purpose" verbs, including *put*, *go*, *do*, and *make*, are among the first and most frequent verbs in many languages (Clark 1978, 1996).

Table 6. *Main verbs and the constructional meanings to which they correspond*

Verb	Constructional meaning	Construction
go	X moves Y	VL: Intransitive motion
put	X causes Y to move Z	VOL: Caused motion
give	X causes Y to receive Z	VOO: Ditransitive
make	X causes Y to become Z	VOR: Resultative

Clark cites data from Bowerman (1973) for Finnish, Grégoire (1937) for French, Sanchés (1978) for Japanese, and Park (1977) for Korean; Ninio (1999), discussed below, provides similar data from Hebrew.

The generality of the meanings of these verbs and their highly frequent and early appearance in children's speech suggests that they may aid children in generalizing patterns from the input. Speculations about the close relationship between certain verbs and argument structure patterns have been made previously by leading researchers in linguistics and language acquisition. Fillmore and coauthors (ms.: section 3.2) observe that "it is possible to think of the argument structure patterns as in some sense 'derived from' the semantics of their most neutral verbs" (see also Goldberg 1998). Clark (1996) likewise speculates that certain early-learned verbs may serve as "templates" for further acquisition on the basis of their semantic characteristics. She demonstrates that children are aware of much relevant semantic knowledge pertaining to their early verbs as evidenced by their discriminating use of various inflectional morphemes. Ninio (1999) has also suggested that syntactic patterns emerge from generalizing the use of particular verbs. With the possible exception of Ninio (1999), discussed in section 8, these researchers do not attempt to flesh out this idea. As Fillmore and coauthors (ms.) note, "when we come to propose this seriously we will have to specify just what sort of 'projection' we are talking about ... and what the mechanism is according to which the pattern of the verb is projected to the more general pattern".

The present hypothesis is that it is the high frequency of particular verbs in particular constructions that allows children to note a correlation between the meaning of a particular verb in a constructional pattern and the pattern itself, giving rise to an association between meaning and form.[2]

6. Experimental evidence

The corpus data demonstrate that a single verb accounts for the lion's share of tokens for all of the constructions considered here. However, it

does not demonstrate that the existence of a high-frequency token facilitates the acquisition of constructional meaning. In order to show a causal relationship, we performed an experiment designed to test just this.

Eighty-one University of Illinois undergraduates took part in the experiment as an extra-credit course assignment. All subjects were native speakers of English and ranged from 18 to 24 years of age.

Subjects were randomly and equally divided into three conditions: the *no-training* condition, the *balanced* condition and the *high-token-frequency* condition. Subjects in both conditions other than the no-training condition saw a short film that consisted of 16 film clips in which puppets acted out scenes. Subjects wore earphones and listened to a tape recording that described each of the scenes as they unfolded.

The descriptions involved novel verbs in a novel construction, "SOV-o", e.g., *the king the ball moopo-ed*. The construction was formally novel in that it had SOV word order as opposed to standard English SVO order. Additionally, the construction was morphologically marked in that all nonsense verbs had the nonsense suffix *-o* attached.

In each film clip, a scene of appearance was depicted: e.g., a dot appeared on the queen's nose, a ball rolled onto the stage from off screen, a clown dropped into a chair from out of sight, a rabbit appeared in a hat, a dragon wriggled out from a hole in a cloth, etc. Thus the construction could be said to designate a scene of appearance. Since there is no construction in English devoted to this meaning, the semantics of the construction was novel as well.

In the balanced condition, subjects heard five different novel verbs, each with a relatively low token frequency (4-4-4-2-2). In the high-token-frequency condition, subjects again heard the same five novel verbs, but this time one had especially high token frequency (8-2-2-2-2). Each scene was repeated exactly twice in each condition. To be consistent with the finding that the most frequent verb had a very general meaning, the high-token-frequency exemplar was designed to encode the meaning of "appearance" in a very general way, without designating a particular manner. It was viewed eight times (in four distinct scenes). The same exemplar (paired with a subset of the same scenes) appeared in the balanced condition four times (in two distinct scenes). The balanced condition included two additional scenes that involved a specific manner of appearance. Subjects were instructed only that they would see some films and that they were to pay close attention because there would be a quiz at the end. In the no-training condition, subjects went directly to the test phase without watching either video.

The test was designed to determine whether subjects had learned anything about the construction's semantics by watching the scenes and lis-

tening to the novel constructional descriptions of each scene. In a forced choice comprehension task, subjects saw two scenes simultaneously on the computer screen and were asked to choose which scene best matched the description they heard. Over earphones, subjects heard the same novel construction with new novel verbs that had not been used in the training conditions. They had to choose between a new scene of appearance and some other scene that involved a related action. For example, in one trial, subjects saw a flower grow from out of the ground in one clip and the same flower simply getting taller, but continuously in view in the other. Given that the description involved the novel construction and this construction was intended to designate appearance, the correct choice would be to identify the scene of appearance. The task is reminiscent of the preferential looking paradigm (Naigles 1990), the main difference being that subjects provided an unambiguous behavioral response, pointing to the matching scene instead of simply looking longer at one scene than another.

Both film clips replayed automatically until subjects pointed to the scene that they believed best matched the description. Clips designating scenes of appearance were randomly assigned to the left or right side of the computer screen. Seven trials with new novel verbs in the novel construction were recorded for accuracy. These trials were randomly interspersed with seven additional distracter items that used new novel verbs but in a simple English transitive construction.

Results are given in Table 7. As expected, subjects in the control no-training condition did no better than chance at choosing the correct scene. The balanced condition showed a statistically significant improvement over the control condition, indicating that they had learned something about the construction's semantics from the training film. As predicted by our hypothesis, the high-token-frequency condition showed a statistically significant improvement in accuracy over the balanced condition.[3] Analysis of variance confirms a significant effect for type of

Table 7. *Experimental results varying token frequency in the learning of a novel construction with novel verbs*

Condition	Number of correct responses (out of 7)	Standard deviation	Median number correct
High token frequency	5.1	.96	5
Balanced	3.8	1.48	4
Control (no training)	2.9	1.23	3

training $F(2, 78) = 23.29$; $p < .001$. Post hoc comparisons using Bonferroni's correction indicate significant differences between all groups at or below the $p < .01$ level.

Thus with less than three minutes of training, subjects demonstrated an ability to learn constructional meaning: they were able to extend the semantics of the construction to new novel verbs and new scenes in this forced choice comprehension task. Moreover, the results demonstrate that high token frequency of a single general exemplar does indeed facilitate the acquisition of constructional meaning. In the following section we outline why this result is in fact expected, given general findings in the nonlinguistic categorization literature.

7. The role of high token frequency in categorization

Research in cognition has demonstrated that there is a strong correlation between the frequency with which a token occurs and the likelihood that it will be considered a prototype by the learner (Nosofsky 1988; Rosch and Mervis 1975). Homa, Dunbar, and Nohre (1991) found that token frequency was an important variable at early and intermediate stages of category learning, with increased token frequency facilitating category learning. In learning generalizations about dot patterns, Posner, Goldsmith, and Welton (1967) demonstrated that the rate at which subjects classified patterns correctly was a direct function of the amount of distortion from their respective prototypes: the less variability or distortion, the faster the category was learned.

Elio and Anderson (1984) set up two conditions relevant to the current discussion. In the "centered" condition, subjects were initially trained on more frequently represented, more prototypical instances, with the study sample growing gradually to include more members of the category.[4] In the "representative" condition, subjects were trained on a fully representative sampling from the start. In both conditions, subjects were eventually trained on the full range of instances. Elio and Anderson demonstrated that the order in which subjects received the more prototypical instances played a role in their learning of the category. In particular, they demonstrated that categories were learned more accurately in the "centered" condition; the "representative" condition yielded poorer typicality ratings and accuracy during the test phase on new instances. Elio and Anderson observe that "[t]he superiority of the centered condition over the representative condition suggests that an initial, low-variance sample of the most frequently occurring members may allow the learner to get a 'fix' on what will account for most of the category members" (1984: 25). They go on to note that "a low-variance sample, in which

there is a maximum amount of similarity among items, is particularly conducive to forming strong category generalizations" (1984: 28).[5]

Similar results were found by Avrahami et al. (1997), who demonstrated that subjects learned categories better when presented with several ideal positive cases followed by borderline cases than if they were presented with sequences that emphasized category boundaries from the start.[6] Moreover, categories that are identifiable with a salient type of stable feature are easier to learn than categories in which the feature is instantiated in different ways, even when the variability is relevant to the feature dimension (Markman and Maddox 2003); the analogy to language is that constructions that are instantiated (to a great extent) by a single verb should be initially easier to learn than constructions that are instantiated by many different verbs.

It is important to bear in mind that we are addressing the question of how the argument structure generalization is initially learned, and *not* the question of how the learner knows when to extend the pattern for use with new verbs, that is, the question of productivity. There has been much discussion in the literature about productivity and we do not attempt to review it all here (Baker 1979; Bowerman 1990; Brooks and Tomasello 1999; Goldberg 1995; Pinker 1989). At least three factors have been proposed in the literature as relevant to predicting a pattern's productivity: the absolute number of distinct items that occur in a given pattern, or a pattern's *type frequency* (Bybee 1985; Goldberg 1995; MacWhinney 1978; Plunkett and Marchman 1991, 1993); the variability of the items that occur in a given pattern, a pattern's *degree of openness* (Bybee 1995; Janda 1990; Pinker 1989); and *statistical preemption*, the repeated witnessing of the word in a competing pattern (Brooks and Tomasello 1999; Goldberg 1995; Pinker 1981).[7]

We simply observe that knowing what an argument structure pattern means is another relevant factor in that it is a necessary condition for extending that pattern. That is, learners cannot readily extend a pattern without having a "fix" on what the pattern means. We suggest that the high token frequency of a single verb in a particular formal pattern facilitates the learning of the meaning of the abstract pattern.

To summarize, we know that frequency and order of acquisition play key roles in category formation in that frequent and/or early training on prototypical instances facilitates category learning (Bruner et al. 1956; Kruschke 1996; Maddox 1995; Nosofsky 1988). This generalization, together with the experimental evidence discussed in the previous section, suggests that the very frequent and early use of one verb in a pattern facilitates the learning of the semantics of that pattern. The corpus findings demonstrate that exactly this sort of tailor-made input is available to

language learners. We suggest, for example, after using many sentences with *put* in the VOL construction as in (11), children come to associate the meaning of *put* with the construction even when the verb is not present, as in (12):

(11) She put a finger on that.
(12) He done boots on. (STE, 28 months; Bates et al. 1988)

The result is that the meaning of roughly "X causes Y to move Z_{loc}" comes to be associated with the Subj V Obj $Obl_{path/loc}$ formal pattern.

We need to emphasize that we are *not* claiming that general-purpose verbs are necessarily the very first verbs uttered. Neither our cross-sectional corpus data nor our experimental data address this question. Moroever, longitudinal studies have yielded differing answers (see Ninio 1999 for a claim that such verbs should be the very first or second verbs uttered; but see Campbell and Tomasello 2001 for evidence that they are not always the very first verbs).[8]

It also must be noted that it is not necessary for there to be a single verb with a frequency far greater than other verbs for successful learning to take place. The correlation between form and meaning can be learned by noting their association across several distinct verbs, each with relatively low frequency. This is in fact evident from our data insofar as subjects in the balanced condition outperformed those in the control condition: they clearly did learn something from witnessing several verbs in the construction, each with relatively low frequency. This is important because in naturalistic data, there is not *always* a single verb that has far greater frequency than other verbs, at least if constructions are defined as generally as possible (e.g., for the transitive construction, see Sethuraman 2002).

Strikingly asymmetric frequencies are found in the corpus data, however, with one verb having far greater frequency than other verbs for each of the constructions discussed here. We have argued that the especially high frequency makes the learning of the correlation that much easier: the meaning associated with the construction requires minimal abstraction from the semantics of the verb as used in the construction. The highly frequent verb serves as a readily available prototype with which other verbs may be associated.

8. "Pathbreaking verbs" analysis

The present proposal focuses on how the semantics associated with argument structure patterns may be learned. In a related proposal, Ninio (1999) notes that the early use of certain verbs may allow the child access to initial syntactic generalizations as well.[9]

Ninio analyzes early uses of SVO and VO patterns in two Hebrew-speaking populations: 15 children in a longitudinal study and 84 eighteen-month-old children in a cross-sectional study.[10] She suggests that children often begin using a single verb with a direct object long before a direct object appears with other verbs; moreover, she notes the overwhelming tendency for these "pathbreaking" verbs to be drawn from the set of general-purpose or light verbs. In particular, in both the longitudinal and cross-sectional studies, the children tended to use verbs meaning 'want', 'make/do', 'put', 'bring', 'take out', or 'give' before other verbs were used.

In the longitudinal study, Ninio further observes that SVO and VO patterns were initially produced with only one or at most a few verbs for a prolonged period lasting between two and fifteen weeks. More and more verbs came to be used in an exponentially increasing fashion; that is, there seemed to be more facilitation after ten verbs than after five and so on. She suggests that this increase stems from the fact that children gradually abstract a more general and purely syntactic pattern on the basis of the early verbs, and that the growing generalization allows them to use new verbs in this syntactic pattern more and more easily.

On both Ninio's account and the present proposal, patterns are learned on the basis of generalizing over particular instances. As vocabulary increases, so does the strength of the generalization, making it progressively more and more easy to assimilate new verbs into the patterns. With Ninio, it is argued here that the instances that play a crucial early role are those involving general-purpose verbs.

The two accounts complement each other, in that Ninio proposes that general-purpose verbs lead the way in the early acquisition of syntax, and the present proposal emphasizes the role of general-purpose verbs in the acquisition of the semantics associated with basic syntactic patterns. It may well be that early uses of general-purpose verbs provide the foundation for both initial syntactic and semantic generalizations, and thus provide a route to the acquisition of form and meaning correspondences, i.e., constructions.

The accounts differ in their explanations as to *why* general-purpose verbs should be learned so early. While Ninio notes that general-purpose verbs are highly frequent and pragmatically relevant, she argues that the tendency for general-purpose verbs to be used early in the VO and SVO patterns stems largely from a high degree of semantic transitivity in these general-purpose verbs. She states, "[t]he 'pathbreaking verbs' that begin the acquisition of a novel syntactic rule tend to be generic verbs expressing the relevant combinatorial property in a relatively undiluted fashion; this is what makes them such good candidates for acquisition" (Ninio

1996); these verbs are argued to necessarily express "a fundamental, unalienable, core notion of transitivity" (1999).

This proposal requires that the general-purpose verbs that appear in the (S)VO pattern early are all highly semantically transitive, since it is this semantic property of the verbs that is argued to encourage their appearance as syntactically transitive verbs. However, as Ninio herself notes, many of the early general-purpose verbs are not highly semantically transitive according to traditional criteria; i.e., they do not involve an agent acting on, or changing the state of a patient argument (see e.g., Hopper and Thompson 1980). For example, the general-purpose verbs, *want*, *see*, *get*, and *have* appear among the very first verbs in Ninio's corpus, and yet they are not highly transitive according to traditional criteria.

Ninio discusses this discrepancy at some length and argues that a notion of *unmarked*, "core", or "inalienable" transitivity is at issue, and not the traditional understanding of semantic transitivity which may be expressed with some type of morphological marking.[11] In describing what the notion of "core" transitivity involves, she notes that many of the general-purpose verbs describe situations that are more likely to result in a change in the subject argument than the patient argument (Ninio 1999).

In support of the claim, Ninio argues that the children's first transitive verbs are the verbs that are typically grammaticalized as transitivity markers cross-linguistically. But while general-purpose verbs do clearly often become grammaticalized as various kinds of auxiliaries (Bybee et al. 1992; Heine 1993), their role as transitivity markers per se is far less clear. As examples of transitivity markers in Indo-European languages, the perfect marker 'have' and the set of Indoaryan complex verbs that involve a general-purpose verb concatenated with a noun or other host are cited. However, the 'have' perfect marker (e.g., Italian *avere*) applies to agentive intransitive verbs as well as to transitive verbs. Further, the general-purpose verbs involved in complex predicates typically include a full range of general-purpose verbs. For example, *shodan* 'become', *âmad* 'come', and *raftan* 'go' all serve as general-purpose verbs in complex predicate formation in Persian alongside transitive verbs (e.g., Goldberg 1996b; Windfuhr 1979).

Do and *give* are two general-purpose verbs that often become grammaticalized as transitivizers or causativizers, but *give* is actually acquired later than many other verbs, most likely because of its more complex syntax. Other transitivizer or causativisers tend to be directionals (Song 1996; Wolfenden 1929) or verbs meaning 'to cause' (Givón 1991). Lacking reason to suppose that the first-learned transitive general-purpose verbs are necessarily semantically more transitive than other verbs, the

proposal ultimately does not explain why general-purpose verbs should appear with transitive syntax before other verbs.

On the present account, meanings of constructions emerge directly from generalizations over particular verbs. The transitive pattern appears with a range of highly frequent verbs, including verbs with low semantic transitivity such as *want*, *see*, and *get*. Thus, the association of semantic transitivity with simple syntactic (S)VO status is predicted not to be overwhelmingly strong. In fact this is the case, as the (S)VO pattern is associated with a very wide range of meanings (e.g., Davis 1996; Dowty 1991).

Another difference between the present account and Ninio (1999) is that we do not presuppose that general-purpose verbs are necessarily the very first or second verbs used in syntactic patterns. Our findings concern frequency: one general-purpose verb accounts for the lion's share of tokens in each of the constructions considered. In the experiment described in section 6, we show that the existence of a high-token-frequency exemplar facilitates the acquisition of constructional meaning. The fact that general-purpose verbs are used so frequently results from their high frequency in the input language and their accessible meanings. The high frequency in the input in turn stems from their generally applicable and highly relevant meanings.

The present account generalizes to other general-purpose verbs that are not transitive, but are also very frequent, and can be seen to form the basis of argument structure meaning. For example, we have seen that the verb *go* is the most frequent verb used in the VL construction and corresponds to the meaning of that construction. The same is true of the pattern (Subj) V Obj1 Obj2, which comes to be associated with the meaning of 'give', and the pattern (Subj) V Obj $\text{Obl}_{\text{path/loc}}$, which comes to be associated with the meaning of 'put'. More generally, the specific formal patterns associated with particularly frequent verbs come to be associated with the meanings of those verbs. The alternative is to assume that each of these patterns and its associated meaning were known to the child at the time of the child's first verbs. How the constructions themselves come to exist would not be explained.

9. Conclusion

This work suggests an account of how children form the argument structure generalizations they do. We argue that the input is structured in such a way as to make the generalization from verb islands to argument structure constructions straightforward. One particular verb accounts for the lion's share of tokens of each argument frame considered in an ex-

tensive corpus study on the Bates, Bretherton, and Snyder (1988) corpus, in both mothers' and 28-month-old children's speech. The dominance of a single verb in the construction facilitates the association of the meaning of the verb in the construction with the construction itself, allowing learners to get a "fix" on the construction's meaning. Previous research in general categorization as well as new experimental results on construction learning presented here support this idea. In this way, grammatical constructions may arise developmentally as generalizations over lexical items in particular patterns.

The implications of this work are potentially far reaching insofar as tokens of constructions are typically centered around one or a few specific words, or around a semantic prototype, even when they potentially occur with a much broader range of words or meanings (Cameron-Faulkner et al., to appear; Diessel 2002; Goldberg 1996a; Hunston and Francis 1999; Scheibman 2002; Thompson and Hopper 2001).

The present proposal for how the semantics associated with constructions is learnable from the input directly undermines the "paucity of the stimulus" argument as it is aimed at this particular problem. Before we decide that language-specific properties must be innate, it is worth investigating how they might be learned, given general cognitive mechanisms such as categorization, together with a closer look at the input children receive.

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University of Illinois
Indiana University, Bloomington

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1. Hare et al. (2003) observe that different argument structure probabilities correlate highly with different senses of the verb (or construction).
2. Stefanowitsch and Gries suggest that the frequency with which a particular verb occurs in a construction is measured against the frequency with which the same verb occurs in other constructions. The hypothesis is that only if the verb is highly predictive of the construction does it become the prototype of the construction (Stefanowitsch and Gries, to appear). However, the fact that *go* is so highly frequent in the intransitive

motion construction and also corresponds to the semantic prototype of the construction detracts from this argument, since *go* occurs even more frequently as a future marker with a verbal complement. Thus *go* is not particularly predictive of the intransitive motion construction and yet, it still accounts for the preponderance of instances of the construction and also corresponds to its prototypical meaning.

3. This experiment raises a number of questions that we are following up on (Casenhiser and Goldberg, to appear). Do we find the same results when testing children? Do the same results hold if the high-frequency verb is assigned a particular manner? Do the same results hold if the video seen in all conditions is identical in all respects?
4. The study involved descriptions of people belonging to one of two clubs, with members' descriptions varying on five four-valued dimensions.
5. Interestingly enough, Elio and Anderson (1984) also found that when subjects were explicitly asked to form hypotheses about what criteria governed category membership, the advantage of learning the centered instances first disappeared. They therefore conclude that the advantage is only evident when the learning is *implicit*. Implicit learning involves knowledge that is not accessible to consciousness, fairly complex and abstract, an incidental consequence of some task demand, and preserved in case of amnesia (Seger 1994). Relevantly, language learning is an excellent example of implicit learning, since it is largely learned below the level of consciousness, is very complex and ultimately quite abstract, is a consequence of trying to communicate, and is preserved in cases of amnesia.
6. Stimuli in this experiment also consisted of nonlinguistic stimuli: variable sized semicircles with variably oriented radial lines.
7. We have argued that the high token frequency of one particular verb in a constructional pattern facilitates the learner's getting a "fix" on the intended interpretation. Bybee (1995) has argued that morphological tokens with especially high frequency do not lead to generalizations because they are routinized to such an extent that their internal structure is unanalyzed and therefore unavailable for analogical extension. Bybee's argument is based on irregular morphological items such as *went* and *am* which clearly do not lend themselves to generalization. It is quite possible that such morphological forms are used without internal analysis.

   However, it is clear that the constructions under discussion represent a different case. They must be analyzed because they contain argument positions that must be filled. The VOL pattern with *put*, for example, has slots that are filled by different arguments from one use to the next. Psycholinguistic experiment has revealed that even frequent VP idioms such as *kick the bucket* are analyzed in on-line sentence comprehension (Pederson et al. 2001). In fact, VP idioms have to be analyzed since their internal structure is minimally variable: the verb may be variably marked for tense or agreement (*kick the bucket; kicked the bucket; kicks the bucket*).
8. See Tomasello and Stahl (to appear) for arguments that extreme care must be taken to avoid confusing high frequency with early acquisition when intermittent sampling techniques are used. Ninio's (1999) data combined parental reports with intermittent sampling, so the data should be reliable (unless high frequency affects maternal reports).
9. See Cartwright and Brent (1997), Morris and Cottrell (1999), and Morris et al. (2000) for suggestions of how more intricate syntactic category and grammatical relation properties may be acquired on the basis of distributional properties of the input.
10. Ninio also includes data from a single English-speaking child, Travis (from Tomasello 1992); however, the English data presented is highly equivocal, since one of Travis's first two SVO expressions (*Big Bird ride horsie*), involved *ride*, a word unattested in any of the Hebrew-speaking children's early transcripts. Travis's second VO combination

was *Find-it funny* which does not clearly involve an object, since *it* is parsed by Ninio as a nonreferential verbal clitic. Also, only one out of four of the earliest VO and SVO utterances involved the idea of "obtaining" although this idea is said to account for 78.1% of the earliest Hebrew utterances. None of these discrepancies are material to the current proposal, since we do not claim that general-purpose verbs are necessarily the very first verbs uttered.

11. Silverstein (1976) observed that patients that are stereotypical in terms of being inanimate and causally affected are often unmarked, *pace* Ninio.

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