January 2001

Kidz in the 'Hood: Syntactic Bootstrapping and the Mental Lexicon

Jeffrey Lidz
University of Pennsylvania

Henry Gleitman
University of Pennsylvania, henry@psych.upenn.edu

Lila Gleitman
University of Pennsylvania, gleitman@psych.upenn.edu

Kidz in the 'Hood: Syntactic Bootstrapping and the Mental Lexicon

Abstract

This paper explores the limits of syntactic bootstrapping and demonstrates that the use of syntactic structure to build verb meanings is constrained to operate only within 'frame neighborhoods,' i.e., complement types that antecedently share formal and interpretive features. The results suggest that inferences over change in number of arguments are easier than inferences over change in type of arguments. This kind of finding establishes the limits within which the 'syntactic bootstrapping' paradigm for verb learning can operate, and also has implications for whether we should think about the architecture of the lexicon in projectionist or constructionist terms.

KIDZ IN THE 'HOOD:

SYNTACTIC BOOTSTRAPPING AND THE MENTAL LEXICON

Jeffrey Lidz, Henry Gleitman and Lila Gleitman

University of Pennsylvania

Recent findings and theorizing on child language acquisition suggest that the verb lexicon is built by an arm-over-arm procedure that necessarily constructs the clause-level grammar of the exposure language on the fly as it acquires individual items (Gleitman, 1990; Gillette, Gleitman, Gleitman, and Lederer, 1999). This active learning process is likely to play a causal role in determining the adult linguistic representations, particularly at the interface between the lexicon and clause structure. This paper presents two experiments designed to explore this idea: The first experiment examines an aspect of child verb learning, its sensitivity to structural information. The other examines adult representations of the same items that figured in the child experiment.

More specifically, the experimental work explores grammatical architecture in regard to relations between clause structures (or "frames") and classes of verb meanings. An apparently paradoxical fact about such verb-to-frame relations is that verbs are very choosy about the structures in which they appear, but at the same time they are "coercible," that is, understandable in brand new structures. For example, the sentence *Horace thought the stick to James* is both bad and good. It sounds "wrong," to be sure. Yet one easily understands it as a case of psychokinesis: Horace is

causing the stick to move to James via an act of thinking.   Our aim is to understand the scope and limits of such comprehensible innovation in adults, limits that apply in analogous ways to constrain the child's structure-dependent verb learning.

In the introductory remarks below, we attempt first to lay out the motivations behind recent theories of the verb learning process that emphasize its sensitivity to linguistic-structural information. Second, we introduce two well-known linguistic proposals of the syntax-lexicon interface that have the potential to account both for the learning facts and for adult representations at this level: the *lexical projection hypothesis* and the *frame semantics hypothesis*. After reporting the experimental work, we will try to adjudicate between these proposals in terms of the findings.

The role of syntactic structure in verb learning

The extralinguistic contingencies for the utterance of a word are extraordinarily variable. Indeed, Chomsky's analysis of the relatively "stimulus-free" character of language use was a major causal factor in redirecting inquiry into the psychology of language in the present generation (Chomsky, 1959). What goes for language use undoubtedly goes for language learning as well. If the adult community cannot be trusted to narrowly circumscribe the conditions under which they will utter a word, then an unaided word-to-world pairing procedure (as described in, e.g., Locke 1690; Hume 1738; Pinker 1989) cannot provide sufficient evidence for vocabulary acquisition.

Recent findings document that this problem is particularly severe for the case of verbs. Verb use even by mothers of very young children lines up very poorly with ongoing events (Lederer,

Gleitman and Gleitman 1995). Relatedly, observation makes available many salient verb-like descriptions of a single observed event (Landau and Gleitman, 1985; Gillette et al., 1999). Consider, for example, a child walking towards her mother, bearing a doll. Suppose that the mother now says "Are you *bringing* the doll?" This event is supportive evidence for learning that /briŋ/ is English for the meaning BRING, to be sure.[1] The trouble is that the same word-world pair is just as supportive for conjecturing that HOLD, BRING, TOUCH, PLAY WITH, NEAR, etc., are the meaning of the new item. This problem reaches the limit with verbs like *give/get*, *lead/follow,* and the like, which describe identical events from different participant-perspectives: Whenever one party can be said to *give*, the recipient can be said to *get.* In these cases, cross-situational observation alone cannot redress the insufficiency of context (Gleitman, 1990).

As a way to overcome the difficulties of observational learning of verb-meaning, the Syntactic Bootstrapping hypothesis posits that one important source of additional information lies in the systematic relationships between verb meaning and syntactic structure (Landau and Gleitman 1985; Fisher, Gleitman, and Gleitman, 1994; Fisher, 1994; Snedeker and Gleitman, submitted). Because they can find a reliable mapping between syntax and lexical semantics, children make use of this mapping in learning verb meanings.

The Syntactic Bootstrapping hypothesis finds support in several results. First, maternal speech in several languages maps a highly overlapping verb-meaning set onto the same range of complement structures (Lederer et al., 1995 for English; Li, 1994 for Mandarin; Geyer, 1998 for Hebrew[2]). Children as young as 16 months old have been shown to be sensitive to properties of

heard speech that could render aspects of these linkages useful, e.g., the thematic/semantic differences between subjects and objects (Hirsh-Pasek et al., 1985). Indeed, there is some evidence that some syntax-semantics correspondences at this level are unlearned. Isolated deaf children project about these same structures for the same predicate meanings in their self-invented gestured languages (Feldman, Goldin-Meadow, and Gleitman, 1978; Goldin-Meadow and Mylander, 1984; Senghas, Coppola, Newport, and Supalla, 1997).

There is also evidence that young children actually make use of structural evidence in their verb learning. For instance, by about 24 months they will use information from the number of noun-phrases in the utterance to choose between situationally plausible interpretations that differ in argument-number of the implied verb (Naigles, 1990). Children this age have also been demonstrated to be sensitive to syntactic cues in learning the specially problematic verbs like *chase/flee*, which differ only by the perspective they take on the events they denote (Fisher, Hall, Rakowitz, and Gleitman, 1994; Fisher, 1994). Finally, in an act-out task in which children were presented with verbs that they already knew in novel syntactic frames, young children systematically altered the meaning of the verb to fit the meaning associated with the syntactic frame (Naigles, Gleitman and Gleitman 1993). For example, asked to act out "Noah comes the elephant to the ark," they pick up first Noah, then the elephant, and move them together to the ark. That is, ditransitive *come* must mean something like BRING. In this sense, young children are *frame compliant,* altering their construal of the verb to fit its new linguistic environment.

All these findings go to the idea that the learning procedure in some way makes joint use of the structures and situations that co-occur with verbs so as to converge on their meanings. Neither source of evidence is strong or stable enough by itself, but taken together they significantly narrow the search space.[3]

Despite all the growing evidence for a structure-aided learning scheme for the verb vocabulary, there is at least one potentially discordant note in this literature. The tendency to reconstrue old verbs in new syntactic environments (*frame compliance* as just desribed, e.g., interpreting 3-argument *come* as BRING*)* diminishes with age (Naigles et al, 1993; Naigles, Fowler, and Helm,1992). Adults and even, to some extent, 5-year olds tend to maintain the original meaning of the verb (they become *verb compliant*: acting as though the speaker must have erred in the grammar, but not in the meaning, of the sentence offered. For instance, when older subjects hear *come* in a ditransitive environment, they are inclined to construe it as they have before: They move Noah to the ark (and forget about the elephant) or they move the elephant to the ark (and forget about Noah).

Why should older children and adults seemingly lose the capacity or inclination to use semantically pertinent structural information (that is, the number of arguments) that they evidently exploited when younger to acquire the verbs in the first place? As we will try to show, the answer will not be that the younger and older populations differ either in their theory of grammar or in their lexical representations. Rather, they differ in the conditions under which they invoke the learning

5

procedure itself (i.e., under which they "bootstrap" the interpretation from the surface syntactic evidence).

Before presenting the experiments, we want to characterize two major views of syntactic-semantic linkages that contend in the linguistic and psycholinguistic literature. These alternative architectures, in our view, hold the key to understanding the relation between structure-dependent learning procedures and adult lexical representations.

The meanings of verbs and their syntactic representations

The *linking* problem, as framed by Carter (1976), concerns the relationship between the meanings of individual verbs and the positions that their arguments take in the syntactic structure of a sentence. No one doubts that there are systematic relations between these levels of language description. Clearly, the number of noun-phrases required for the grammaticality of a verb in a sentence is a function of the number of participants logically implied by the verb meaning. It takes only one to sneeze and therefore *sneeze* is intransitive but it takes two for a kicking-act (kicker and kickee), and hence *kick* is transitive.

Of course there are quirks and provisos to these systematic form-to-meaning correspondences, even within single languages. Moreover, interactions of this lexicon-syntax interface with the morphology and surface-structure architecture of particular languages add further layers of complexity in individual cases.

6

At the same time, *universal* linking regularities go beyond the participant-to-nounphrase regularity that we have mentioned so far. A crucial instance is the relation between argument type (i.e., thematic role) and argument position in clause structure (Stowell, 1981; Perlmutter and Postal 1984; Baker, 1985): In the hierarchical geometry of the clause, the agent is higher than the theme which is higher than the recipient.

Interestingly, the correlation just mentioned rises to the level of a universal absolute for the case of transitive activity verbs. In English and all languages we know of, the agent of a kicking act (and all simple acts of motion/contact) will occur in the subject position in sentences about kicking. We find no verbs (like a hypothetical verb *skick)* which could mean roughly what *kick* means but whose agent is realized in object position (cf. Carter 1976):

(1)   a.   John kicks Bill

        b.   * Bill skicks John

To return to the more general point, verbs that share certain semantic properties also share properties of their syntactic distribution (Carter 1976; Grimshaw 1990; Gruber 1965; Jackendoff 1972, 1983, 1990; Levin 1993; for experimental evidence, Fisher, Gleitman, and Gleitman 1991; Kako, 1999). The existence of such linking regularities in natural language suggests that speakers' grammatical knowledge includes principles that provide a systematic mapping between semantic and syntactic structures. Of course, such knowledge constrains both understanding and speech, including the speech of adults to young children.

Within this general and by now uncontroversial framework, there is a bifurcation of theories about the architecture of the syntax-semantics interface at this level. We mention these briefly here, reserving further discussion until the results of the experimentation have been presented:

The lexical projection hypothesis (LPH): This kind of linking theory relies very heavily on verb meanings as the source of lexicon/syntax regularities (Chomsky 1981, Grimshaw 1990, Levin and Rappaport 1995). It holds that the meaning of a verb determines its syntactic distribution, in accordance with a set of (possibly universal) linking rules. The set of possible verbs is determined by these same rules. Hence a verb like *kick*, with the meaning given in (2a), identifies two thematic roles (given in (2b)) which map onto an argument-structure representation (2c) in accordance with a thematic hierarchy:

(2) a. <u>kick</u>: X touches Y forcefully with X's foot   (meaning)

b. X = agent, Y = patient   (theta-roles)

c. (X (Y))   (argument-structure)

The *projection principle* (Chomsky 1981) requires that all of this lexical information be syntactically represented. Hence, prominence in the argument-structure maps to syntactic prominence (Grimshaw 1990). Therefore, given a structure like (3), the agent must occur in subject position and the patient in object position.
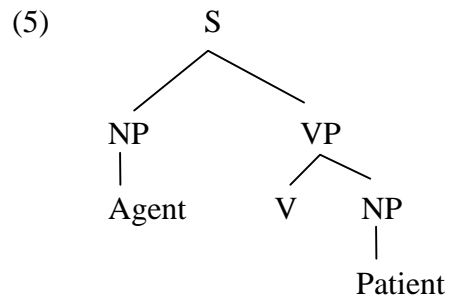
(3)

```
                  S
              /       \
           NP           VP
            |         /     \
         X_agent     V       NP
                     |        |
                   kicks    Y_patient
```
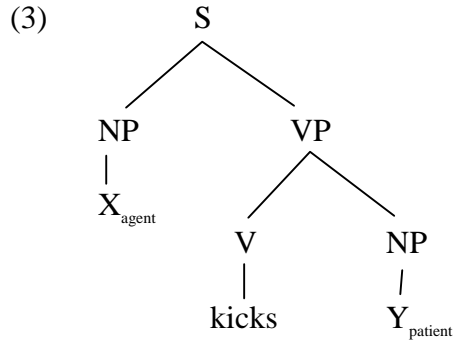
The frame semantics hypothesis (FSH). This hypothesis accounts for the observed syntactic-semantic correspondences with quite a different apparatus (Fillmore and Kay, 1993; Goldberg, 1995). Though its general perspective can be identified in many different guises in the hands of different theorists, the basic idea is that syntactic structures bear meaning over and above the meanings of the lexical items in them. The interpretation of a sentence is dependent on unification of the verb's meaning with the structure's meaning. On this view, the lexical entry includes a meaning and the number of participants entailed by that meaning, as in (4).
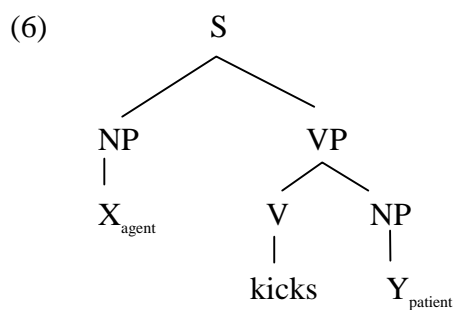
(4)   <u>kick</u>:   touch forcefully with foot; 2 participants

The lexical entry for the transitive construction indicates a syntactic structure and the thematic roles assigned in the relevant positions of that structure:

9

(5)

```
              S
           /     \
         NP        VP
         |        /   \
       Agent     V     NP
                       |
                    Patient
```

The lexical entries of the verb and the construction are then unified so that the interpretations assigned to the participants entailed by the verb are attributable to the structure and not to any inherent property of the verb:

 (6)

```
              S
           /     \
         NP        VP
         |        /   \
       X_{agent}  V     NP
                  |     |
                kicks  Y_{patient}
```

The syntax-lexicon interface, and the vocabulary learning problem

The experimentation that we now report attempts a partial adjudication of these approaches, by asking how children exploit syntactic information in heard sentences. Methodologically, we build upon the findings of Naigles et al (1992, 1993), discussed earlier, about child responses to old verbs in new syntactic environments. Here we enlarge the types of ungrammatical structures that we ask our subjects to understand so as to find the edges of a learning procedure that can make use of syntactic information. We believe that the boundary conditions on this procedure -- the limits

within which syntactic evidence influences the interpretation of co-occurring events -- are informative about the character of the linking theory itself

An experimental inquiry: The Limits of Frame Compliance

Design and Procedure

As in Naigles et al 1993, we asked young children to act out utterances using a Noah's Ark toy, complete with animals, as the vehicle. The stimulus set consisted of 32 utterances containing eight verbs, two from each of four verb classes as shown in Table 1.

Table 1:

	come/fall	lift/drop	ask/tell	think/guess
Intransitive	*Grammatical*	*	*	*Grammatical*
Transitive	*	*Grammatical*	*	*
Infinitival complement	*	*	*Grammatical*	*
Tensed S complement	*	*	*	*Grammatical*

The full set of utterances for two sample verbs was:

(7)   a.   The giraffe falls
          b.   * The zebra falls the giraffe
          c.   * The zebra falls the giraffe to jump
          d.   * The zebra falls that the giraffe jumps

(8)   a.   * The giraffe asks
          b.   * The giraffe asks the zebra

c.   The giraffe asks the zebra to jump

d.   * The giraffe asks that the zebra jumps

Each child was asked to act out eight such sentences, four of them grammatical and four of them ungrammatical.[4] Within the ungrammatical items, each child's stimulus list contained sentences that we characterized as either "Far" or "Near," depending on the following properties of the verb's normal complement with respect to the complement in the frame: *Ask, tell, think,* and *know* are "S-expecting" because they take sentential complements that denote propositions whereas *come, fall, drop* and *lift* are "NP-expecting," because they take NP complements that denote entities.[5] An NP-expecting verb in an ungrammatical NP-expecting frame is classified as "Near," whereas such a verb in an ungrammatical S-expecting frame is characterized as "Far". Similarly, an S-expecting verb in an ungrammatical S-expecting frame is characterized as "Near," whereas such a verb in an ungrammatical NP-expecting frame is characterized as "Far."

As can be noted from inspection of the examples in (7-8), sentences in the "Far" category sound noticeably more anomalous than those in the "Near" category: that is, (7c) sounds "worse" than (7b) because the former, but not the latter, violates the expectation of argument-type. As the examples in (7-8) also show, even when the verb occurs with a frame of the type it normally expects, the utterance may still be ungrammatical. Thus (8d) exhibits a*sk* in an "S-expecting" frame, but in a tensed-sentence complement of the kind that is more natural to such verbs as *think* (*The giraffe thinks that the zebra jumps*). In (8c), we observe *ask* in its licensed S-expecting frame, one with an infinitival sentence complement. Relatedly, the NP-expecting frames also subdivide, this time

according to the number of argument positions in the clause. Thus, c*ome* and *fall* differ from *drop*

and *lift* in that the former verbs take only one argument (as in 7a) while the latter take two

arguments.

Summarizing, the materials subdivide in two cross-cutting ways; first, according to the

"Near" and "Far" categories; and second, into "grammatical" versus "ungrammatical."

Table 2:

		NP-expecting Verbs		S-expecting Verbs	
		come/fall	drop/lift	ask/tell	think/know
NP-frames	Intransitive	*Grammatical*	NEAR	FAR	*Grammatical*
	Transitive	NEAR	*Grammatical*	FAR	FAR
S-frames	Infinitival	FAR	FAR	*Grammatical*	NEAR
	Tensed S	FAR	FAR	NEAR	*Grammatical*

Subjects

The subjects were 22 children between the ages of 3:1 and 3:10 (mean age =3:7), tested

individually. Subjects of this age were chosen because children at this age were most likely to be

frame-compliant in previous studies (Naigles, et al., 1992, 1993) and we wanted to determine the

extent of frame-compliance that would be found with a broader range of verbs and frames than had

been previously tested. Each subject was asked to act out ten sentences using toy animals from a

Noah's ark playset, two grammatical warm-up sentences containing *jump* and *hit,* followed by 8 test

13

sentences consisting of 4 grammatical and 4 ungrammatical sentences in random order. With this number of subjects performing this number of the actions, each test sentence was probed four times. Two subjects were eliminated from the study because they acted out only one grammatical sentence out of four as expected. The test items for these subjects were then given to two new subjects.

Coding

A coding scheme was developed during a pilot experiment in which we determined what actions were typical for grammatical sentences in the relevant frames. For ungrammatical sentences, the child's actions were coded as "Frame compliant" if they were similar to one that was typical for a grammatical verb in that frame. Actions were coded as "Verb compliant" if they ignored the frame and relied instead on the meaning of the verb.

For example, consider the sentences in (9). (9a) contains the verb *think* in one of its syntactically normal contexts. In response to this utterance, the subjects generally picked up a zebra and made it jump. Now if a subject confronted with (9b) did the same, we coded her response as frame compliant. If instead she acted out a scene in which the giraffe falls or one in which the giraffe jumps, the trial was coded as verb compliant.

(9) a. The giraffe thinks that the zebra jumps

    b. The giraffe falls that the zebra jumps

To assess the reliability of the coding scheme, a second coder observed the videotaped child actions for the responses of 6 subjects under the following conditions: This coder was not told what

utterances the subject was acting out, but rather was asked to describe the subject's actions according to the coding categories. The categorizations chosen were the same as those of the original coder in 91.67% of cases (44 out of 48).

Results

Grammatical Sentences: If the coding scheme is valid, then it ought to produce "frame compliant" responses to grammatical sentences. Overall, 79.17% of the grammatical verb-frame pairings were acted out as predicted by the coding scheme (see Table 3 for a breakdown of frames), a percentage that is acceptably high given the open-ended nature of the task and the tender age of our subjects (Intercoder reliability for the grammatical sentences was 95.8% (23/24)).

Table 3: Percent Predicted Responses to Grammatical Sentences

Frames	Intransitive	Transitive	Infinitival	Tensed S
W/Grammatical Verbs	70	90	80	87.5

Ungrammatical Sentences: Turning now to the test sentences, we found that subjects were more likely to give frame compliant responses on "Near" verb-frame pairs than on "Far" verb-frame pairs. This was determined in the following way. For each subject we calculated a difference score which consisted of the percentage of frame-compliant responses for "Far" verb-frame pairs subtracted from the percentage of frame-compliant responses for "Near" verb-frame pairs. If the difference score was positive, then the subject was more likely to be frame compliant in "Near" trials than "Far" trials. 14 out of 22 subjects had positive difference scores, with 5 having zero difference scores and 3 having

15

negative difference scores (by a runs-test, this tendency toward positive difference scores is significant, p < .021). We next pooled across subjects to derive a mean difference score of +27.05 which is significantly different from 0 (t = 2.72; p < .014).

Table 4 shows the percentage of frame compliant responses given for Near verb-frame pairings and for Far verb-frame pairings for each frame, as well as the difference score for that frame (see also Figure 1). It is clear that, on a frame-by-frame basis, subjects were more likely to act out Near verb-frame pairings as grammatical than they were to act out Far verb-frame pairings as grammatical.

Table 4

Frame	%FC(near)	%FC(far)	Difference Score
Intransitive	85.71	14.29	71.42
Transitive	42.86	7.14	35.72
Infinitival	57.14	30.77	26.37
Tensed S	71.43	50	21.43

The mean difference score for all frames was +37.73, which is significantly different from 0 (t=3.43; p>.042).

Discussion

We pointed out in introductory remarks that very young children efficiently adjust their understanding of a verb meaning in response to new information about the structures in which that verb appears, an adjustment process that we have called *frame compliance*. One of the linguistic-theoretical approaches to lexicon-syntax linking rules seems to have a ready explanation for this effect. This is the frame semantics hypothesis (FSH), for it postulates that some meaning or interpretation is directly carried on this new structure (Goldberg 1995). If, for example, ditransitivity as represented in the geometry in (10)[6] just "means" *transfer*, then it follows that *come* in *"the giraffe comes the elephant to the ark"* must represent the giraffe's transfer of the elephant's position.

(10)

```
                    S
              ⁄        ＼
          NP            VP
         agent      ⁄      ＼
                   V          VP
                  verb     ⁄      ＼
                        NP          V'
                       theme     ⁄    ＼
                              V          PP
                                        goal
```
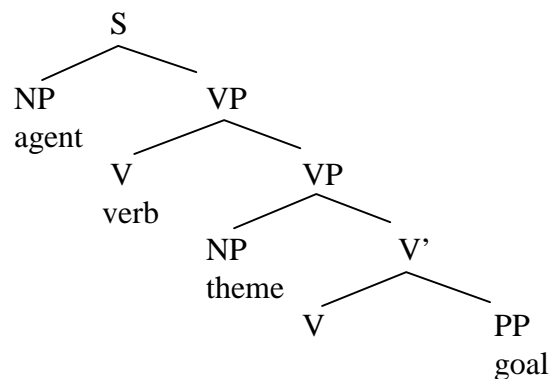
However, as we shall discuss further, this hypothesis has no ready explanation for the present experimental finding: that there are differential tendencies toward frame compliance as a function of what we have called the "Near/Far" distinction. Here, the lexical projection hypothesis (LPH) seems to offer the more telling explanation. Depending on the core lexical meaning of a verb, certain structures are projected for it. Therefore, the more semantically disparate a verb and a frame

17

are, the more anomalous will that combination appear. Once part of a verb's meaning is known, the space of possible meaning extensions for that verb is limited by the possible linkings set up by universal restrictions on syntax-semantics correspondence. In other words, the meaning of a verb and that verb's potential for occurring in a given syntactic environment is not simply a function of the set of constructions that the verb occurs in in the input. Rather, the verb's constructional privileges are determined both by the input and by inherent restrictions on the syntax-semantics mapping.

To further solidify this position, we now turn briefly away from the learning issues – that is, from the response characteristics of toddlers -- to look at how adults respond to the anomalies we have been discussing.

Experiment 2. Adult (Un)grammaticality judgments and the limits of verb-frame integration

Naigles, et al. (1993, 1992) found that frame-compliance diminishes with age and with experience with particular verbs. Adults, and even children by age four, for very common verbs, become verb compliant instead. In response to *The giraffe comes the elephant to the ark*, they are likely to move either the giraffe or the elephant. But, unlike the younger children, they do not impute causation to the giraffe in their act-outs. However, in a more metalinguistic task, subjects are able to interpret certain kinds of ungrammatical sentences consensually (Fisher 1994; Kako, 1999 ; Nagy and Gentner 1990). In the present experiment, we used a scaled ungrammaticality judgment task to determine whether we could find verb-frame neighborhood effects with adults.

Materials, Design, and Procedure

      The materials for this experiment mirror those of Experiment 1. As before, we had two groups of NP-expecting verbs and two groups of S-expecting verbs. In the stimulus materials, all these verbs occurred in the following four frames: Intransitive, Transitive, Infinitival and TensedS, as illustrated in Table 5. And again these sentences were divided into the cross-cutting Near and Far categories, as shown in Table 6:

Table 5

		NP-expecting Verbs		S-expecting Verbs	
		come/go/fall	*bring/lift/drop*	*ask/tell/teach*	*think/dream/guess*
NP-frames	*Intransitive*	Grammatical	*	*	Grammatical
	Transitive	*	Grammatical	*	*
S-frames	*Infinitival*	*	*	Grammatical	*
	TensedS	*	*	*	Grammatical

Table 6

		NP-expecting Verbs		S-expecting Verbs	
		come/go/fall	*bring/lift/drop*	*ask/tell/teach*	*think/dream/guess*
NP-frames	*Intransitive*	Grammatical	Near	Far	Grammatical
	Transitive	Near	Grammatical	Far	Far
S-frames	*Infinitival*	Far	Far	Grammatical	Near
	TensedS	Far	Far	Near	Grammatical

These sentences were randomized and listed on a sheet of paper with a scale next to each

sentence; for example:

(11)   *The zebra came the elephant to the arc   1   2   3   4   5 6 7*

An instruction sheet accompanying the stimulus list asked the subjects to judge on this scale

the degree of (un)grammaticality of the sentences, where 1 represented "perfectly normal" and 7

represented "extremely strange." All grammatical sentences were excluded to avoid compressing

the range of responses for ungrammatical sentences.

Subjects:

The subjects were sixteen undergraduates from the University of Pennsylvania, given lab credit for their participation.   For half of these subjects, the order of the sentences on the response sheet was reversed.

Results

The order in which subjects received the stimulus materials had no effect so we collapse across these order-groups in presenting the results. Mean scores of verb-frame pairings are given in table 7. In Table 8, we collapse these results according to the Near/Far distinction.

Table 7

		NP-expecting Verbs		S-expecting Verbs	
		come/go/fall	*bring/lift/drop*	*ask/tell/teach*	*think/dream/guess*
NP-frames	*Intransitive*	Grammatical	2.29	2.85	grammatical
	Transitive	4.83	Grammatical	2.71	4.06
S-frames	*Infinitival*	5.54	4.25	Grammatical	4.61
	TensedS	5.4	5.71	3.89	grammatical

21

Table 8: all frames

Near	Far
4.167	4.611

The mean difference score for all frames is +0.44, which is significantly different from 0 (t=3.061, p>.0023). This positive difference score means that for adult judgments, just as for child act-outs in Experiment 1, there is an effect of neighborhoods. "Near-extensions" are less anomalous than "Far-extensions."

However, a further result of the present manipulation differs from that obtained for the children: There is an interaction between Frame types (S-frames vs NP-frames) and the Near-Far distinction. This is because, while (as for the child subjects) there is an effect for Near vs. Far among the S-frames, there is no effect for Near vs. Far among the NP-frames for the adults (see Table 9; Figure 2).

Table 9: Verb-type x Frame-type

	NP-expecting Verbs	S-expecting Verbs
NP-frames	3.56 (near)	3.21 (far)
S-frames	5.22 (far)	4.25 (near)

Discussion

One of the major features of the child act-out task was reproduced when adults were asked to provide scaled grammaticality judgments. The subjects did not simply make a yes/no decision (using only the "1" and "7" on the grammaticality scale) but gave higher anomaly scores to the "Far" instances than to the "Near" ones. So in these rankings we see a survival of the child's tendency to find some extensions of verb-frame linkages more natural than others. For adults, much as for children, there are "neighborhoods of frames."

The other finding is that adults are more accepting of extensions of frame privileges within the NP-frames. We suspect that this difference is due to the flexibility associated with the English intransitive frame. The sentences used in this experiment were in present tense. The combination of the present tense with the intransitive frame yields an elliptical reading which is acceptable almost no matter the semantics of the individual verb item. For example, such sentences as "John hits," are rarely heard, just because this verb strongly associated with transitive frames. Yet such a structure will occasionally be used, in case one is describing *hitting* as one of John's habitual activities, his regular business: your son's nursery-school report card might say "John hits" if he is the class bully (or "John tells" if he is the class snitch, "John lifts" if he is the acrobatic expert; and so forth). More to the present point, the availability of elliptical readings for intransitive verbs means that the neighborhood effect shown both for NP-frames and S-frames in the child experiment was reproduced for adults only for the latter verb group.

23

General Discussion

The two experiments just reported add to the literature on how verb semantics can (and cannot) be extended by altering the structural environment. As in the earlier work of Naigles et al. (1992; 1993), we found that children countenanced the use of known verbs in previously unheard frames, and understood the semantic implications of such extensions. We know from Naigles et al. that adults are more reluctant to perform such extensions but, in a weaker test (judgments of grammaticality), we found a residue of the same capacity. Adults found many extensions to be, to a greater or lesser degree, well-formed. The new result in the current studies was that such extensions are not treated uniformly by either population. Adults and especially children drew a line in the sand about certain verb-to-construction pairings, beyond which they would not venture. As one of our child subjects plaintively remarked when asked to act-out *Noah thinks the giraffe to jump*, "What do you want me to do?" We sympathize. That pairing is not even in the neighborhood.

We begin the discussion by describing this *neighborhood effect* as it emerges from these studies. Thereafter, we discuss what this effect may suggest about the architecture of the verb lexicon. The position we attempt to defend is that the neighborhood effects derive from constraints (partly unlearned) on how verb semantics is projected onto the syntax of the clause, just as maintained under the Lexical Projection Hypothesis (Chomsky 1981; Baker 1985; Levin 1993). Consensual verb-extension (or "coercion") effects derive from the heuristics of a learning procedure

that deduces verb meanings by working backwards from the principles of Lexical Projection (cf. Pinker 1989:263ff).

Frame neighborhoods

An important descriptive outcome of the present studies was to reveal the psychological potency of the notion of frame neighborhoods. Evidently, there is internal structure to the frame set in a language. For the sake of an analogy, consider the familiar case of phonetic segments. It is not just that there are 30 or 40 sound categories in a language. Rather, the set of phones is cross-classified into a number of subgroupings, with the consonants divided from the vowels, the stops from the fricatives, and so forth. Within the set, some items are closer to each other than others, a closeness that can be understood in terms of a metric of feature overlap. The potency of the classificatory system shows up in a variety of psychological effects ranging from the perception of phonotactic regularities, to systematicities in language change and linguistic rules generally, tongue-twisters, perceptual confusions, and acquisition phenomena.

Just so, evidently, for syntactic frames. In these manipulations, we could notice two crosscutting properties of frames. Verbs form one subclass that has to do with the category of complement that they license (NP-expecters versus S-expecters). Extension across this boundary is disallowed: Children cannot comprehend it, and adults hear it as grossly malformed. Within each of the two subclasses there are further subdivisions(tensed vs infinitival sentence complementation; argument number for NP-expecters). Extension within these subdivisions is allowed: Children acted out old verbs in these new environments consensually, and adults found them moderately acceptable.

25

In sum, in both phonological theories and in linking theories, explanation is based not on the observable elements -- segments or syntactic frames -- but on the system underlying them, such as feature geometries and clause-projection geometries.

We want to discuss two further issues here as they emerge from the results of this and related experimentation.   The first has to do with the general usefulness of the two linking hypotheses (Lexical Projection and Frame Semantics) for describing grammatical organization, a matter we have repeatedly touched on but will expand below. The second is the place of these hypotheses in understanding how the child constructs knowledge of the language to which he or she is exposed. In so doing, we will posit a distinction -- to us it seems a critical one -- between the heuristics drawn upon as part of a learning algorithm and the knowledge state that is built up on the basis of using that algorithm.

Frame semantics and lexical projection (again)

At the present state of the art, neither of these general approaches has been shown sufficient to handle all of the ornate facts about the syntax-lexicon interface and its construction by language learners. But, as we next discuss, each of these hypotheses has its particular descriptive and explanatory strengths. Perhaps primary for LPH is the scope of this position in explaining cross-constructional linking properties for given verbs and sets of verbs. Symmetrically, the particular strength of FSH is in explaining the properties of coercion, i.e, the environments in which a verb's meaning seems to subordinate itself to the meaning of the frame.

One Good Reason to Believe in Lexical Projection: An important virtue of LPH is that it has a

principled account for why many linking regularities are cross-constructional. That is, properties

of argument realization are not restricted to individual constructions, but rather are equivalent across

syntactic environments. Consider, as illustration, the linking properties of the verb *stuff*. (7) shows

that *stuff* takes a goal argument and an optional theme argument. However, the presence of the

theme depends on the presence of the goal. The theme may occur as the direct object only if the goal

is also syntactically realized (Wasow 1977; Levin and Rappaport 1986).

(12)   a.   I stuffed the pillows.

         b.   * I stuffed the feathers.

         c.   I stuffed the feathers into the pillows.

Importantly, this restriction on the presence of the theme argument also holds in adjectival passive

constructions with the verb *stuff*, as illustrated in (13). Here the presence of the theme as subject in

the adjectival passive depends on the expression of the goal (13b. vs 13c.)

(13)   a.   The pillows remained stuffed.

         b.   * The feathers remained stuffed.

         c.   The feathers remained stuffed in pillows.

If the linking behavior of a verb is due to properties of the construction, as under FSH, then we will

need to stipulate the theme restriction for the transitive construction in (12) as well as for the

adjectival passive construction in (13). On the other hand, if the linking behavior of a verb is due

to inherent lexical properties of the verb in conjunction with general principles of projection, as

27

under LPH, then cross-constructional linking behavior is precisely what we expect. Thus, cross-constructional linking regularities provide evidence in favor of LPH over FSH.

One Good Reason to Believe in Frame Semantics: The meanings of certain verbs are affected by the structures in which they occur. For example, certain verbs of mental state can be interpreted as denoting motion events when they occur in the frames that motion verbs occur in. Consider (14), in which we find a mental verb in a motion frame.

(14)   John thought the book to Mary

To the extent that this sentence is understandable, it denotes an event in which John has telekinetic powers and, by thinking, causes the book to go to Mary (Fisher 1994; Gleitman 1990; Goldberg 1995; Kako, 1999). That a verb's meaning can be coerced by the structure in which it occurs is surprising under LPH. If a verb's meaning determines the range of syntactic structures that it can occur in, then we must say that *think* is motion verb in order to explain the consensual interpretation of sentences like (14). However, thinking events are not normally motion events. Moreover, in other syntactic frames, *think* does not denote a motion event:

(15)   a.   John thought about Mary.

          b.   John thought that Mary was intelligent.

In sum, (14) leads us to the conclusion that *think* is a motion verb and thus can occur in the sentences licensed by motion meanings while (15) leads us to the conclusion that *think* is not a motion verb. And so, LPH requires two lexical entries for the verb *think* despite our intuitions that it is the same verb in (14) and (15). FSH, on the other hand, naturally explains the interpretation of (14). Because

the motion interpretation comes from the frame and not from the meaning of the verb, the interpretive contrast between (14) and (15) falls out for free.[7]

Because the most urgent property of a language description is to account for the unlimited nature of use, the FSH seems here to have won not merely a skirmish but rather to have taken the field. This is because of its natural account of verb extension, or coersion. However, an important detail that vitiates the "explanation" just given in FSH terms is that (14) wasn't grammatical in the first place. To be sure, this sentence is consensually understandable, but all the same it is not quite kosher. *Think* does not "occur" in (14). Rather, it can be "coerced" to go there. In short, the right linking theory must explain two things: why verbs appear in the environments in which they do, and why other (and at the same time, not all) verbs can be made to go there[8] As we will now describe, FSH is best seen as a learning heuristic which works just because it draws on the underlying principles of LPH.

Linking Linking to Learning

Findings under the heading of syntactic bootstrapping have been taken by some to support FSH (Goldberg, 1995; Kako, 1999) whereas the present authors have been rather more agnostic in regard to the lexical architecture that gives syntax-aided learning its ginger (e.g., Gleitman, 1990; Fisher et al., 1994). After all, the FSH story goes, if learners (as well as adults) can make semantic inferences on the basis of syntactic frames, then the frames must carry some semantic load. In the context *The giraffe came the zebra to the table,* the frame adds the meaning CAUSE to the motion

29

semantics (COME) that is supplied by the verb; hence, the composite meaning is equivalent to "*the giraffe brought (=* CAUSED-TO-COME*) the zebra to the table*".

But there is another solution, just the one that is viable under LPH. Via two interrelated principles of lexical syntax, participants in an event will line up one to one with noun-phrases in the clause (Chomsky 1981):

(16)   The projection principle: lexical properties are syntactically realized.

(17)   The theta-criterion: there is a one-to-one relation between thematic-roles and argument positions.

These principles guarantee that *bring (*and not *come)* will license three-argument structures. Because *bring* denotes a two- to three-argument event, the projection principle forces there to be at least two and up to three argument positions (one for the bringer, one for the brought and one, optionally, for the goal). The theta-criterion forces these positions to be filled by independent noun phrases. Similarly, *come* will license one or two argument positions (one for the comer and one, optionally, for the goal). A third argument position for *come* (or a fourth for *bring*) will violate the theta-criterion since we will have no thematic-roles remaining to fill this position.

As just stated, such "principles of language design" seem at first glance too abstract to be in the heads of toddlers. But an implicit appreciation of such form-to-meaning correspondences is made more plausible by considering a variety of well-known phenomena in which these principles appear to figure.

Cross-linguistic regularities in form-to-meaning mappings

In every language, no matter how different these are in other regards, verbs meaning BRING will accept three noun phrases in the clause. For instance, not all languages have different root forms for *bring* and *come*. In Kannada, a Dravidian language of southwestern India, c*ome* (*baru*) and *bring* (*barisu*) share a root *bar-*, the latter word including a causative suffix (*-isu*) (Sridhar 1990). But, whether the root form is the same as in Kannada or different as in English, verbs with these meanings universally will differ in their argument structure in a predictable way. The causal component of *bring*/*barisu* guarantees one argument position more than the noncausative *come/baru* so that the causer can be expressed. Stated more generally, the Projection Principle and Theta-criterion map participants in an event one-to-one onto NPs in the clause.

The invention of language by children:

Another reason to suppose that Principles (16) and (17) are unlearned was mentioned in the introduction to this paper: These principles seem to be required to explain the innovations of isolated deaf children who invent their own communication systems (Goldin-Meadow and Mylander, 1984; Cuppola et al, 1997). For example, Feldman, Goldin-Meadow, and Gleitman (1978) showed that omission and word-ordering patterns in such a self-invented manual system could be understood by supposing that these uninstructed children assigned argument positions on these same principles, with *come* requiring one NP, *throw* two, and *bring* three.

Verb-learning effects: "Overgeneralization"

The ordinary process of verb-learning in children provides further evidence that machinery formally equivalent to the Projection Principle is implicitly guiding the process. As Bowerman (1982) so tellingly demonstrated, we see these principles at work primarily when they have been extravagantly overused, e.g., when the child says "*Don't giggle me"* to convey the idea "Don't make me giggle." To express externally caused giggling requires an additional argument for the ordinarily intransitive *giggle*.

In possession of such principles concerning the syntax-semantics interface, the child learner is not so helpless, as recently suggested by Tomasello (1992; 2000) and Goldberg (1999), as to have to learn the meaning and the syntax of each verb item separately.   Bowerman's findings argue instead that the child who has culled the meaning from informative transactions with the world can project the syntax, based on general principles.

Verb-learning effects: Choosing among situationally plausible interpretations

We have just discussed inferences from verb meanings to verb syntax in young children. The literature also shows us learning influences from the other direction. Very often the child's observations of the scene in view will underdetermine the meaning of a new verb then said, and then the child will choose the meaning consistent with *both* the syntactic and the extralinguistic environment.   A well-known case is from Naigles (1990) who showed infants circa 22-24 months a scene in which a rabbit pushed a duck into a squatting position while both rabbit and duck wheeled

their free arm in a circle. A verb then heard could mean FORCE TO SQUAT or WHEEL ARM.   As shown

in a preferential-looking experiment, these infants (whose spontaneous speech was limited to one

or two words at a time) chose on the basis of the syntactic context in which the word was introduced:

Those who heard "The duck is blicking the rabbit" later looked preponderantly at a video showing

forcing-to-squat without arm-wheeling; symmetrically, those introduced to *blicking* in the context

"The duck and the rabbit are blicking" later looked predominantly at a scene predicting arm-

wheeling without forcing to squat.   In some implicit line of thinking true of young 2-year olds these

subjects must have reasoned "Caused motion requires NPs in two argument positions," i.e., they

honored principles (16) and (17) in selecting among interpretations consistent with the extralinguistic

happenings (for further evidence, see Fisher et al, 1994; Fisher, 1994).

We have just claimed that both children's projections of syntax from knowlege of verb

meaning, a la Bowerman, and their projections of verb meaning from knowledge of syntax, a la

Naigles et al., 1993, and Fisher et al., 1994) derive from their underlying knowledge of lexical

projection principles. For our own familiar *come/bring* example (*The zebra came the elephant to

the ark*), learners apparently did the same. Faced with the ungrammatical sentence, and knowing that

come was a motion verb, the child is able to interpret the sentence causatively. We posit that the

child's deduction from the observed surface form to the meaning is based on the rules that generate

the surface form, that is, on LPH, not on the surface form itself, as hypothesized by FSH. To

illustrate concretely, suppose that the child with an LPH grammar has the lexical entry for *come* in

(18):

33

(18)   a.   <u>come</u>: Y move towards a deictically determined location

        b.   Y = theme

Now, when the child hears this verb in a transitive sentence like (19), the language acquisition device

(LAD)[9] makes the following deductions. "Given that *come* is motion verb and that some motion

verbs have causative counterparts, the lexical entry for *come* must really be (20):"

(19)   The zebra comes the giraffe.

(20)   a.   <u>come</u>: (X cause) Y move towards a deictically determined location

        b.   X = agent, Y = theme.

On this interpretation, the fact that young children were frame compliant is not due to the frames

bearing independent semantic content. Instead, it is due to two factors: (a) they did not have rich

enough lexical representations to distinguish *come* from *bring*, and (b) what they did know about the

meaning of these verbs was compatible with the frame extensions they observed. More generally,

the fact that learners can make semantic deductions on the basis of surface syntactic information does

not entail that such surface information bears that semantic weight in the grammar itself.

Neighborhoods and the linking problem:

We have just suggested that LPH has a principled explanation for our findings and, more generally,

for consensual verb-frame extensions by young children. But the *failures* that we obtained in frame-

compliance argue the case as well as or better than its successes. Recall that the child learners did

not exhibit frame compliance in all cases. They apparently accepted *The zebra comes the giraffe*

acting out a plausible scene with the toy animals. But in response to *the zebra comes that the giraffe jumps*, even these youngsters who have not yet solidified their verb representations balked. As they said, they "don't know what to do." Under LPH, but not under FSH, we can explain why the "Far" verb-frame pairs will not allow such extensions.

Consider what LPH predicts when the child hears a sentence like (21). The child has the lexical representation for *fall* given in (22):
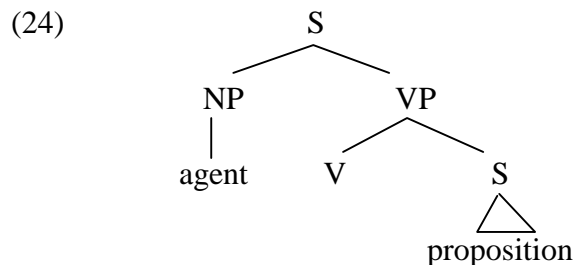
(21)   the zebra falls that the giraffe jumps

(22)   a.   <u>fall</u>:   X move downward

          b.   X = theme

The LAD then makes the following deduction. "In order for this to have been uttered, *fall* must denote a relation between an agent and a proposition. But *fall* is a motion verb and motion verbs, by their nature, never have this character. The speaker made an error. I give up."

A child with an FSH grammar, however, should not be so limited. On this view, the child hears (21) and has the lexical entry for *fall* as in (23) and the lexical entry for the tensed S construction as in (24):

(23)   <u>fall</u>:   move downward. 1 participant

(24)

```
                    S
                 /     \
              NP        VP
              |        /    \
            agent    V       S
                            /\
                        proposition
```

35

The LAD then determines a way that these two entries can be merged, such as: "The giraffe falls while thinking, 'the zebra jumps;'" or, "The giraffe falls and says 'the zebra jumps;'" or, "The giraffe's falling causes him to realize that the zebra jumps;" or something similar which merges the propositional attitude information associated with the frame with the falling activity associated with the verb.

The choice between theories is now straightforward. The LPH predicts the limits of syntactic bootstrapping because of its very nature. Only when a given frame is plausibly projected by the child's hypothesized meaning of a given verb does that frame provide usable information to the learner. The Far cases in our experimentation are naturally excluded. To the extent that frames carry semantic information, they do so by virtue of the rules of lexical projection. If they carried them on their own, the learner would have no reason to reject certain verb-frame pairings and accept others, given that their experience with all of these ungrammatical pairings is equal, that is, zero. If verb-meaning determines the range of possible syntactic structures that a verb occurs in (i.e., LPH), then we expect more frame compliance with "Near" verb-frame combinations than "Far" verb-frame combinations. In short, LPH is a more psychologically useful approach as a description of the lexicon-syntax interface because it predicts the obtained Neighborhood Effect. Of course it is possible to doctor current FSH descriptions so as to limit the frames in which certain meaning-categories of verbs can occur. But to do so is just to eradicate the crucial regard in which these theories differed in the first place: LPH is a theory whose explanation of frame differences makes specific reference to the meanings of the verbs themselves. Insofar as FSH must acknowledge such

verb-specific limits on clause structure, the two positions come closer together; in the limit, they may merge into the same theory.

Age and Lexical Innovation

Naigles et al. (1993, 1992) found another effect in the Noah's Ark procedure that we have so far not discussed: Learners become more and more reluctant with passing developmental time to extend the meanings of old verbs when confronted with their new syntactic environments: Frame compliance diminishes and verb compliance increases with age even though, as Experiment 2 showed, a residue of frame compliance can be seen in the graded nature of adult grammaticality judgments.   Why does frame compliance decrease?

As we have presented the child's use of LPH, the answer to this question is straightforward. The deduction of verb meaning based on an analysis of the surface structure is a learning heuristic. The learning device is asking itself, in effect: Assuming Principles (16) and (17), what could be the meaning of a verb now heard, such that these principles projected this observed (surface) structure for it?   Such a deductive procedure will be invoked only when the learner does not have secure knowledge of the verb in question. We see the procedure at work, therefore, in the child's attempt to understand the new verb *blick* under complex observational introducing conditions (Naigles, 1990). We also see it in the Noah's ark situation for youngest learners who plausibly have not yet closed shop on the meanings of the common verbs. They are still taking in information, guided by the principles of lexical projection, as to what partly-known verbs may mean. Once the learner has secure knowledge of *fall* he considers himself on firm ground in concluding that anyone who says

37

"The monkey falls the giraffe" has mispoken herself by uttering too many or too few NP's in the clause. This is verb compliance.

Final thoughts

Our main purpose in the present work was to understand an apparent paradox. On the one hand, verbs are very choosy about their syntactic environments. *The soup that eats like a meal* and similar deviations from these fixed patterns make most of us wince. But on the other hand, such innovations are common and often effortlessly understood. Poets use them. So do children. Why this rigidity, and why the partial flexibility?

To explain the choosiness of verbs, we defended the position, widely accepted within linguistics, that verbs project their semantics onto clause structure in fixed ways. To explain the innovations, we pointed out that there is some lattitude in this system, which will allow children to over- and under-generalize in certain ways in the course of learning, and will allow verbs to be understood in new environments -- as long as these extensions are in the neighborhood.

Our second aim was to understand some properties of verb learning that have always been known to be connected to this interface of the verb's meaning with its licensed forms. We have suggested that the child's innovative behavior, much broader than that of adults (and often cute as hell), results from his relative ignorance. If the verb's meaning isn't fixed, then neither (within limits) is its syntactic form. But whereas novices may be ignorant of the exact meanings of certain verbs, they display a systematic understanding of the mapping rules themselves, those that generate

the frame-verb correspondences. Because this is so, they are capable of going beyond their input

information in at least two ways. They can pretty well deduce the subcategorization privileges of

verbs whose meanings they know, without having to hear every verb in all of its licensed frames.

And, as we documented in the present studies, they can deduce from newly obtained frame

information new semantic properties of partly-learned verbs.

References:

Baker, M. (1985) *Incorporation*, University of Chicago Press, Chicago.
Bowerman, M. (1982) "Evaluating Competing Linguistic Models with Langauge Acquisition Data,"
    Quaderni di Semantica 3:5-66.
Carter, R. (1976) "Some Constraints on Possible Words," Semantikos, 1, 27-66.
Chomsky, N. (1959) "Review of B.F. Skinner's *Verbal Behavior*," *Language* 35:26-58.
Chomsky, N. (1981) *Lectures on Government and Binding*, Foris: Dordrecht.
Feldman, H., S. Goldin-Meadow, and L. Gleitman (1978). "Beyond Herodotus: The creation of
    language by isolated deaf children," in J. Locke, ed. *Action, Gesture and Symbol*. Academic
    Press: NY.
Fillmore, C. (1971) "Types of Lexical Information," In D.D. Steinberg and L.A. Jakobovits (eds)
    Semantics, Cambridge University Press: Cambridge.
Fillmore, C. and P. Kay (1993) *Construction Grammar,* ms., UC Berkeley.
Fisher, C. (1994) "Structure and Meaning in the Verb Lexicon: Input for a Syntax-aided Verb
    Learning Procedure," *Language and Cognitive Processes*, 9, 473-517.
Fisher, C., G. Hall, S. Rakowitz and L. Gleitman (1994) "When it is Better to Receive than to Give:
    Structural and Cognitive Factors in Acquiring a First Vocabulary," *Lingua* 92, 333-376.
Fisher, C., H. Gleitman and L. Gleitman (1991) "On the Semantic Content of Subcategorization
    Frames," *Cognitive Psychology* 23, 331-392.
Geyer, H.(1998) "Subcategorization as a Predictor of Verb-meaning: Evidence from Hebrew,"
    Unpublished ms. University of Pennsylvania.
Gillette and L. Gleitman (1995) "The Role of Syntax in Verb Learning," in Ritchie and Bhata (eds.),
    Encyclopoedia of Language Acquisition, Academic Press: NY.
Gillette, J., L. Gleitman, H. Gleitman and A. Lederer (1999) "Human Simulation of Vocabulary
    Learning," *Cognition* 73(2):135-176.
Gleitman, L. (1990) "Structural Sources of Verb Learning," *Language Acquisition*, 1, 1- 63.

Gleitman, L., Gleitman, H., Miller, C., and Ostrin, R., (1996) "'Similar' and Similar Concepts," *Cognition*, 55, 321-376.

Goldberg, A. (1995) *Construction Grammar,* University of Chicago Press: Chicago.

Goldberg, A. (1999) "The Emergence of the Semantics of Argument Structure Constructions," in B. MacWhinney, ed. *The Emergence of Language*. Lawrence Erlbaum Publishers: Mahwah: NJ.

Goldin-Meadow, S. and C. Mylander (1984) *Gestural communication in deaf children: The effects and non-effects of parental input on early language development.* Monographs of the Society for Research in Child Development 49.

Grimshaw, J. (1990) *Argument Structure,* MIT Press: Cambridge.

Gruber, J. (1965) *Studies in Lexical Relations* Ph.D. Dissertation, MIT.

Hirsch-Pasek, K., R. Golinkoff, F. DeGaspe-Beaubien, A. Fletcher and K. Cauley (1985) "In the Beginning: One Word Speakers Comprehend Word Order," Paper presented at Boston University Conference on Language Development, Boston.

Hume, D. (1738/1970) *A Treatise of Human Nature, vol 1.* Dent: London.

Jackendoff, R. (1972) *Semantic Interpretation in Generative Grammar*, MIT Press: Cambridge.

Jackendoff, R. (1983) *Semantics and Cognition,* MIT Press: Cambridge.

Jackendoff, R. (1990) *Semantic Structures,* MIT Press: Cambridge.

Kako, E. (1999) *The Event Semantics of Syntactic Structure*. Ph.D. dissertation, University of Pennsylvania.

Landau, B. and Gleitman, L. (1985) *Language and Experience: Evidence From the Blind Child*. Harvard University Press: Cambridge.

Larson, R. (1988) "On the Double Object Construction," *Linguistic Inquiry* 19:335-391.

Lederer, A, Gleitman, L., Gleitman, H. (1995) "Verbs of a Feather Flock Together: Structural Properties of Maternal Speech. In M. Tomasello and E. Merriam, (eds.), *Acquisition of the Verb Lexicon*. Academic Press: NY.

Levin, B. (1993) *English Verb-classes and Alternations,* University of Chicago Press: Chicago.

Levin, B. and M. Rappaport (1986) "The Formation of Adjectival Passives," *Linguistic Inquiry*, 17, 623-661.

Levin, B. and M. Rappaport-Hovav (1995) *Unaccusativity*, MIT Press, Cambridge.

Li, P. (1994) "Maternal Verb Usage in Mandarin Chinese," Unpublished ms. University of Pennsylvania.

Li, P., Burgess, C., & Lund, K. (in press). "The acquisition of word meaning through global lexical co-occurrences," In E. Clark (ed.) Proceedings of the 30th Child Language Research Forum. Cambridge University Press: Cambridge.

Lidz, J., H. Gleitman and L. Gleitman (in prep.) "Morphological Causativity and the Robustness of Syntactic Bootstrapping," University of Pennsylvania.

Locke, J. (1690/1964) *An Essay Concerning Human Understanding*. Meridian Books: Cleveland.

Mintz, T. H., Newport, E. L., and Bever, T. G. (1995). Distributional regularities of form class in speech to young children. In J. Beckman (Ed.), Proceedings of the 25th Annual Meeting of the North Eastern Linguistics Society. GLSA: Amherst, Mass.

Nagy, W. and D. Gentner (1990) "Semantic Constraints on Lexical Categories," *Language and Cognitive Processes* 5:169-201.

Naigles, L. (1990) "Children Use Syntax to Learn Verb Meanings," *Journal of Child Language* 17:357-374.

Naigles, Fowler and Helm (1992) "Developmental Changes in the Construction of Verb Meanings," *Cognitive Development*, 7, 403-427.

Naigles, L. Gleitman, H. and Gleitman, L. (1993) "Syntactic Bootstrapping and Verb Acquisition," In E. Dromi (ed), *Language and Cognition: A Developmental Perspective*, Ablex: NJ.

Perlmutter, D. and P. Postal (1984) "The 1-advancement Exclusiveness Law," in Perlmutter and Rosen, eds. *Studies in Relational Grammar 2*. University of Chicago Press: Chicago.

Pinker, S. 1989 *Learnability and Cognition*. MIT Press: Cambridge.

Senghas, A., Coppola, M., Newport, E.L., & Supalla, T. (1997). "Argument structure in Nicaraguan Sign Language: The emergence of grammatical devices," In E. Hughes, M. Hughes, & A. Greenhill (eds.), *Proceedings of the 21st Annual Boston University Conference on Language Development: Vol. 2*. Cascadilla Press: Somerville, MA.

Snedeker, J. and L. Gleitman (submitted) Why it is Hard to Label our Concepts

Sridhar, S.N. (1990) *Kannada*. Routledge: London.

Stowell, T. (1981) *Origins of Phrase Structure*. Ph.D. Dissertation, MIT.

Tomasello, M. (1992) *First Verbs: A Case Study in Early Grammatical Development*. Cambridge University Press: Cambridge.

Tomasello, M. (2000) "Do Young Children Have Adult Syntactic Competence," Cognition 74(3): 209-253.

van Hout, A. (1996) "Event Semantics of Verb Frame Alternations," Ph.D. Dissertation, University of Tilburg.

Wasow, T. (1977) "Transformations and the Lexicon," in Culicover, Wasow and Akmajian (eds.), *Formal Syntax*, Academic Press, New York.
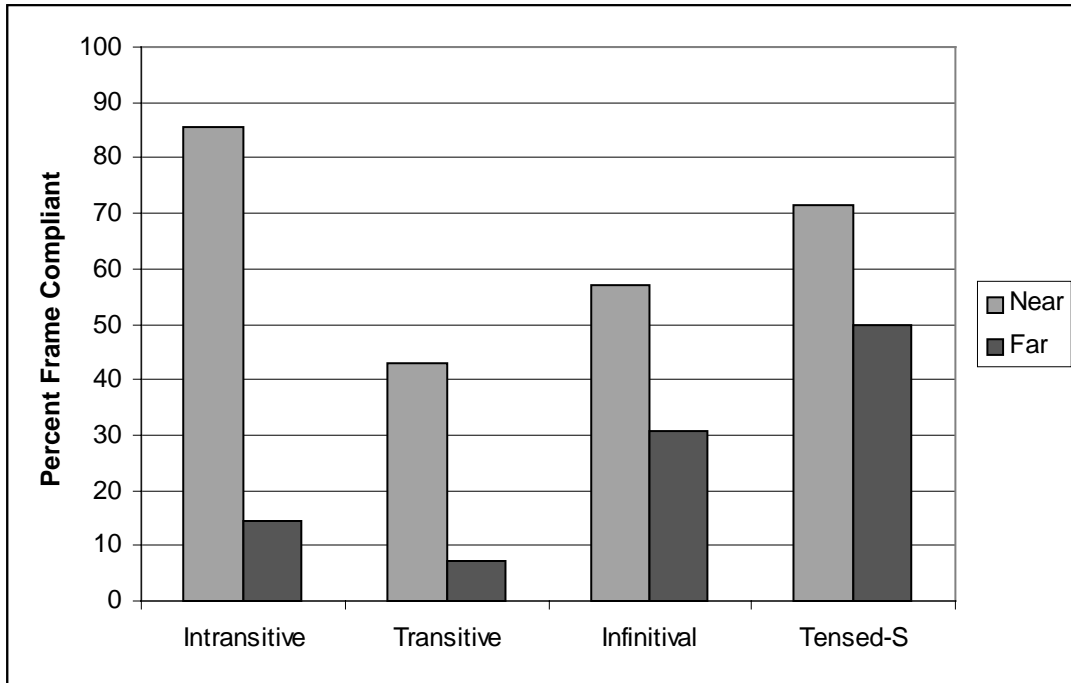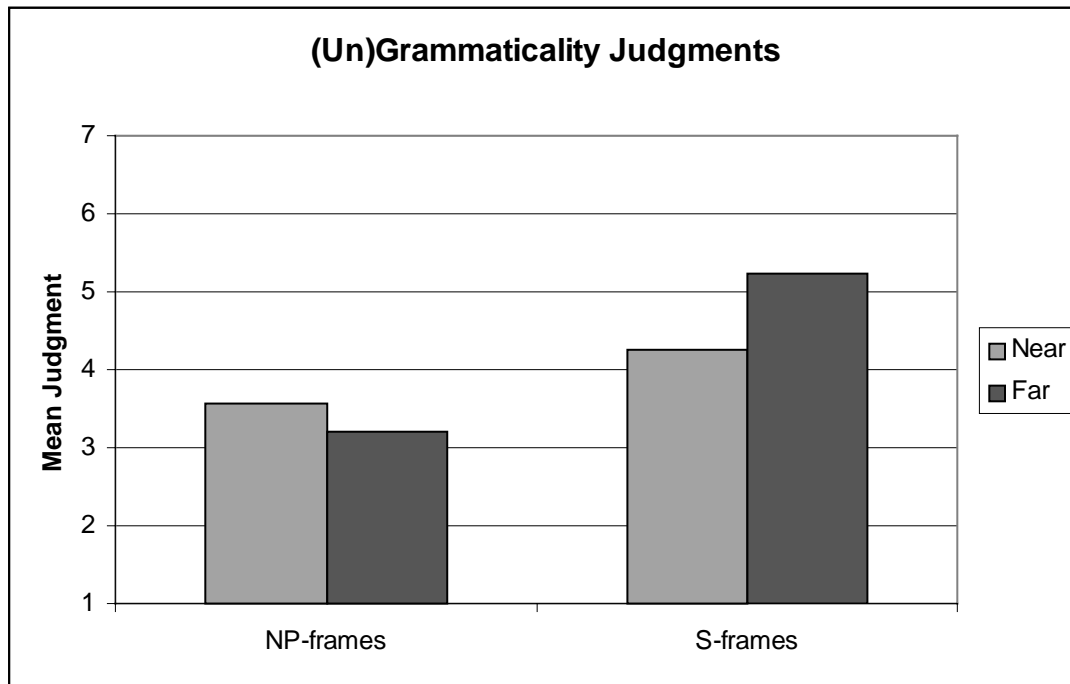
Figures:

41

Figure1

Figure 2

(Un)Grammaticality Judgments

---

[1] We will represent meanings with capital letters and forms in italics.

[2] The languages in these studies were chosen on the basis of their morphosyntactic differences from English, though these differences ultimately do not figure into the mapping between verb-meaning and complementation type. See also, Lidz, Gleitman and Gleitman, in prep.

[3] Recent findings from the experimental literature (Gillette, et al., 1999; Snedeker and Gleitman, submitted) and from corpus analysis (Mintz, Newport and Bever 1995; Li, Burgess and Lund in press) suggest that co-occurrence and selectional restrictions add further probabalistic constraints to the verb-meaning discovery process.

[4] Although there are many more ungrammatical cells in the table than grammatical ones, we presented each subject with an equal number of grammatical and ungrammatical sentences in order to avoid losing subjects due to a large proportion of ungrammatical sentences.

43

---

[5] Note that *come* and *fall* are unaccusative.

[6] See Larson 1988. The proper analysis of the phrase structure of ditransitive sentences is by no means settled (see Pesetsky 1995; den Dikken 1995 and references cited therein). Nothing in our paper hinges on the outcome of this debate.

[7] Richard Kayne (personal communication) points out that not all mental state verbs are grammatical/interpretable in the frame in (9):

      (i)   * John realized the book to Mary

      (ii)   * John knew the book to Mary

What this illustrates is that the aspectual type of a verb must be part of its lexical entry under FSH (just as it is under LPH) and that the lexical aspectual information must be consistent with the aspectual requirements of the frame. Thus, activity verbs like *think* are grammatical in this frame while achievement verbs like *realize* and stative verbs like *know* are not. (see van Hout 1996 for a version of FSH with aspectual information lexically represented). Such "verb class restrictions" on versions of FSH vitiate its claim that frames represent semantics independent of the verbs they contain, and thus make FSH and LPH harder to distinguish.

[8] Coersion does not always result in perceived ungrammaticality, to be sure. In fact, one of the strongest cases adduced within FSH (Goldberg, 1995; see also Kako, 1999) is a sentence like *John sneezed the book off the table.* This sentence sounds perfectly grammatical, albeit slightly metaphorical (i.e., acceptable by analogy to *John threw/slid/blew the book off the table*; these are all *motion verbs*, and their prepositional phrase describes the direction or goal of that motion). The FSH has taken the normality of *sneeze* in this structural environment as an argument favoring separation between the parts of meaning that are "in the verb" and the parts of meaning that are "in the frames" themselves, independent of the verb. This argument is not really as strong as the proponents of this view sometimes claim, however. Notice that *sneezing* (also *caughing*) is the kind of physical act which under many circumstances *can*

cause movement; it is one subcase of *blowing* in this regard.   Therefore its naturalness in this linguistic environment follows from particulars of the verb meaning.   In contrast, other inalienable acts – those that create no puff of air or other caused motion – are grotesque in this same environment (e.g., *John listened/looked the book off the table).*

[9] More accurately, the language understanding device causes the language acquisition device to make the appropriate deduction.