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Edward Kako  
*University of Pennsylvania*

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## Subcategorization Semantics and the Naturalness of Verb-Frame Pairings

# Subcategorization Semantics and the Naturalness of Verb-Frame Pairings

Edward Kako

## 1. Introduction

Do subcategorization frames have meanings independent of the verbs which appear in them? Advocates of the Projectionist position have answered “no” to this question, arguing that subcat frames serve only to satisfy the structural demands imposed upon sentences by the semantics of verbs (e.g., Chomsky, 1981; Pinker, 1989; Levin, 1993). Proponents of the Constructionist position, by contrast, have answered “yes” to this question, arguing that whether a verb and frame can peaceably cohabit in a sentence depends upon whether the two are “compatible” (e.g., Goldberg, 1995).

There are at least two compelling reasons to believe the Constructionist position. The first has to do with verb learning. In many cases, children can't acquire verb meanings just by pairing phonological forms with simultaneous events: Verbs are often uttered when the events they label are not happening (Gillette, Gleitman, Gleitman & Lederer, forthcoming); some events, like thinking, can't be observed at all (Gleitman, 1990); and many events can be labeled by two different verbs, depending upon perspective (e.g., *buy/sell*; Fisher, Hall, Rakowitz & Gleitman, 1994). Learners can use subcat frames to overcome these problems, to “bootstrap” their way into verb meanings when observation proves inadequate (Gleitman, 1990). To take a simple example, a child who hears the novel verb *gorp* in the sentence *Go gorp your truck to Grandma* can infer from its appearance in the dative frame that it likely involves transfer. What *sort* of transfer the child can't know without additional information. But having even this abstract sense can give the learner a substantial leg up in her efforts to fix the word's meaning.

The second reason to believe the Constructionist position comes from comprehension. Adult comprehenders often encounter novel verb-frame pairings which they interpret with little or no difficulty. Consider the two examples below:

- (1) It would be fascinating if adolescents were able to make telephone handsets rocket off their cradles just by thinking at them.  
(Carl Sagan, *The Demon-Haunted World*, 1996)
- (2) We are screamed into submission by the music.  
(Frank DeFord, NPR's *Morning Edition*, 11/15/95)

The verb *think* is not typically a verb of contact, and *scream* is not typically a verb of causation. But when inserted into the frames above (the conative and transitive, respectively), they assume these new meanings. According to the Projectionist line, comprehenders should balk at these innovations precisely because the verbs are put to such extraordinary uses. All the comprehender can do is to look up all meanings of the verb and check to see which meaning would project the attested frame. If no such meaning exists, comprehension ought to fail; the mismatch between verb and frame should prove disastrous. And yet it does not, suggesting that the needs of the verb are not the only ones that matter; indeed, comprehenders take quite seriously the interpretive demands imposed by the frame.

Recent psycholinguistic evidence further supports the Constructionist position. Naigles, Fowler and Helm (1992), for instance, have found that young children interpret novel verb-frame pairings in accord with the demands of the frame, rather than those of the verb. When given a set of toys and instructed to act out the sentence *The zebra goes the lion*, for example, preschoolers make the zebra push the lion rather than make the zebra go *to* the lion (on the plausible assumption that the preposition had somehow been deleted). Since adults never use *go* with this meaning, the causal component could have come only from the frame.

Fisher (1994) has demonstrated a similar finding for adults: When asked to paraphrase dative sentences containing verbs not licensed for that structure (e.g., *Mary thought the book to John*), the vast majority of subjects offered responses including some form of transfer (e.g., "Mary made the book go to John through some kind of mind power."); since *think* does not have this property, it could have come only from the frame.

If subcat frames have meanings of their own, two things ought to be true. First, adult speakers should be able to define these meanings. And second, the naturalness of a verb-frame pairing should depend in large measure on the semantic overlap between the two. The closer in meaning the two are, the more natural their pairing should be.

## 2. Experiment One

How does one ask adult speakers to define subcat frames? One possibility is to ask for paraphrases (e.g., “Tell me what *The rom gorped the blickit to the dax* means”), but responses are highly variable and extraordinarily difficult to code. In order to produce useful data, subjects must have guidance. I thus surveyed the literature on the lexical semantics of verbs – in particular, Jackendoff (1983), Levin (1993) and Pinker (1989) – and assembled a promising set of syntactically relevant semantic properties. Adopting a method developed by Gleitman, Gleitman, Ostrin and Miller (Gleitman, Gleitman, Miller & Ostrin, 1996) to study symmetrical verbs, I then presented these properties as questions to be answered about the verbs in various subcat frames – e.g., “Does *verbing* involve someone or something moving?”

### 2.1. Method

#### 2.1.1. Subjects

Fourteen undergraduates at the University of Pennsylvania participated for credit in an upper-level psychology course. All were native speakers of English.

#### 2.1.2. Materials

Subjects were given, in a printed packet, a set of six sentences, each with nonsense words in the open-class positions, and each with a different subcat frame: intransitive (*The filp tiggged*), intransitive with a prepositional phrase (*The bilp fridded to the aggit*), transitive (*The grack mecked the zarg*), dative (*The rom gorped the blickit to the dax*), sentence complement (*The riff pimmed that the zuff would*

*seb*), and noun phrase plus sentence complement (*The zill ormed the crug to prit*). Following each sentence, subjects answered (on the same page, right below the sentence) a series of questions about the meaning of the novel verb. Table 1 below presents the complete list of questions.

For each question subjects had to answer either “yes” or “no”; across questions, they were permitted to give either answer as often as they saw fit.

### 2.1.3. Procedure

Before beginning, subjects read instructions which told them they would be answering questions about sentences with made-up words. They were told that while they would not know exactly what the sentences were about, they should nonetheless have “a rough idea.” Subjects were also instructed to answer based on what the sentence told them, rather than on what they might imagine to be true.

**Table 1:** List of questions subjects were asked about the nonsense verbs in Experiment One.

<b>Does verbing involve someone or something...?</b>
changing location?
exerting force on someone or something else?
changing possession (being transferred)?
making physical contact with someone or something else?
changing appearance?
being created?
perceiving or sensing something?
having a thought, idea, etc.?
communicating something?
emitting light or sound?
being changed in some way (physically)?
moving in some way?
wanting something?
causing something to happen?
enabling something to happen?
preventing something from happening?

## 2.2. Results

Despite the oddity of this task, subjects had little difficulty identifying the semantic properties of subcat frames, answering in ways one would expect given previous work in lexical semantics. Table 2 presents the results, with the proportion of “yes” responses converted to plus and minus symbols for ease of presentation.

A couple of examples illustrate the systematicity of subject responses. For the dative frame, subjects assented to the properties CHANGE OF LOCATION, TRANSFER, MOTION, and CAUSATION, but rejected (among others) the properties MENTAL ACTIVITY and PERCEPTION. For the sentence complement frame, conversely, subjects assented to PERCEPTION, MENTAL ACTIVITY and COMMUNICATION, but rejected (among others) CHANGE OF LOCATION, FORCE, and CAUSATION.

**Table 2:** Results of Experiment One, showing proportion of subjects answering YES, categorized as follows:

-- < .10; - < .30; + > .70; ++ > .90

	I	I-PP	T	Dat	SC	NP-S
change of location		+	-	+	--	-
force		-	++		--	
transfer	-	-	--	+	--	-
contact	-	-	++		--	
change of appearance		-		-	-	--
creation	-	--	-	--	-	--
perception	-	--	-	--	++	--
mental		-	-	-	++	--
communication			-		+	
emission of light/sound			-	--	-	--
physical change		-		-	-	
motion	+	+		+	--	
wanting	-	--	-	--		--
causing	-			++	-	
enabling	-	-	-		-	
preventing	-	-	-	-	-	

I = intransitive; I-PP = intransitive plus PP; T = transitive;  
 Dat = dative; SC = sent comp; NP-S = NP plus sent comp

### **2.3. Discussion**

The results of this experiment confirm Prediction 1: Adult speakers of English can, with guidance, define the meanings of subcat frames, even when the frames lack open-class content. Exactly **how** subjects do so is not clear. They could be reading semantic properties directly from the frames, or they could be “looking up” the verbs which appear in them, and then reading the properties from the verbs. The answer bears directly on the debate between Projectionism and Constructionism; I return to this important issue in the General Discussion.

### **3. Experiment Two**

On the Projectionist position, verbs place strict demands on the shapes that sentences can take; subcat frames exist only to reflect the underlying semantics of verbs. If subcat frames have independent meanings, we might expect them to place demands of their own on sentences. More specifically, we might expect them to require that the verbs which appear with them be similar in meaning.

In order to test this prediction, I had to (a) identify the meanings of some real verbs to complement the frame meanings identified in Experiment 1; (b) collect judgments about how naturally these verbs and frames go together; and (c) quantify the degree of verb-frame overlap for the different pairings. I could then use the overlap measure to predict the naturalness judgments.

Note that because phases (a) and (b) are intermediate steps, and not experiments in and of themselves, I will report only on the methods of these phases, and not on the results. The only result I will report is from using semantic overlap to predict naturalness.



### **3.1. Phase One: Identifying the Semantics of Real Verbs**

#### **3.1.1. Method**

##### **3.1.1.1. Subjects**

Twelve undergraduates at the University of Pennsylvania participated for credit in an introductory psychology course. All were native speakers of English.

##### **3.1.1.2. Materials**

Subjects were presented, in a written packet, with 12 real verbs of English, two each from six well-known semantic classes: Perception (*see, listen*), Cognition (*think, know*), Communication (*tell, promise*), Motion (*jump, run*), Transfer (*send, give*), and Causation (*throw, push*). Following each verb, subjects saw the same questions as did the subjects in the Frame Properties task of Experiment One (see Table 1 for list). Once again, they had to answer “yes” or “no” to each.

##### **3.1.1.3. Procedure**

Subjects were told that they would be answering questions about the meanings of verbs in their language.

### **3.2. Phase Two: Judgments of Verb–Frame Naturalness**

#### **3.2.1. Method**

##### **3.2.1.1. Subjects**

Eight undergraduates at the University of Pennsylvania participated for credit in an upper-level psychology course. All were native speakers of English.

##### **3.2.1.2. Materials**

The six subcat frames used in the Frame Properties task were “crossed” with the 12 verbs used in the Verb Properties task,

resulting in 72 different verb–frame pairings. All content words except the main verb were converted to nonsense, yielding sentences like *The rom thought the blickit to the dax*. Subjects rated the naturalness of these pairings on a scale of one to seven, one being “awful,” four being “somewhat strange,” and seven being “natural.” Nonsense words did not repeat. The sentences were presented nine per page, arranged such that contiguous sentences never had the same subcat frame, or verbs from the same semantic class.

### 3.2.1.3. Procedure

Before beginning, subjects read instructions which told them they would be rating the naturalness of sentences whose main verbs were real but whose other words were made-up. They were told to ignore the nonsense words as much as possible and to focus on how good the verb sounded in the sentence as a whole.

### 3.3. Phase Three: Calculating Verb–Frame Overlap

To calculate the semantic overlap between a given verb and frame, I used the following equation:

$$\sum_{i=1}^{16} \left( \%YES_{\text{Prop N, Frame X}} - \overline{\%YES}_{\text{Frame X}} \right) \left( \%YES_{\text{Prop N, Verb Y}} - \overline{\%YES}_{\text{Verb Y}} \right)$$

The equation above looks at each of the sixteen semantic properties and checks to see whether the verb and frame “agree,” where agreement can mean either that both *possess* the property, or that both *lack* the property. A frame (or verb) possesses a property if the percentage of “yes” responses given to that property exceeds the average percentage of “yes” responses across all properties for that frame; conversely, a frame lacks a property if the percentage of “yes” responses given to that property is less than the average percentage of “yes” responses across all properties for that frame. Thus a property which registers as “above average” for a particular verb or frame will have a positive value in the equation above, while a property which registers as “below average” will have a

negative value. If a verb and frame agree on a property, the polarity on either side (positive or negative) will be the same, and the product of these values will be positive; if they disagree, their polarities will differ, and the product will be negative. When these products are summed over all sixteen properties, the resulting value reflects the total overlap between verb and frame. A large positive value reflects strong agreement, while a large negative value reflects strong disagreement.

### **3.4. Results**

The correlation between naturalness ratings and verb–frame overlap is 0.50. How do we interpret this value? Is it small or large? Correlations can range in (absolute) value from 0 to 1, where 0 indicates no relationship at all, and 1 represents a perfect relationship. Thus a value of 0.50 represents a moderately strong relationship between semantic overlap and naturalness. Another way to interpret this value is to consider that the square of the correlation represents the amount of variance in naturalness accounted for by semantic overlap. In this case the square of the correlation is 0.25, meaning that 25% of the variance in naturalness ratings can be attributed to the semantic overlap between verb and frame.

### **3.5. Discussion**

While the relationship between semantic overlap and naturalness is meaningful, it is also far from perfect. If frame meanings are as critical as I have suggested, why is the correlation not higher? There are at least three reasons: (1) my tasks neglect some critical semantic properties; (2) frame polysemy creates the appearance of mismatches where none exist; and (3) some facts about subcat behavior can't be reduced to semantics at all.

#### **3.5.1. Properties not accounted for**

Consider the two verb–frame pairings below, both of which were presented to subjects in the Verb–Frame Judgment task:

- (3) The rom listened that the dax would seb.  
(4) The rom saw that the dax would seb.

According to subjects in the Verb Properties task, *listen* and *see* have identical semantic profiles: Both are verbs of PERCEPTION. And since subjects in the Frame Properties task also attributed PERCEPTION to the sentence complement frame, (3) and (4) should both sound natural. But (3) sounds decidedly worse than (4). Why? The answer is that perception takes more than one form; it can be either passive (as with *see*) or active (as with *listen*). Verbs of PASSIVE PERCEPTION take sentential complements, whereas verbs of ACTIVE PERCEPTION take PP complements (as in *The rom listened to the dax*). Why this should be so is not entirely clear. What **is** clear is that I've neglected a difference that makes a difference, thereby deflating the overall correlation between overlap and naturalness.

Another semantic property neglected in this work is aspect. It's become increasingly apparent over the last few years that aspect plays a critical role in the subcat system (Hoekstra, 1992; Tenny, 1994; van Hout, 1996). Consider the following two sentences, both seen by subjects in the Verb–Frame Judgment task:

- (5) The rom thought the blickit to the dax.  
(6) The rom knew the blickit to the dax.

Even though neither of these sentences sounds especially natural (except, perhaps, in a world with ESP), (6) sounds much worse than (5). Why should this be, given that both *think* and *know* involve MENTAL ACTIVITY? The answer is that *think* and *know* differ in aspect: The first is active, the second stative. Because of the event structure it encodes, the dative frame demands that its main verb be an activity (van Hout, 1996). But because my properties assessment tasks don't account for aspect, they underestimate the mismatch between verb and frame in (6).

### 3.5.2. Frame polysemy

The number of semantic classes far outnumbered the number of subcat frames, forcing frames to assume multiple meanings. Responses in the Frame Properties task suggest that subjects were

sensitive to frame polysemy. Given the sentence complement frame, for instance, subjects assented both to PERCEPTION and to COMMUNICATION—mutually exclusive options. The semantic overlap between the sentence complement frame and, say, *think* appears lower than it actually is because subjects have attributed to the frame a property they have not attributed to the verb. But in reality no mismatch exists; *think* may **select** one meaning of the SComp frame over others, but selection is quite different from mismatch.

### 3.5.3. Syntactic idiosyncrasy

While the subcat system hinges in crucial ways on the meanings of verbs and frames, it nonetheless cannot reduce to semantic facts alone. Consider the sentence

(7) The rom knew the blickit.

Subjects in the Verb-Frame Judgment task rated this sentence as highly natural, even though *know* and the transitive are, according to the properties assessment tasks, badly mismatched. The fact that *know* can take an NP as its complement appears to be a syntactic fact, inexplicable on purely semantic grounds (Grimshaw, 1979). Syntactic idiosyncrasies of this sort reduce the overall correlation between overlap and naturalness.

## 4. General Discussion

The findings I've reported here falsify a strong version of Projectionism, one which denies that meaning could ever be extracted from subcat frames alone. But a weaker version of Projectionism is still defensible. Perhaps comprehenders extract meaning from a subcat frame by running their grammars in reverse, isolating one or more verbs known to appear in that frame, and then reading the relevant properties off the verbs. This position, which I'll call "Reverse Projectionism," closely approximates Constructionism, as it too can explain the phenomena which motivate the claim of subcat meanings.

Their many similarities aside, Reverse Constructionism and Projectionism imply different lexico-syntactic architectures. Under Reverse Projectionism, subcat frames don't "own" their semantic properties, but can only borrow them from their lexical allies. Comprehension of lexical innovations would thus entail the access of appropriate verbs. If so, this access process should reveal itself in on-line processing experiments. One might expect, for instance, that access time would vary with the number of verbs a frame takes: the larger the set, the longer the access time. If, however, subcat frames do own their semantic properties, as Constructionism asserts, we should see no such difference. Future work will help to tease these possibilities apart.

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Department of Psychology  
University of Pennsylvania  
3815 Walnut St.  
Philadelphia, PA 19104–6196  
*kako@psych.upenn.edu*