When nonce words behave like "real" words

A case study of the Japanese verb *oso(wareru)*

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1 Introduction

It can never be false to say that the meaning of word *w* in a specific context *C(w)* results from the complex interaction of *w*’s "lexical" meaning *m(w)* and the meaning of *w*’s meaning *m(C(w))* i.e., the "meaning of its context." No lexicographic work can be done without assuming the distinction between *m* and *m(C)* but it is not at all obvious how to make such a decision because we hardly know what *m(w)* really is. This is, in part, what makes it difficult to tell exactly what *m(w)* really is. We approached to this problem experimentally, hoping to forge a connection from the theory of language to real human behaviors.

Based on psychological experiments, called the task of semantic feature rating (SFR) on a Japanese verb, we do two things in this paper. First, we show that the meanings assigned to nonce words in specific contexts are predictable if we suppose that semantic interpretation is situationally based, as claimed by Frame Semantics (FS) [4] and Berkeley FrameNet (BFN) [6, 19] and if we are able to specify, say, in the form of a lattice, the hierarchical system of situations for which candidate sentences are interpreted. We suggest that the situational view could lead to a successful specification of how co-composition [17] is constrained. Second, we pose the question of how contextually induced complex meanings are constructed. Note that such meanings can be specified not only for constituents like "NP-wo V," namely VP of Japanese, but also for nonconstituents like "NP-ga V".[1] How this is handled theoretically is an open question, but we are skeptical of whether an account based on “movements at LF” is a valid account of it since there is no guarantee that an account of this type fits the observed human behavior unless LF movements are proved to be “real.” [NOTE explain LF]

1.1 The basic idea

If human understanding is, as FS claims and BFN assumes, situationally based, it follows that:

(1) *Interpretation as selection:* the interpretation of a sentence *s* = *w*1 *w*2 ... *w*n (*W(s) = { *w*1, *w*2, ..., *w*n }) is not simply "constructed" from the set of lexical meanings { *m*1, *m*2, ..., *m*n } (*m*i is the meaning of *w*i) but is given as a "selection" from a predetermined set of possible situations for which *s* can be interpreted.

(2) *Attraction-to-situation (A-to-S) effect:* Given this selectional property, interpretations of a given sentence *s* are expected to be “attracted” to a particular situation, and word sense modulation arises as a “side effect” of this attraction.

This predicts the following:

(3) A-to-S is effective even if all arguments of a predicate ("governor" in the sense of FrameNet [6]) are not explicitly given as long as “frame-evoking elements,” which do not need to be words and can be collocational units, evoke frames strongly enough.

We tested this prediction (3) experimentally and obtained positive results. To this aim, we used the SFR technique [15]. In an SFR task, roughly, participants are asked to rate a word or phrase within a sentence for a pre-determined set of (usually fine-grained) semantic features or characteristics that seem to be necessary to fully account for the interpretational variation of *S*. Details of the SFR technique are presented in §2.3.

1.2 Why the latent semantics of nonce words?

As pointed out above, a semantic description of any lexical item, say a word *w*, presupposes an appropriate discrimination of *w*’s lexical meaning from the meaning it gains from its context *C(w)*, i.e., so-called "contextual effects.” There is no guarantee, however, that good discrimination can be achieved on all occasions because, in principle, there is no way to do it. We would like to say that this is the “dark side” of co-composition [17]. At present, all we can do is rely almost entirely on the intuition of lexicographers and linguists. We hope that...
our research into the latent semantics of nonce words\(^2\) will contribute to the investigation of a systematic account of contextual effects.

1.3 A theory of semantic attraction

1.3.1 Comparison of “constructivist” and “selectival” theories

Most theories of semantic interpretation, e.g., Generative Lexicon Theory (GLT) [17], are “constructivist” ones in that the meaning of a complex unit (e.g., phrase and sentence) is constructed from the lexical meanings of its “parts.” This is the traditional view of the meaning of construction. However, another kind of model is conceivable. We may refer to a “selectival” theory (as in the Darwinian theory of evolution). Let us begin by examining what will happen if semantic interpretation is “selectival” rather than purely constructive in nature.

One of the best examples of a selectival theory of semantic interpretation would be Optimality Theory (OT) [2, 16]. It is selectival in that it characterizes the interpretation of a given sentence as the selection of an “optimal” interpretation. An optimal interpretation is the interpretation that wins out of a set of “candidate” interpretations generated in some way.

Note that, under this selectival view, semantic interpretation need not be truly compositional. The component for candidate generation, usually called GEN in the OT literature, may need to be compositional, whereas the component for output evaluation, usually called EVAL, cannot be. What the evaluation component does is select the one best candidate. In OT, this is implemented by a “ranking mechanism.” Candidates generated by GEN are “scored” against a set of “constraints” and ranked according to their scores.

A more radical model is conceivable, however. Note that even GEN need not be compositional when candidate generation is done by enumeration. We interpret Frame Semantics (FS) as implementing such a radical model in a sense to be explained later.

It is well-known that GLT argues against the so-called “sense enumerative lexicon.” But it is not clear what happens if we conceive of a database that enumerates all the situations for which all sentences are interpretable. We investigate this in some detail below.

1.3.2 Test of the selectival view of interpretation

We interpret FS as another, more radical selectional theory, since FS allows words and phrases in a discourse to freely “evoke” frames independently of each other. In a radical interpretation, there is no requirement for structure building to occur.

Based on this, we can hypothesize the following:

(4) Possible semantic interpretations of a given sentence \(S\) are “attracted” to (ideally) one of the most likely situations.

If this prediction is correct, then a nonce word \(w^*\) should be feature-rated very much like a real word if the context of its occurrence \(C(w^*) = W(s) - w^*\) (meaning word sequence except \(w^*\) ”evokes” a specific situation strongly enough. We tested this hypothesis through psychological experiments using sentences containing osou. As explained in §2.1, the Japanese verb osou is a rather polysemous verb. Its English translations include attack, hit, and seize (see Appendix 2.1 for relevant details). The setting for our experiments is explained below using English analogs.

In our experiments, we used cases such as those in (5) for \(C(w^* \text{ for } \{\text{victim}\})\) and cases such as those in (6) for \(C(w^* \text{ for } \{\text{harm-causer}\})\):

(5) \(\{\text{a. was attacked by}; \text{b. was hit by}; \text{c. was seized by}; \text{d. suffered from}\} \text{ (harm-causer)}\) (or

(6) \(\{\text{victim}\} \{\text{a. was attacked by}; \text{b. was hit by}; \text{c. was seized by}; \text{d. suffered from}\}\).

Our prediction will be confirmed if SFRs for nonce words in \(C_1\) and \(C_2\) conditions are interpreted like real words in \(C_1\), on the one hand, and if they are different from \(C_3\), on the other:

(7) For the passive form “\(X\)-ga Y-ni osowareta,”

a. \(C_0\): \(X\) is a real word for \(\{\text{victim}\}\); \(Y\) is a real word for \(\{\text{harm-causer}\}\) (Baseline 1)

b. \(C_1\): \(X\) is a real word for \(\{\text{victim}\}\); \(Y\) is a nonce word for \(\{\text{harm-causer}\}\)

c. \(C_2\): \(X\) is a nonce word for \(\{\text{victim}\}\); \(Y\) is a real word for \(\{\text{harm-causer}\}\)

d. \(C_3\): \(X\) is a nonce word for \(\{\text{victim}\}\); \(Y\) is a nonce word for \(\{\text{harm-causer}\}\) (Baseline 2)

In (7b), the attraction effect of the word for \(\{\text{harm-causer}\}\) in the osowareru-context can be detected. In (7c), the attraction effect generated by the word for \(\text{victim}\) in the osowareru-context can be detected. We tested this prediction using psychological experiments and obtained positive results.\(^3\) The results for \(C_1, C_2,\) and \(C_3\) were obtained from different groups of participants.

1.4 Review of research into the “semantics of nonce words”

As far as we know, no intensive research into the “semantics of nonce words” has been attempted to date. One study [10] investigated the meaning of “syntactic frame/patterns” in the following way. Nonsensical sentences such as The rom gorped the blickit to the dax, The grack mecked the zarg were presented to participants, who were asked to rate the likelihood of various

\(^2\)We know this phrase sounds really like an oxymoron, but we do not know of any other term to express our concept. This might, we suspect, explain why this line of research is very rare.

\(^3\)To be precise, experiments on osou-contexts and osowareru-contexts were conducted on different occasions, so they are not directly comparable. This paper reports on the latter experiment.
semantic properties that could be true of the nonsense verbs in them. The results suggested that the syntactic frames encoded specific meanings, even if the verbs did not have lexical meanings. This experiment used the same technique as ours, but it had different goals and implications from our results.

2 Specifying “attractors” of interpretation

2.1 Semantics of osou

Let us briefly describe the relevant semantics of the Japanese transitive verb osou that we used in our experiment. It is a rather polysemous verb used to denote a wide range of situations or cases of victimization (but note that Japanese has distinct words for victim, i.e., gisei-sha (犠牲者) and higai-sha (被害者)). Its English translations span over different classes of verbs. The overall picture can be seen from Figure 1. As easily seen, the meanings of osou and osowareru at the most abstract level are (harm-causer)-ga (victim)-wo osou (meaning "(harm-causer) attacks/hits (victim)") and (harm-causer)-ni (victim)-ga osowareru (both mean "(victim) is/are attacked/hit by (harm-causer)").

2.2 Identifying the situation lattice

The system of situations for which F1 and F2 are interpreted is represented by the lattice in Figure 2, which is called a hierarchical frame network (HFN). This was manually constructed from the corpus examples and validated through psychological experiments.

It should be noted, however, that it would not be appropriate to interpret the lattice in Figure 5 as a lattice of osou's lexical meanings. A better interpretation would be that the HFN specifies the (partial) ontology of harm or harm-causation to which osou-sentences always refer. This interpretation was confirmed experimentally in [15].

2.2.1 How the HFN is related to “senses” of osou

Words senses are sensitive to granularity. This means that word sense definitions will make no sense unless they make reference to a level of granularity. The lowermost situations F01, F02, . . . , F15 would correspond to the finest-grained word senses. Most definitions for osou in Japanese lexica come between those two granularity levels. The top division between volitional subjects (\{A, B\}) and nonvolitional subjects (\{C, D, E\}) corresponds to the most basic division of sense differentiation. It is suggestive of osou can be translated as attack or assault for situations under \{A, B\}, whereas it cannot be translated in this way for situations under \{C, D, E\}. For the latter, hit and seize are translations. In particular, seize is appropriate for situations under \{F13, F14, F15\}, except for idiomatic cases like panic attack and heart attack.

The most coarse-grained distinction does not correspond to the distinction between the literal and metaphorical senses. Metaphorical senses appear all around the lattice, as indicated by links in magenta with an “MMI” index, where source and target domains are indicated.

It is reasonable to question if the situation/sense lattice for osou-sentences in Figure 5 has a wide enough coverage of osou-senses, if not exhaustive. Though indirect, we have two sources of evidence. First, the lattice is the result of a careful manual annotation/analysis of all instances (413 in total) of osou- or osowareru-sentences taken from a reasonably large corpus [20] of 500,000 Japanese-English pairs. For instances out of 413, 95% instances of the corpus data were successfully classified. We conducted another psychological experiment [15] to see to what degree the sense hierarchy is valid and obtained a positive result.

Another source is an informal study that found that, while the sense lattice in Figure 5 was constructed to account for the sense variation of osou-sentences, the lattice covered the sense variations of gisei-sha and higai-sha, both meaning victim in English with different connotations. Roughly, 80% of gisei-sha uses and 60% of higai-sha uses were covered, though precise evaluation has not been done yet. In this sense, we guess that the lattice in Figure 5 is not only a lattice of osou-sentences, but also a lattice of victimization situations in general.

2.2.2 HFN specifies units of selectional restrictions

It is reasonable to believe that the situations in the HFN correspond to the “units of selectional restrictions” on osowareru-\mu\text{-}sentences in that each situation specifies a combination of finer-grained semantic roles and only a limited number of combinations are allowed for osowareru-\mu\text{-}sentences. Possible combinations are as follows: (i) “(natural disaster)-ga (area)-wo osou” (meaning “(natural disaster) hit (area)”), (ii) “(man with mal-intention)-ga (opponent)-wo osou” (meaning “(man with mal-intention) hit (opponent)”), (iii) “(robber)-ga (bank)-wo osou” (meaning “(robber) attacked (storehouse of valuables)”), and (iv) “(social disaster)-ga (domain of activity)-wo osou” (meaning “(social disaster) hit (domain of activity)”). This is admittedly a strong claim, but it has been validated through psychological experiments reported in [14].

2.3 Background for SFR

The semantic feature rating (SFR) task, defined in [15], is an experimental procedure in [9], based on a (reasonable) theoretical assumption (8):

\begin{align*}
\text{F01, F02, F06, and F07, and it is hard to use this verb to refer to other situations.}
\end{align*}

\begin{align*}
\text{F01, F02, F06, and F07, and it is hard to use this verb to refer to other situations.}
\end{align*}

\begin{align*}
\text{gisei-sha tends to refer to one or more victims who were seriously injured and dead, whereas higai-sha tends to refer to one or more victims who survived.}
\end{align*}
<table>
<thead>
<tr>
<th>English verbs that translate OSOU</th>
<th>L0 = Sub L1 Level</th>
<th>L1 Semantic Classes at Level 1</th>
<th>L2 Semantic Classes at Level 2</th>
<th>L3 Semantic Classes at Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>attack[+human(s)]; rob</td>
<td>4</td>
<td>7</td>
<td>10 Resource-threatening situations</td>
<td>51 Intended Harm-causation[+animate]</td>
</tr>
<tr>
<td>attack[+human(s)]; rob: break into</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; rob: make off with MONEY</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; rob: hold up</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; rob: threaten</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]</td>
<td>23</td>
<td>23</td>
<td>42 Life-threatening by human</td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; kill</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; assault</td>
<td>9</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; assault: raid</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; assault: shoot</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; assault: shoot: wound</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s); assault: rob</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s)]; assault: stab</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s),+animal(s)]</td>
<td>7</td>
<td>8</td>
<td>9 Life-threatening by nonhuman</td>
<td></td>
</tr>
<tr>
<td>attack[+human(s),+animal(s)]; kill</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attack[+human(s),+animal(s)]; assault[+metaphoric?]; turn on</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: hit</td>
<td>3</td>
<td>8</td>
<td>18 Natural disasters</td>
<td>39 Disasters = Harm-causation[animate]</td>
</tr>
<tr>
<td>hit, strike: rock</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: strike</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: pound</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>hit, strike: destroy: wreak on</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: destroy: ravage</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: roar through</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: sweep through</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: wrought devastation</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: IMPICIT in earthquake</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: IMPICIT in in PLACE</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike: there is</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric, +human(s)]; occur[=attack]</td>
<td>1</td>
<td>2</td>
<td>21 Social disasters[+metaphoric]</td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; hurt</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; hit</td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; paralyze</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; IMPICIT in shocks from</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; overtake</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; take a toll</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; besiege</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; engulf</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; occur</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; fall on</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; IMPICIT in in PLACE</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; IMPICIT in problems</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hit, strike[+metaphoric]; IMPICIT in turmoil</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer</td>
<td>3</td>
<td>5</td>
<td>10 Sufferings</td>
<td>10 Sufferings = Harm-experience</td>
</tr>
<tr>
<td>suffer: IMPICIT in victim</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer: be injured</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer: feel pain</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer: bring sorrow to people</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>suffer: feel anxiety</td>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>suffer: seized with</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer: suddenly begin a SYMPTOM</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suffer: experience attack[human(s), +metaphoric]</td>
<td>2</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 1: English translations of OSOU: variables like L1 and L2 refer to the “granularity” levels defined in Figure 2.
Figure 2: A lattice of situations for which an event sequence is interpreted. Solid black links indicate elaboration relationships. This lattice was designed to capture generalization from more concrete types (e.g., eavesdropping) to more abstract types (e.g., HumanVictimization).
Construct an HFN with a good coverage. Note: an HFN is not verb-specific: it applies to a set of verbs. It is not obvious, however, what verbs belong to what HFN. Determining this requires empirical research.

Find a set of features such as \( f_1 = \text{[visible]()} \), \( f_2 = \text{[carnivorous]()} \) that, in combination, account for the entire HFN. This gives a feature set \( F(n) = \{ f_1, f_2, \ldots, f_n \} \).

Reduce \( F(n) \) to \( F(m) = \{ f_1, f_2, \ldots, f_m \} \) \((m < n)\) by removing redundant features. Such features can be detected if multivariate analysis such as Factor Analysis is applied to \( F \).

Construct the base of the semantic vector \( V_0 = [f_1, f_1, \ldots, f_m] \) based on \( F_0 \). Note that \( V_0 \) defines a “semantic feature space” \( S \) specific for an HFN.

Feature representation of lexical meanings is very common both in psychological research and connectivism modeling. However, as far as we know, there has not been any serious research into what features are needed for what kind of task on a large scale. A noticeable exception is [13], in which the authors attempted a “standardization” of semantic features commonly used in psychological research. If an array of semantic features is interpreted as a semantic vector, then a semantic space approach is possible. Many behavioral studies take this line. On the other hand, though, many psychologists seem to be skeptical of whether sentential meanings can be represented in the same way. This would explain why we did not find any previous research that attempted to represent sentential meanings in semantic vectors.

Several caveats are necessary. First, it is usually efficient if several features are determined in step (10) in the sense that [because?] they contribute to the differentiation of nodes of the HFN.

Different HFNs define different types of [values of?\] \( V_0 \). Thus, \( V_0 \) needs to be modified or sometimes constructed from scratch when a different HFN is investigated. Step (12) can be omitted when \( F \) is not very big. (In fact, Step (12) was skipped in this experiment.)

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### 2.3.2 Why not a binary feature system?

It is traditional in linguistics to represent word meanings as “bundles of features.” Our method deviates from this in that it uses continuous values for features. There are two strong reasons why we did this instead of using the traditional binary values, i.e., 1 (true) or 0 (false). First, most, if not all, features have degrees, so binary decision is simply unnatural. Second, participants are more ready to make semantic judgments with a range of confidence, expressed on a scale from very true (1) to very false (0).

Additionally, binary representation is known to have limitations and to need refinement, especially in a behavioral research setting and in computational modeling of cognitive activities, one of which is language modeling. If the value of a feature is not continuous, then the behavior of the system becomes too brittle and clumsy.

### 2.3.1 Constructing a vector space through SFR

Given a set of sentences \( s_1 = \ldots = s_i \ldots = s_k \) (e.g., a family was hit by a runaway truck) in which target units \( u_1, \ldots, u_k \) (e.g., a family) are to be rated for semantic features \( F(n) = f_1, \ldots, f_m \). Ask a group of participants to rate \( u_i \) in the context of \( s_i \) against all features of \( F(n) \). Average their ratings.

Under (8), the simple procedure in (9) is expected to give a good approximation to the meaning of \( u \) in the specific context of \( s \), which should have undergone co-composition [17], rather than giving the lexical meaning of \( u \).

What the procedure in (9) gives us is an approximation to the location of \( u \) in a high-dimensional space defined by the feature set \( F(n) \). If \( F(n) \) receives a good degree of dimensional reduction to become \( F(m) \) \((n \ll m)\), it is very likely that we will get a set of minimal factors \( F(m) \) that account for the semantics of \( u \).

The approach we took to represent the sentential meanings could be a “semantic vector space” approach to sentential meanings in the following senses.

First, the method we called “semantic feature rating” (SFR) is a natural extension of Osgood’s semantic differentiation method (SD method) [3]. The differences are as follows. In the SD method, the target is lexical meanings, whereas in our method, the target is sentential, complex meanings. In SD, the domain of measurement is limited to a small set of usually emotional or evaluative adjectives: measurements are made on the scales of antonymous adjectives such as good–bad, tall–small, whereas in our model, the domain of measurement is general and basically open-ended propositions such as [alive\((x)\)]: measurements are made on scales encoded by semantic features.

Admittedly, empirical research on how such features are discovered needs to be done. We turn to this in the next section.
2.3.3 Comparison with LSA

A comparison with a relatively well-known model Latent Semantic Analysis (LSA) [12] may be helpful here. In LSA, unlike our approach based on behavioral data, semantic vectors are constructed from corpus data (through a dimension-reduction technique called “singular value decomposition”), though the idea of representing word meanings in vector form is shared. The main difference is that semantic vectors in LSA are very big and that the notion of features is no longer tenable.

Furthermore, sentential meanings are constructed under strict compositionality: the meaning of a sentence $s = w_1 \cdot w_2 \cdots \cdot w_n$ is defined as the (logical) conjunction of semantic vectors $v_1, v_2, \ldots, v_n$ (where $v_i$ denotes the semantic vector of word $w_i$), which corresponds to a particular point in a semantic space.

### Figure 3: 24 features/characteristics used for rating experiment.

3 Experiments

3.1 Procedure

In our SFR task for osou-sentences (explained in §3.2), participants are presented with Japanese sentences in which (i) the main verb is osou (active form) or osowareru (passive form) and (ii) either the subject or object NP is a bisyllabic nonce word, which, therefore, has no lexical meaning.

Participants were asked to rate each of the 24 features in Figure 3 on a five-point scale (from “very true” 5.0 to “very false” 1). The results were averaged. Several types of multivariate analyses (e.g., Principal Component Analysis (PCA) and Factor Analysis (FA)) were applied to it.

3.2 Materials

A Japanese sentence of the form “X-ga Y-wo osou” [active] or “Y-ga X-ni osowareru” [passive]) denotes a situation in which Y is victimized by X, a (harm-causer).

All Japanese examples (in the 6th column) of Figure 4 were constructed for a lattice of situations, presented in Figure 2, with 15 lowermost, most finely grained levels (F01, . . . , F15).6 The lattice of situations in Figure 2 was constructed from a frame-based manual analysis of the 413 examples from a corpus [20], whose validity was confirmed by an independent psychological experiment [15]. We assumed that contextual effects on $w_i$ from its context $s_t$ were factored out and controlled in this way, though this point could, we are aware, be controversial.

4 Results and Discussion

4.1 Main results

For both osou- and osware-sentences, nonce words were rated very much like real words in the way pre-

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6 This does not mean, however, that there are no classifications with a finer granularity than F01, . . . , F15. We plan to conduct an experiment to see if hyper-fine-grained situations in which (attack by a large predatory animal) and (attack by a small predatory animal) can show as much convergence as we had in our experiment that confirmed those 15 situations.
Situation ID | Subject NP denoting Victim | PP denoting Harmer | Translation (word-by-word translation from Japanese assuming that noun translates to attack) | Natural Translation | Original Example (in Passive form)
--- | --- | --- | --- | --- | ---
F01: Power conflict between human groups | The President | an assassin | The President was attacked by an assassin. | 大統領が暗殺に遭われた。 |
F02: Invasion | a country | (other) armed country | An armed country was attacked by another armed country. | ある国が軍事国に攻撃された。 |
F03: Robbery on larger scales | a bank branch | a masked man | A bank branch was attacked by a masked man. | 銀行が蒙面の人物に攻撃された。 |
F04: Persecution/Violence | passengers-by | a lapsed man | Passengers-by were attacked by a lapsed man. | 通行人が障害者に遭われた。 |
F05: Sexual assault | a woman | a pervert | A woman was attacked by a pervert. | ある女性が性的誘惑に遭われた。 |
F06: Preying animal attack | zebras | lions | Zebras were attacked by lions. | シマウマがライオンに遭われた。 |
F07: Nonpaying animal attack, usually for defense | children | 'waps | Children were attacked by waps. | 子どもがススメパラに遭われた。 |
F08: Accident | a family | a runaway truck | A family was attacked by a runaway truck. | ある家族が逃走トラックに遭われた。 |
F09: Natural disaster on smaller scales | a town | gust of wind | A town was attacked by gust of wind. | ある集落が台風に遭われた。 |
F10: Natural disaster on larger scales | a local area | a hurricane, a typhoon | An area was attacked by a hurricane. | ある地域が台風に遭われた。 |
F11: Epidemic spread | a city | influenza, Black Death | A city was attacked by influenza. | ある都市がインフルエンザの流行に遭われた。 |
F12: Social disaster | the stock market | a debacle (or a downturn, sharp fall) | The stock market was attacked by a sharp fall. | 株式市場が崩壊の根拠に遭われた。 |
F13: Long-term sickness | a man | cancer, malignant tumor | A man was attacked by cancer. | ある人が悪性のガンに遭われた。 |
F14: Short-term mental disorder OR sickness | an old man | panic | An old man was attacked by panic. | ある老人が不安に遭われた。 |
F14.3 Short-term mental disorder OR sickness | a man | a sharp pain | A man was attacked by a sharp pain. | ある男性が激しい痛みに遭われた。 |
F15: Short-term mental disorder | a young man | strong jealousy | A young man was attacked by strong jealousy. | ある若者に激しい嫉妬に遭われた。 |
NONSENSICAL | zebras | a masked man | Zebras were attacked by a masked man. | シマウマが蒙面の男性に遭われた。 |

Figure 4: Materials used for experiment, with English translations (passive cases only).

Figure 5: SFR profiles for F13 and F10 (Group 1) and F08 and F11 (Group 2) for “(victim(Y))-ga (harm-causer(X))-ni osowareta” (X = NW (nonsense word), Y = RW (real word)) contexts, comparing the results for the real-word rating (in blue) and two response patterns. For Group 2, two response patterns (both in orange) were differentiated. For comparison, NW-NW response (Baseline 2) is marked in green for F13 and F10.
dicted by the A-to-S effect. This is indicated by the fact that in cases F13 and F10, for example, nonce words for \{victim\} were feature-rated as like real words (a man and a local area, respectively) in the corresponding full sentences, as indicated by the left-side profiles in Figure 5. The same was true of the nonce words for the \{harm-causer\}.

Green graphs for F13 and F10 indicate the NW-NW response. It is reasonable to think, from theory, that these represent the lexical meaning of oso(warer)u. Differences from it indicate the effects of co-composition. It is also reasonable to think of the specific situation closest to the NW-NW response as being the prototypical situation of the events that can be referred to by oso(warer)u. It turned out that F06: \{predatory victimization\} was the nearest situation when the Euclidean distance in the space defined by the first three principal components of the semantic features was used as a measure of dissimilarity. We found that this was a reasonable result.

4.2 Discussion

4.2.1 When metonymic adjustment is called for

SFR patterns for F08 and F11 behaved somewhat differently from the others. Unlike other cases, they reflect "logical metonymy" for \{victim\}, giving rise to two different rating patterns, which correspond to two different orange graphs overlaid in the right-side profiles in Figure 5. It seems that in one response pattern, nonce words for \{victim\} were characterized like [individuals] (e.g., a family) that were at that location at that time;? in another, they were characterized like \{location\}s where \{victims\} were located at the time of victimization. For the former case, a metonymically based reference shift from [place] to [individuals] is observed.

Despite problems like this, it was found that the interpretations of oso(warer)u-sentences do not exceed the range of possible interpretations specified by the situation lattice in Figure 2. This suggests that conventional metaphors are lexicalized and are not as productive as claimed by [11], in agreement with the claim in [1].

4.2.2 Strengths of A-to-S effects

Different nouns have different degrees of A-to-S effects. This is not at all surprising, but it should be noted that nouns showing strong A-to-S effects are names for representative instances of \{harm-causer\} or \{victim\}. Nouns that denote \{harm-causer\}s, on average, were found to have stronger A-to-S effects than nouns that denote \{victim\} when combined with osoou.

4.2.3 Scalability

There is no reason to doubt that this result can be extended to other constructions because there seems to be nothing special about the behavior of the oso(warer)u construction that we investigated. It shows the normal behavior of a polysemous verb.

It is not at all easy, however, to see what will actually happen with other constructions. First of all, if we decided to do the same experiment with another verb V, a different set of situations, desirably in the form of an HFN, would need to be constructed for V. For example, if we decided to test y-ga x-kara nigeru (meaning "y ran away from x" in English), we would need to construct an HFN for this verb. This task would, admittedly, be very painstaking. We have a hope of semi-automated of this take using the method tested in [9].

4.2.4 Trouble with the basic units of evocation

It is hard to reconcile what we have shown with the traditional account of semantic interpretation in which meaning construction is define as a rule-governed, compositional process, but let us try.

As Frame Semantics tells us, words and phrases evoke specific situations, or "frames" in the sense of FS/BFN. Evoked frames are integrated, thereby giving the semantic representation of a complex unit, say of a sentence. Frame integration should be a compositional process. Nothing is wrong so far. But here comes an annoying question, What are the "basic units" of situation/frame evocation? — Are they words or larger units like collocational patterns?

Our results strongly suggest the that larger units have stronger situation/frame-evocation effects than smaller units like words. This implies that collocations patterns are better units of evocation than words. This poses a challenge to any lexicon-building attempt because it questions one of its most important assumptions: Is it really promising to try to build a lexicon that should provide a (desirably) necessary and sufficient information for semantic description? because a lexicon, by its definition, mainly, if not only, gathers meanings of lexical items, typically words. If not, what shall we do?

This also implies that the semantics of regular units may not be as much compositional as is usually supposed to be, because if pairings of surface forms and their meanings are evocation-based, their semantics need not be compositional in the sense of traditional linguistics and logic. In this scenario, semantic specifications are directly associated with collocational patterns, and it is very likely that what Hunston and Francis [8] call "patterns" and what Wray [21] calls "formulaic language" play more vital role than in the traditional account. A similar insight plays an important role in Corpus Pattern Analysis (CPA) [7, 18].

Thus, there seems to be a serious need to establish a good theory of the semantics of collocational patterns, i.e., "superlexical" units, on the one hand, and to reconcile the description of lexical items and that of collocational patterns, on the other. We are not professional lexicographers, and clearly are not qualified to propose any solution to this problem, but we can suggest, we believe, some workaround that would make a lexicon-building task more realistic, building on the seminal work by [5]. We also hope it is compatible with the basic idea underlying CPA.

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?For F08, a family is understood to refer to its members as individuals.
The workaround we have in mind is to make a clever use of ontological information specified in HFNs like the one in Figure 2. Let us explain the basic idea with a few examples. Suppose we are on specifying the semantics of “NP attack NP.” Sentences like The lions attacked a herd of impalas. A group of killer whales attacked a humpback whale can be seen as instances of the \( \{ \text{predator} \} \text{attack} \{ \text{prey} \} \) schema interpreted against the situation of \( \{ \text{predation} \} \). Assuming a proper definition of \( \{ \text{predation} \} \), we can say \( \{ \text{the lions} \} \text{instance-of} \{ \text{predator} \} \), \( \{ \text{a herd of impalas} \} \text{instance-of} \{ \text{prey} \} \), \( \{ \text{killer whales} \} \text{instance-of} \{ \text{predator} \} \), and \( \{ \text{a humpback whale} \} \text{instance-of} \{ \text{prey} \} \), using instance-of link. Recall that the HFN in Figure 2 is the partial specification of the ontology of harm-causation, of which \( \{ \text{predation} \} \) is an instance.

It is important to note that many, if not all, situations are associated with \textbf{role names} equivalent to \textit{predator} and \textit{prey} for the \( \{ \text{predation} \} \) situation. For one, \textit{victim} is the role-denoting noun that is valid to denote any instance of \( y \) on the entire HFN in Figure 2. We have role hierarchies like \( \{ \text{bank} \} \text{is-a} \{ \text{victim} \} \) for \( \{ \text{bank robbery} \} \), \( \{ \text{prey} \} \text{is-a} \{ \text{victim} \} \) for \( \{ \text{predation} \} \). Based on this, we suggest that it is promising to build a lexicon in which senses of the arguments of a predicate (e.g., \textit{attack}) are defined by referring to the \textbf{role hierarchies} derived form the situation hierarchies like the HFN in Figure 2. A clever use of this kind of information should make a lexicon more realistic and amenable to the information encoded by collocational patterns, we believe.

## 5 Conclusion

In this paper, we tried, by presenting psychological evidence, to argue for a radically selectional theory of semantic interpretation based on Frame Semantics, and contrasted it with purely constructivist theories of semantic interpretation. We also pointed out that logically based models of sentential meaning need to be somehow modified to make them compatible with vector space models of it, because there is a large gap between the logical forms and the behavioral data obtained through psychological experiments. We suggested that lexicon-building task can be made more realistic if we employ roles hierarchies derived from situation hierarchies.

### References


