Obtaining Japanese Lexical Units for Semantic Frames from Berkeley FrameNet Using a Bilingual Corpus

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Abstract

An attempt was made to semi-automatically obtain "lexical units" (LUs) for Japanese from the English LUs defined in the semantic frame database provided by Berkeley FrameNet (BFN) using an English-Japanese bilingual corpus. This task was a prerequisite to building a complete database of semantic frames for Japanese. In the task, a Japanese word is first translated into an English word or phrase, *E*. *E* is one of the lexical units that evoked a particular semantic frame, *F*, in the BFN database. When other lexical units of *F* are translated back into Japanese, this defines a candidate set of *F* for the lexical units of *F* in Japanese. The viability of the proposed method was tested on a Japanese verb (*X*-ga *Y*-wo) *osou* (roughly meaning "*X* attack(s) *Y*," "*X* hit(s) *Y*," "*X* surprise(s) *Y*" in English, showing that it is a relatively polysemous word). The resulting translation was compared to semantic descriptions provided by IPAL and Nihongo Goi-Taikei (A Japanese Lexicon), two well-known language resources for Japanese, and also by the Frame Oriented Concept Analysis of Language (FOCAL). The comparison revealed that FOCAL, BFN, Goi Taikei, and IPAL provided finer-grained descriptions in this specific order.

1 Introduction

Making use of deep semantics in information processing is one of the major problems confronting today's NLP community. More and more NLP researchers are realizing that they need semantic/lexical resources that go beyond such ones as WordNet (Fellbaum, 1998) that only specify hierarchical semantic relationships. One of the crucial reasons for this is that raw linguistic data embodies semantic associations that are difficult to capture in terms of such hierarchical relationships, one of which is the so-called "semantic field" effect, a class of associative relationships among words (or concepts). To deal with these issues, deeper semantics are needed with descriptions that incorporate ontological inferences. Let us assume that *X attacked Y* is to be interpreted.[1] This is a complex situation. In interpreting *The man attacked a bank*, it may be necessary to specify (by inference) that the subject used a weapon (e.g., a gun) and his purpose was to obtain money (illegally), whereas in interpreting *The wolf attacked a flock of sheep*, it may be necessary to specify that the subject never used a weapon and its purpose was to eat one or two individual sheep (rather than the entire flock) after killing them. Relevant inferences are clearly situation-based, or "case-based" in the sense of Case-based Reasoning (Kolodner, 1993), and difficult to specify in terms of the lexical semantic descriptions available in resources such as WordNet (Fellbaum, 1998) which don't specify associative relationships among concepts, including the relationships between ROBBER (e.g., a *man*) and WAREHOUSE OF VALUABLES (e.g., a *bank*, *museum*, *jewelry shop*), and the one between a PREDATOR (e.g., a *wolf*) and its PREY (e.g., *sheep*, *rabbit*). Thus, the NLP community has a critical need for resources that encode this kind of information.

Along with PropBank (Kingsbury and Palmer, 2002; Ellsworth et al., 2004), Berkeley FrameNet

[1] One of the anonymous reviewers told us that it was unclear how ontological inferences of this sort are related to BFN's frame definitions. The question boils down to the question of definition, i.e., what kind of information we need to define semantic frames to encode, and as we will see later, this is exactly the question addressed by FOCAL claiming that BFN frames are too coarse-grained to be used as an effective knowledge-base for ontological inferences.

(BFN) (Baker et al., 1998) is an ongoing research project that is attempting to meet the demand for resources that encode deeper lexical semantics by providing a semantic frame lexicon (sometimes called the "FrameNet") and a corpus annotated for semantic information encoded in terms of semantic frames.

Thus far, BFN has produced "a lexical database that currently contains more than 8,900 lexical units, more than 6,100 of which are fully annotated, in more than 625 semantic frames, exemplified in more than 135,000 annotated sentences" (cited from the FrameNet web page). Other ongoing projects, i.e., the German FrameNet or "SALSA" (Erk et al., 2003), the Spanish FrameNet (Subirats and Petruck, 2003), and the Japanese FrameNet (Ohara et al., 2003), are trying to build lexical resources that are compatible with the BFN, but for Japanese at least, no data has been released in a usable form, except for a few annotation examples for verbs of motion.

In sum, no useful resource exists for frame-based description/analysis of Japanese. This is one of the reasons that we attempted the task in this paper, along with our efforts to assess the usefulness of the database provided by BFN.

The anonymous reviewers of our paper pointed out that there have been some similar projects and other methodologies that have tried to translate BFN into other languages automatically, such as BiFrameNet (Chen and Fung, 2004) and Romance FrameNet[2], and that it would have been better to include the comparison against them.

BiFrameNet presented an automatic approach to constructing a bilingual semantic network using the Chinese HowNet, which is a Chinese ontology. While it is an interesting approach, we have not compared their results with ours, mainly because they seem to have used different resources and had somewhat different goals, along with the space consideration.

No papers are released, let alone being available to us, related to the Romance FrameNet project for the time being. We couldn't help putting a comparison with it on hold.[3]

[2] `http://ic2.epfl.ch/~pallotta/rfn/`

[3] One of the anonymous reviewers criticized us for failing to mention Romance FrameNet project in our paper; it is just unreasonable. The project was announced on June 1 on the Corpora Mailing List, just one week before the submission deadline. This means that we had little chance to know about the project unless we were "insiders."

2 Proposed Procedure

We used a bilingual corpus (Utiyama and Isahara, 2003) to examine which semantic frames of BFN contained LUs relevant to the Japanese verb *osou*. JFN, for example, used a mono-lingual corpus to construct the semantic frames. In cases like this, the construction might be inefficient because they have to construct all semantic frames by themselves. But this affects on the reliability of the frames identified and described. This risk of arbitrary description can be reduced by using a bilingual corpus, if it is of high-quality.

2.1 Identifying English equivalents of "osou"

We chose Japanese-English alignments from the bilingual corpus in which the Japanese text contained *osou*, i.e., the target verb. We obtained 135 alignments from the corpus.

The bilingual corpus is consists of two subcorpra. One subcorpus is made of one-to-one alignments. Another is of one-to-many alignments. In the latter, one Japanese sentence is aligned with several English sentences.

In the first case, it was straightforward to specify an English word or phrase that translated the target verb, *osou*. In the second case, however, it is not. So, we singled out an English sentence that corresponds to a Japanese sentence that contained *osou*. In this process, the identification of *osou*'s English translations was done manually.

After this procedure, the following five verbs were identified as English translations of *osou*: *assault, attack, hit, pound,* and *strike*[4].

2.2 Identifying relevant semantic frames

Based on these five verbs, we extracted semantic frames using FrameSQL (Sato, 2003). Semantic frames with LUs that included any of the five verbs were chosen from the BFN semantic frame database (referred to here as BFN).

[4] There were a few other verbs or constructions that served as English translations of *osou* in the alignments: for example, *besiege, engulf, feel pain, occur, hurt, kill, rob, shoot, stab, suffer, wreak on* were used as its translations. But we filtered out those less frequent items (whose frequency is less than 3) for purposes of simplicity.

Based on Frame Semantics (Fillmore, 1982), BFN posits that a semantic frame is an organization of "semantic roles," which BFN terms as "Frame Elements" (FEs). Usually, LUs are instantiations or lexical realizations of FEs. Thus, an LU in a frame, F, is a word, or phrase, that, according to the assumptions of Frame Semantics, "evokes" frame F. The definition of the ⟨Attack⟩ frame in the BFN database is used in Figure 1to illustrate the procedure. As indicated, *assault*, *attack* and *strike* are listed as LUs of the ⟨Attack⟩ frame.

After manually examining all the semantic frames thus obtained, the five BFN frames were recognized as relevant to the various senses of the target word *osou*: 1. ⟨Attack⟩; 2. ⟨Cause_harm⟩ 3. ⟨Experience_bodily_harm⟩ 4. ⟨Cause_impact⟩ 5. ⟨Impact⟩

Semantic frames in the BFN database are supposedly related to one another. There are various relationships, some of which are sometimes encoded by establishing explicit "frame-to-frame relations" (such as "is_used" relation) between two frames. Using this information, we obtained the following relationships between the five frames: 1. ⟨Attack⟩; 2. ⟨Cause_harm⟩, is_used: ⟨Experience_bodily_harm⟩; 3. ⟨Cause_impact⟩, uses: ⟨Impact⟩

2.3 Identifying relevant frame-evoking LUs in English

Each semantic frame has a number of FEs, each of which has lexical realizations, which called LUs. In the work reported here, only verbal LUs were selected as relevant from the English LUs made available in the BFN database.[5] Admittedly, there are a few nominal LUs in certain frames in the BFN, but we ignored them because they found them to be less relevant to our specific task.

After identifying all the relevant LUs for the three frames above, we obtained all the English verbs that translated the senses of the target word *osou* identified in terms of Frame Semantics.

For example, the relevant LUs for the ⟨Attack⟩ frame are the following verbs: *ambush, assault, attack, charge, invade, jump, lay, set, storm, and strike*

As was the case with the ⟨Attack⟩ frame, we extracted the relevant LUs for the ⟨Cause_harm⟩ and ⟨Cause_impact⟩ frames. We manually merged the extracted LUs, and obtained 93 verbal LUs relevant to the Japanese verb *osou*.

2.4 Obtaining LU candidates for Japanese FEs

Table 1: 15 most frequently occurring nouns

Noun	Freq.
jiken (incident)	39
boukou (criminal assault)	32
josei (woman)	28
taiho (arrest)	23
hikoku (accused, defendant)	21
yougi (charge, suspicion)	20
kougeki (attack)	20
shounen (boy)	14
tero (terrorism)	14
shougai (injury)	13
higai (damage, harm)	12
kenkei (prefectural police department)	12
manshon (apartment)	12
butai (military unit)	10
fujo (girl and woman)	10

Using the bilingual corpus again, we gathered alignments that had English texts containing the English LUs specified in the way previously described. We obtained 262 alignments. This procedure defined a set of Japanese sentences containing Japanese words or phrases that were natural translations of the LUs in the BFN.

[5] On this point, we recognize a certain kind of discrepancy between the theory and the practice in the BFN framework. If a LU is, according to its defintion, a lexical realization of a certain FE of a certain frame, more nominals should be identified and listed as LUs. For example, in *Jack ordered a hamburger at McDonald's*, *hamburger* is a noun that evokes the ⟨Cooking_creation⟩ frame. While the ⟨Selling⟩ frame is evoked by *order.v*, this means that, according the definition of LU, *hamburger.n* needs to be identified as an LU of the ⟨Cooking_creation⟩ frame; more specifically, it is an LU that instantiates the ⟨Food⟩ FE of the frame. It is obvious that the QUALIA STRUCTURE (Pustejovsky, 1995) of *hamburger.n* contains information of this sort. We suspect that this aspect of "frame-evocation by nominals" does not seem to be properly recognized and coded, and that BFN's current practice of mostly identifying predicates as LUs is somewhat misleading, if we could say so, because it conceals the fact that there can be, and actually are, many kinds of frame-evoking effects. BFN has been concentrating on identifying LUs for "governors," not LUs for the entire set of FEs, for whatever reason. In this respect, it is crucial to note that not all frame-evokers are frame-governors: *hamburger.n* clearly evokes the ⟨Cooking_creation⟩ frame, but there the noun does not govern the ⟨Cooking_creation⟩ frame. Arguably, it is unreasonable and even gratuitous to posit the ⟨Hamburger⟩ frame to make *hamburger.n* a governor.

Attack
Definition:
An Assailant physically attacks a Victim (which is usually but not always sentient), causing or intending to cause the Victim physical injury. The Weapon used by the Assailant may also be mentioned, in addition to the usual Place, Time, Purpose, and Reason. Sometimes a location is used metonymically to stand for the Assailant or the Victim, and in such cases the Place FE will be annotated on a second FE layer.

As soon as he stepped out of the bar he was SET upon by four men in ski-masks.
Is he INVADING Iraq just to cover other shortcomings?
Then Jon-O's forces AMBUSHED them on the left flank from a line of low hills.

FEs:
Core:
Assailant [Asl] The person (or other self-directed entity) that is attempting physical harm to the Victim.
The mysterious fighter ATTACKED the guardsmen with a sabre.
Victim [Vic] This FE is the being or entity that is injured by the Assailant's attack.
The mysterious fighter ATTACKED the guardsmen with a sabre.

Lexical Units
ambush.n, ambush.v, assail.v, assault.n, assault.v, attack.n, attack.v, charge.n, charge.v, fall.v, incursion.n, invade.v, invasion.n, jump.v, lay_((into)).v, offensive.n, onset.n, onslaught.n, raid.v, set.v, storm. v, strike.n, strike.v

Created by infinity on Fri Nov 22 14:05:22 PST 2002

Figure 1: BFN definition of ⟨Attack⟩ frame (partial)

It should be noted, however, that there is no established method of recognizing these units automatically; they are part of a text without being marked as such. To solve this problem, we hypothesized that their statistical properties in the texts could be used to pick them up; i.e., we assumed that these LUs were relatively specific to these types of texts and would appear at higher frequencies than usual in the collected text.

We collected nouns with higher frequencies under this assumption using a KH Coder [6].

The results were sorted according to the parts of speech. The high-frequency nouns thus obtained are listed in Table 1.

This provided little information about the semantic classification of the nouns because there was no indication of the LUs that they instantiated. Semantic groupings are latent, however. This meant that we were able to "cluster" the nouns based on certain generic properties to obtain an initial approximation of these groupings. We used a tool called `msort` (standing for "meaning sort") (Murata et al., 2001) to establish generic, domain-independent semantic groupings.[7][8]

Nouns occurring more than three times were obtained, as shown below:[9]

human *dansei* (man), *danshi* (boy), *josei* (woman), *fujo* (woman), *joshi* (girl), *danji* (young boy), *joji* (young girl), *youjo* (infant girl), *shounen* (boy), ...

organization *kokka* (country), *gaikoku* (foreign country), *kokusai* (international), *sekai* (world), ...

product *yakubutsu* (drug), *manshon* (apartment), *heya* (room), *keesu* (case), *naifu* (knife), *shoujuu* (rifle), ...

[6] The KH Coder is a free analyzer that uses a combination of ChaSen (Matsumoto et al., 1999) and MySQL. This is freely available at `http://khc.sourceforge.net/`.

[7] `msort` sorts a given set of nouns based on their encodings in a Japanese thesaurus *Bunrui Goi-hyou* (National Language Research Institute, 1964).

[8] One of the anonymous reviewers commented on this "domain-independence" with a critical tone, questioning the validity of the proposed method. This evaluation is clearly based on a misunderstanding: the semantic association, or conceptual dependence, between the ⟨Assailant⟩ and the ⟨Victim⟩ FEs is *already* encoded when we collected only sentences whose main verbs are *osou* (in Japanese texts) or its translations (in English texts). What we have done with `msort` is to get *sub*groupings given a larger semantic grouping of "harm-causing" at a more generic level. Based on our coding experience, we are sure that subclassfication of a given semantic class is based on "semantic types" rather than semantic roles. To give proper subgroupings of the events that the ⟨Attack⟩ frame is relevant, it is necessary to know whether an ⟨Assailant⟩ is a human ([+human, +animate, ...]) or an animal ([−human, +animate, ...]), or whether a ⟨Victim⟩ is a human ([+human, +animate, ...]) or an animal ([−human, +animate, ...]). If we insist that such subclassifications in terms of semantic types into messy details are irrelevant, we are committing what we meant by "mere generalizations for generalizations," failing to recognized what is *really* needed in NLP tasks.

[9] The listings ending with "..." are partial.

body part *itai* (body), *soshiki* (organization)

plant *dansei* (man), *josei* (woman), *soshiki* (tissue)

space *genba* (field), *chiiki* (region), *mokuteki* (purpose), *hokubu* (northern area), *shinai* (city center)

amount *gruupu* (group)

relation *jijou* (circumstances), *keesu* (case), *jitai* (matter), *jiken* (incident), *ryakushiki* (informality), *kankei* (relationship), *mokuteki* (purpose), *genkou* (current), ...

activity *jisatsu* (suicide), *satsugai* (slaying), *shougai* (injury), *juushou* (serious injuries), *ishiki* (consciousness), *utagai* (doubt), *yougi* (suspicion), *sousa* (investigation), *sousaku* (search), *shirabe* (investigation), ...

2.5 Identifying LUs for Japanese FEs

Based on the generic semantic groupings produced by `msort`, we classified nouns into subclasses by intution, so that they corresponded to the FEs of the BFN frames in the following way:

Recall that a semantic frame is a collection of semantic roles, or FEs. In the case of ⟨Attack⟩, the frame has two "core" FEs, i.e., ⟨Assailant⟩ and ⟨Victim⟩, and some other "peripheral" or "noncore" FEs such as ⟨Place⟩, ⟨Time⟩, and ⟨Weapon⟩. Thus, ⟨Attack⟩ denotes a situation in which an agent recognizable as an ⟨Assailant⟩ causes (or tries to cause) some ⟨Harm⟩ or ⟨Injury⟩ to someone or a group of people recognizable as a ⟨Victim⟩ at some ⟨Place⟩ and ⟨Time⟩, sometimes using an item recognizable as a ⟨Weapon⟩.

This means that all we need to do is to classify the nouns in Table 1 into semantic classes such as ⟨Assailant⟩, ⟨Victim⟩, ⟨Place⟩, ⟨Time⟩, or ⟨Weapon⟩, with appropriate subclasses where human assailants are distinguished from nonhuman assailants.[10] The groupings provided by `msort` turned out to be useful for this purpose.[11]

Using this procedure, the nouns obtained on a frequency-basis for ⟨Attack⟩ were classified into the two core FEs, as follows:

- ⟨Assailant⟩: *dansei* (man), *goutou* (burglary/burglar, robbery/robber), *heishi* (soldier), *hikoku* (accused person), *butai* (military unit), *kyoudan* (religious group)
- ⟨Victim⟩: *danshi* (boy), *josei* (woman), *fujo* (girl and woman), *joshi* (girl), *danji* (young boy), *joji* (young girl), *youjo* (infant girl), *shounen* (boy), *shoujo* (girl), *aite* (opponent), *nihonjin* (Japanese), ...

2.6 Advantages of proposed method

Using `msort` turned out to be more beneficial than anticipated when it came to selecting noncore FEs. `msort` helped to determine noncore FEs correctly to a certain extent. The ⟨Attack⟩ frame, for example, includes noncore FEs such as ⟨Place⟩, ⟨Time⟩, ⟨Purpose⟩, and ⟨Reason⟩ in addition to its core FEs, ⟨Assailant⟩ and ⟨Victim⟩. `msort` automatically groups *naifu* (knife), *raifuru* (rifle), and *pisutoru* (pistol) into the "product" category, which corresponds to the ⟨Weapon⟩ FE. Similarly, it automatically groups *chiiki* (Regional site), *hokubu* (northern area), and *shinai* (Inner city) into the "location" category, which corresponds to ⟨Place⟩. Thus, part of the FE assignment task can be done automatically using `msort`.

The procedure also produced some interesting results. For example, the proposed method automatically specifies a set of lexical items (or lexical units) that clearly have the frame-evocation effect but that are not properly identified as frame elements of a semantic frame in BFN, either in terms of core FEs or peripheral FEs (= noncore FEs). The semantic groupings that were thus automatically identified are enumerated below:

1. Names denoting an act(ion) of *N* (*N suru* (or *sareru*)) ("(make) do *N*"): *ranbou* (violence), *boukou* (criminal assault), *bouryoku* (violence), *jikkou* (execution), *shuugeki* (assault), *kougeki* (attack)
2. Names denoting a state of affairs *N* (*V shita* + *N*) (*N* that *S V*): *satsugai* (slaying), *shougai* (injury), *goutou* (burglary/burglar, robbery/robber), *satsujin* (murder), *sasshou* (killing and wounding)
3. Result (*(Y ni) V shite, N wo owaseta*) ("did *V*, and inflicted *N* to *Y*): *juushou* (serious injuries)
4. Parts of the compound words: *kyoushuu* (assault force) (a part of "assault" force)
5. LUs of crime-related frames resulting from ⟨Attack⟩: *utagai* (doubt), *yougi* (charge, suspicion), *sousa* (investigation), *sousaku* (search), *shirabe* (investigation), *kentou* (investigation), *hanketsu* (judgement), ...

A second look at the lexical items in 1 above confirmed that most of these words or phrases can

[10] It is important to note that the target data selection procedure of BFN is biased. For example, they put aside a number of problematic cases like metaphorical expressions, and this is clearly reflected in the current frame definitions. We repeated noticed that metaphorically extended senses of a word were systematically dropped in the current release of BFN. For illustration, the sense of *attack.n* in *heart attack* is not described in BFN. Descriptive "gaps" of this sort are clearly undesirable; some specific kinds of mapping problems between English LUs provided in BFN and Japanese LUs arise from this.

[11] We were sometimes unable to identify an FE for a noun class based solely on the output of `msort`. In these cases, we looked at its usage in the corpus to determine its FE.

be seen as LUs that realize, in Japanese, some of the FEs of BFN's ⟨Attack⟩ frame.[12] As sets of lexical items were not classified automatically, we had to determine all classifications manually.

2.7 Overall results

When the procedure was applied to ⟨Attack⟩, ⟨Cause_harm⟩ and ⟨Cause_impact⟩, the following Japanese LUs for their major FEs were specified:

1. Core FEs of ⟨Attack⟩:

⟨Assailant⟩: *dansei* (man), *goutou* (burglary/burglar, robbery/robber), *heishi* (soldier), *hikoku* (accused person), ...

⟨Victim⟩: *danshi* (boy), *josei* (woman), *fujo* (girls and women), *joshi* (girl), *danji* (young boy), ...

2. Noncore FEs of ⟨Attack⟩:

⟨Place⟩: *genba* (field), *chiiki* (region), *hokubu* (northern part), *shinai* (city center)

⟨Weapon⟩: *naifu* (knife), *shoujuu* (rifle), *tanjuu* (pistol)

3. Core FEs of ⟨Cause_harm⟩:

⟨Body_part⟩ : *senaka* (back)

4. Core FEs of ⟨Cause_impact⟩:

⟨Impactee⟩: *doru* (dollar), *shijou* (market), *ginkou* (bank), *shokoku* (some countries)

⟨Impactor⟩: *saigai* (disaster), *jishin* (earthquake), *fukyou* (depression), *dageki* (damage)

3 Comparison with other resources

To evaluate our results, we compared them with other Japanese resources and methods for analysis, i.e., IPAL (IPA, 1987) and *Nihongo Goi Taikei* (a Japanese lexicon) (hereafter called Goi Taikei) (Ikehara et al., 1997), which are widely used lexical resources, and semantic frame analysis by FOCAL (Nakamoto et al., to appear; Kuroda et al., 2004), which is a recent framework being developed with the aim of providing BFN-style semantic annotation and analysis for Japanese independent of the Japanese FrameNet (Ohara et al., 2003).

3.1 Comparison with Goi Taikei descriptions

Goi Taikei contains detailed information on the predicate-argument structure classified according to usage. Its semantic description of *osou* is given below:

[12] For the reason of this argument, see note 5 above.

(1) 20 *zokusei henka* (property change) (motion)
N1 *ga* N2 *wo osou*
N1 *strike* N2
N1 (1270 *shimpai* (concern) 1262 *kanashimi* (sorrow) 2056 *sainann* (disaster) 2359 *kishou* (atmospheric phenomena) 1000 *tyuushou* (abstract)) N2 (2 *gutai* (object))

(2) 23 *shintai dousa* (physical motion) (motion)
N1 *ga* N2 *wo osou*
N1 *attack* N2
N1 (3 *shutai* (subject) 535 *doubutsu* (animal) 2416 *byouki* (disease)) N2 (2 *gutai* (object))

(3) 23 *shintai dousa* (physical motion)
31 *kanjou dousa* (affective motion) (motion)
N1 *ga* N2 *no fui wo osou*
N1 *surprise* N2
N1 (4 *hito* (man) 1001 *tyuushoubutsu* (abstruction/abstraction?) 1235 *koto* (event)) N2 (4 *hito* (man))

The word meanings were classified from the properties of *osou* for nouns related to surface cases of the verb. When we compared the frames in BFN and the description provided by Goi Taikei, and examined how the BFN frames corresponded to the Goi Taikei definitions, we obtained the following relationships:

Table 2: BFN/Goi-Taikei correspondences

Attack	(2) 23 *shintai dousa* (physical motion)
Cause_harm	(1) 20 *zokusei henka* (property change)
Cause_impact	(1) 20 *zokusei henka* (property change)

First, we did not obtain the meaning "An unexpected event occurred" like (3) in the Goi Taikei. It was difficult to extract words whose meanings described a manner of action, such as *fui wo* (by surprise) using this method. It was also insufficient to extract only co-occurring nouns from sentences related to verbs. As might be expected, there was a close relationship between (2) and the ⟨Attack⟩ frame. However, we were unable to find ⟨Assailant⟩s such as *sickness* in the BFN FEs. Finally, the ⟨Cause_impact⟩ frame and (1) were very similar, except that assailant in (1) includes feelings such as *worry* or *sadness*.

There was a good correlation between the semantic frame constructed from BFN and the one from Goi Taikei. With this method, however, we met difficulties in extracting frames that did not appear on the surface, such as ⟨manner of action⟩.

3.2 Comparison with IPAL descriptions

We compared the frames we obtained with the definitions from the IPA Lexicon (IPA, 1987). Below is an excerpt from the description of *osou* from IPAL:

- Caption: osou001001 Semantic definition: An undesirable thing unexpectedly occurs to someone.
  Sentence valence pattern: N1 *-ga* N2 *-wo*
  Noun phrase 1: *bouto* (rioter), *goutou* (burglary), *kuma* (bear), *sentouki* (fighter plane), *boufuu* (wind storm), *jishinn* (earthquake), *ekibyou* (plague), *keizai kiki* (economic crisis)
  Noun phrase 2: *tabibito* (traveler), *fune* (ship), *ningen* (human)/*kokudo* (national land), *kuni* (country), *kouban* (police box)
  Example 1: *Boufuu ga fune wo osotta*. (A stormy wind struck a ship.)

- Caption: osou001002
  Semantic definition: Undesirable feelings and physiological phenomena happening suddenly.
  Sentence pattern: N1 *-ga* N2 *-wo*
  Noun phrase 1: *takamaru fuann* (increased anxiety), *shi no kyoufu* (fear of death), *iyana kimochi* (unpleasant feelings)/ *hageshii hiroukan* (acute tiredness), *nemuke* (drowsiness)
  Noun phrase 2: *kare* (he)
  Example 1: *Nemuke ga totsuzen kare wo osotta*. (Drowsiness fell upon him suddenly.)
  Example 2: *Kanojo ha fuann ni osowareta*. (She became uneasy suddenly.)

The IPAL description of *osou* identifies its two senses[13] We compared the BFN frames and the IPAL descriptions (in terms of predicate frames) and obtained the following correspondences:

Table 3: BFN/IPAL correspondences

Attack	osou001001
Cause_harm	osou001001
Cause_impact	osou001001

All of the frames obtained from BFN seemed to be classified into the first meaning in IPAL, e.g., there were no BFN frames in which ⟨Assailant⟩ recognized "sickness." With IPAL definitions, it was difficult to distinguish the difference between *The bear attacked the traveler* and **An economic crisis attacked the traveler*, the latter of which sounds unnatural and quite odd, whereas we can do it with BFN definitions: the former can be classified as an expression in the ⟨Attack⟩ frame, whereas the latter can not. The reason for this is probably that BFN frames successfully specify the semantic interdependence between the ⟨Assailant⟩ and ⟨Victim⟩ roles, whereas such interdependece is not encoded in the IPAL descriptions. We believe this is one of the strengths of frame-based semantic description.

BFN definitions are not detailed enough, however. They face problems when we try to account for the constrast between *The shark attacked the swimmer* and ?**The shark attacked the bank*, for example. The latter sentences doesn't makes sense unless it is reinterpreted some way, while it is straightforward to interpret the first sentence against a predatory situation.

In interpreting the second, there is a clear conflict or "competition" between two strong readings: one interpretation (reading 1) is against the situation of ⟨Predation⟩, where *the shark* is interpreted as a ⟨Predator⟩ and *the bank* as a ⟨Prey⟩. Another (reading 2) is against the situation of ⟨Bank Robbery⟩, where *the shark* is interpreted as a ⟨Bank Robber⟩ and *the bank* as a ⟨Warehouse of Valuables⟩ (or simply as a ⟨Bank⟩). If reading 2 wins out, an implicit "type coercion" (Pustejovsky, 1995) takes place to *the shark* so that the referent of *the shark* is switched to a human who acts as a ⟨Robber⟩ with a nickname "shark." If reading 1 wins out, by contrast, another kind of implicit type coercion takes place to *the bank* so that the referent of *the bank* is switched to an animal (an instance of fish, dolphin, or whale) which acts as a ⟨Prey⟩, being called "the bank" for some unclear reasons. The preference of the reinterpretation for reading 2 over the other can be accounted for if we are allowed to say that to find someone being called "shark" is more likely than to find some animal being called "bank."

What this suggests is this: pieces of semantic information that would account for "selectional restrictions" of this sort are not specified in the BFN definitions (yet). Therefore, it can be said that the frames constructed from BFN do not classify all meanings of *osou* in the same way IPAL does not, but these frames specify some finer-grained, selectional aspects of *osou*'s lexical meaning than the IPAL description. As we will see in the next section, this is one of the strong

[13] A term, "predicate frame," is used in the IPAL to characterize semantic properties of a predicate. While the idea of predicate frames is somewhat related to semantic frames, predicate frames are not defined as semantic frames in the sense of Frame Semantics/BFN.

motivations that a framework called FOCAL has tried to extend the BFN.

3.3 Comparison with FOCAL descriptions

FOCAL is a theoretical framework for semantic analysis and annotation. Its development has been strongly influenced by BFN, but it also tries to extend BFN's scope of semantic analysis to the next stage.

In the case of *X-ga Y-wo osou*, FOCAL recognizes 15 frames in total, listed in Table 4, specifying their hierarchical organization.[14]

These frames are identified and classified based on the semantic co-variations between ⟨Harm Cause(r))⟩ X, a special case of ⟨Cause(r)⟩, and ⟨Harm Experiencer⟩ Y, a special case of ⟨Experiencer⟩. This is important to note that FOCAL puts more emphasis on the specification of the semantic co-variation between X and Y in terms of semantic features because they are crucial characteristics of a semantic frame, which are not captured in the Goi Taikei and IPAL descriptions, and are not clearly encoded even in the BFN description.

In FOCAL, frames are defined as idealized models of situations such as Robbery, Predation, assuming that human understanding is situation-based. The descriptive task of FOCAL, then, is to recognize situations and give adequately detailed descriptions to them. Given $\mathscr{R}$ is a set of situation-specific roles $\{r_1, \ldots, r_n\}$, which are called semantic roles in BFN. Semantic frames are useful only if they serves as specifications of the co-variations among such *R*s.

For example, F06, as a subclass of the ⟨Attack⟩ class event is defined as follows:

Definition of F06: Attack($\mathscr{R}$) = Attack(Predator(X), Prey(Y))
= Hunt(Hunter(X), Target(Y), Purpose(Z))
where Z = Eat(Eater(X), Food(Y), Purpose(Z'));
where Z' = Satisfy (r_1(Z), Hunger)

There seems to be no English noun that names r_1.

These are the frames that account for more or less all possible readings of *X-ga Y-wo osou*. The validity of this claim was confirmed through psychological experiments, and reported in (Kuroda et al., 2004; Nakamoto et al., to appear). The BFN identifies 3 frames relevant to the semantics of *osou*, while FOCAL uses a total of 15 frames to determine the range of situations against which people understand the sentences whose main verb is *osou*.

[14] Space limitation disallowed us to show that the 15 frames thus recognized are nearly optimal to exhaustively specify all the situations against which the senses of *osou* are determined. This was confirmed by multivariate analyses on psychological experiments (Nakamoto et al., to appear). We regret this because the result would surely have answered the question from one of the anonymous reviewers.

Table 4: 15 FOCAL frames with groups G1–G5

G1	F01	harm to Y caused by conflict between groups X and Y
G1	F02	harm to Y caused by X's invasion
G1	F03	harm to Y caused by X's robbery
G1	F04	harm to Y caused by X's violence
G1	F05	harm to Y caused by X's raping
G2	F06	harm to Y caused by X's preying attack
G2	F07	harm to Y caused by X's nonpreying attack (e.g., X's defense)
G3	F08	harm to Y due to an unexpected accident X
G3	F09	harm to Y caused by a natural phenomenon X (on a smaller scale, e.g., gust)
G3	F10	harm to Y caused by a natural phenomenon X (on a larger scale, e.g., earthquake, flood)
G3	F11	harm to Y caused by a natural phenomenon X (on a larger scale, e.g., spread of an epidemic)
G4	F12	harm to Y caused by a social phenomenon X
G5	F13	harm to Y caused by a disease X (nontemporary, e.g., cancer)
G5	F14	harm to Y caused by a disease symptom X (temporary, e.g., heart attack)
G5	F15	harm to Y caused by a bad feeling X (temporary, e.g., drowsiness)

The 3 BFN frames have been compared with the 15 frames below to assess how well they correspond to one another:

Table 5: BFN/FOCAL correspondences

Attack	Part of G1	F01–F05
Cause_harm	[UNCLEAR]	[UNCLEAR]
Cause_impact	[UNCLEAR]	[UNCLEAR]
[UNCLEAR]	G5	F13–F15

This comparison revealed several differences. First, FOCAL specifies situations that the ⟨Attack⟩ frame applies to in much greater detail, although its descriptions are based on semantic frames like BFN's descriptions are. This is mainly because FOCAL identifies frames in terms of conceivable differences in the "purposes," or "intended effects" of the ⟨Harm

Cause(r)⟩[15], of which BFN's ⟨Assailant⟩ is a special case. This suggests that BFN frames can be further elaborated according to the subclassification of ⟨Assailant⟩ in terms of its purpose.[16]

The same is conversely true of ⟨Cause_harm⟩ and ⟨Cause_impact⟩ frames. These BFN frames need to be generalized so that they include nonhuman, nonintentional agents, which is not done in the current BFN. Better matches would be found if the ⟨Cause_harm⟩ and ⟨Cause_impact⟩ frames were further classified according to the properties of the ⟨Harm_causer⟩ and ⟨Impactor⟩ just as in the ⟨Attack⟩ frame.

While FOCAL explicitly groups the F01–F05 frames into G1 and combines it with another group, G2, to yield a more general semantic class {G1, G2}, it is not clear whether BFN captures this hybrid class, since the hierarchical relationships among frames are not sufficiently specified.

In fact, the comparison with FOCAL revealed that BFN does not classify the ⟨Assailant⟩ types in as much detail as FOCAL does. According to FOCAL's assumptions, it is ⟨Assailant⟩'s ⟨Purpose⟩ (including the "null" value) that defines the differences in otherwise similar situations. To identify such subtle differences is exactly what humans are very good at and computers are not. Specification of information of this kind is one of the serious demands arising from many of the NLP tasks.

To conclude, we noted that the granularity of the semantic descriptions provided by BFN, IPAL, Goi Taikei, and FOCAL had the following hierarchy: FOCAL $>$ BFN $\approx$ Goi Taikei $>$ IPAL This suggests that, while BFN is clearly useful for a variety of purposes, its semantic descriptions are not detailed enough, particularly when dealing with the polysemy of relatively frequent words like *osou* in Japanese or *hit* in English.

While our result is only suggestive at best, let us make a brief comment on some methodological aspects of the BFN framework.

Overall, BFN definitions for semantic frames are much more oriented or even "biased" for descriptions of activities intended and caused by human, volitional agents. In fact, BFN took a methodological decision not to include metaphorical uses and other "problematic" uses of words for ease of lexicon-building, thereby sacrificing its descriptive range, causing a problem with biased data coverage, as far as we could see. In the case of *osou*, for example, there were clearly many examples in which harm is not caused by a human, i.e., cases described by FOCAL frame clusters G2: F06–F07, G3: F08–F11, G4: F12, and G5: F13–F15. Therefore, as far as we are concerned with the viability of the frame-based description of situations that can be expressed using *osou* in Japanese, the current status of the BFN database is only partially successful in that it successfully captures the class of situations specified by G1.

4 Conclusion

We proposed a new translation-like method using BFN to find Japanese LUs that corresponded to English LUs in BFN semantic frames. We evaluated a technique of identifying Japanese LUs based on English LUs using a bilingual corpus. We evaluated the results by comparing them with other Japanese language resources and analyses, IPAL, Goi Taikei, and FOCAL. The comparison revealed that FOCAL, BFN, Goi Taikei, and IPAL provided finer-grained descriptions in this specific order.

Our method allowed us to easily find Japanese LUs that corresponded to LUs in BFN semantics and at the same level of granularity as BFN. Even if all the relevant sentenceswere not manually examined when the semantic frame was constructed, we were able to collect several members of FEs. Our method also automatically specified a set of lexical titems that clearly had the frame-evocation effect but that were not properly identified as Frame Elements of a semantic frame in BFN.

There are several problems still remaining that need to be addressed. Because the bilingual corpus used was a newspaper corpus, the target se-

[15] This is not the same as BFN's ⟨Harm_causer⟩ role, which is much more specific than ⟨Harm Cause(r)⟩ in FOCAL's sense.

[16] The question of "where to stop," addressed by one of the anonymous reviewers, would have been answered if we had enough space to show that those 15 frames/situations are nearly optimal to account for all the semantic classifications reflected in selectional restrictions, as explained in note 14. Clearly, we do not need to identify *all semantically possible* subclassifications; we just need to identify *psychologically real* subclassifications.

mantic domains were limited. There is therefore a possibility that we failed to identify certain semantic frames. We plan to do further experiments using a greater number of bilingual corpora with a wider domain coverage.

In the comparison of the analyses by BFN and by FOCAL, only one target verb *osou* is used in this work. Clearly, this is insufficient and our result is only suggestive at best. To draw a realistic conclusion, we will definitely need to examine more target words and make the comparison more reliable.

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