A Database of Relations between Predicate Argument Structures for Recognizing Textual Entailment and Contradiction

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Abstract

In this paper, we present a database of logical relations between predicate argument structures (PASs) in Japanese for recognizing relations between statements. We have defined nine logical relations between PASs and manually collected argument structures and logical relations for verbs from definition sentences in a machine-readable Japanese dictionary. In addition, we augmented the relations in our database with a thesaurus of verb argument structures, which identifies synonymy and antonymy between PASs. Our database consists of 29,555 entries and 45,905 relations between PASs. In a preliminary experiment with this database, we constructed a system that recognizes synonymy between PASs in Web documents with a precision of about 0.80.

1. Introduction

Recent advances in information retrieval enable us to easily get access to an explosive number of Web documents on any topic, which are becoming an important information source used for a broad range of decision making in daily life. However, these documents do not always tell the truth about a topic. They sometimes include factually incorrect statement, prejudiced opinions, and obsolete ideas. To judge whether a statement in a Web page is credible or not, it is crucial to see what other documents say about the same topic. Namely, a statement can be considered credible if it is compatible with those in other pages while it may be doubtful if it is contradicted by expert or authoritative pages. Clearly, however, this is not an easy job for Web users, who are provided only with the current type of search engines.

Motivated by this problem, we are developing natural language processing technology for automatically detecting logical relations such as similarity (or compatibility) and contradiction between statements from different texts. For example, the following are statements which are all about "*steroids*" as treatment for atopic dermatitis, translated from Japanese sentences extracted from distinct Web pages:

(1) a. *Steroids are commonly prescribed for patients with atopic dermatitis.*
b. *Recently, de-steroid therapy is becoming very popular.*
c. *Having been treating children with eczema for over ten years, we have never seen a single child suffering from side effects of steroid creams.*

Statements (1a) and (1b) are opposite opinions, and statement (1c) can be considered as a support for statement (1a). From these statements, one can learn at least that the use of steroids for atopic dermatitis is a controversial issue which should be considered before choosing them. We defined a set of logical relations between statements for judging credibility of statements. This set includes *equivalence, entailment, contradiction* and *grounds*.

We aim to provide the user with a bird's eye view of a given set of statements, which displays the logical relations detected between the statements as a graph. We call this overview graph a *statement map*. An example is shown in Figure 1. In this map, a node consists of a set of similar statements, and an edge represents a logical relation between such sets of statements. A statement map helps the user gain an overview of related but diverse statements and judge whether each statement is credible.

Recognizing logical relations between statements requires a huge amount of knowledge about relations between various expressions such as nouns, verbs, adjectives, modality expressions, and so on. In this paper, we present a database of relations between predicate argument structures (PASs) in Japanese.

This paper is organized as follows. In Section 2, we introduce related work. In Section 3, we discuss a database of logical relations between Japanese PASs, and in the following section, we describe a process of collecting such rela-

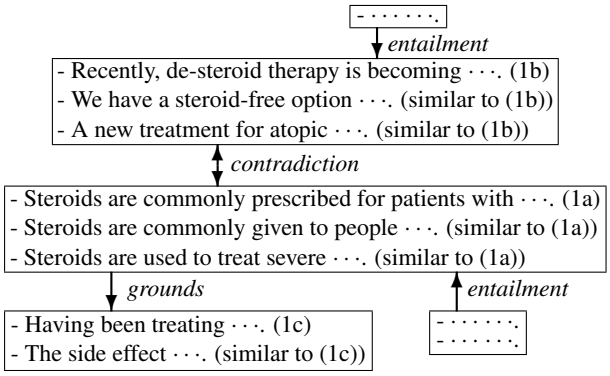

Figure 1. A statement map for "steroids".

tions from a dictionary and specify information about subject/object control for each verb in the database. In Section 5, we report the results of an empirical evaluation of the database. In Section 6, we conclude this paper.

2. Related work

Recognizing logical relations between statements requires knowledge about relations between predicates as well as entities. In English, there are several databases including a huge scale of such knowledge, such as WordNet[6], FrameNet[2, 13], MindNet[12] and VerbOcean[4]. For predicates, these databases mainly deal with synonyms and hypernyms, and are often used for recognizing textual entailment (RTE), which has recently attracted the attention of researchers[5].

There is research on creating large-scale collections of knowledge about relations between predicates in Japanese. For example, the *Bunrui Goi Hyo* thesaurus[10], a thesaurus of verb argument structures[15] and Japanese WordNet[3] are manually created. Some methods of collecting knowledge about logical relations between predicates from large corpus are proposed by Inui et al.[7], Torisawa[16], and Abe et al.[1]. Kaji et al.[8] and Suzuki et al.[14] have proposed methods of automatically acquiring such knowledge from a dictionary of Japanese.

As described in Section 4.1, we propose a method of extracting logical relations between PASs from definition sentences in a machine-readable Japanese dictionary. We identify several kinds of logical relations between PASs, as illustrated in Section 3, for recognizing logical relations between statements, while the logical relations acquired by Kaji et al.'s method [8] are limited to hypernyms and synonyms. The database created by Suzuki et al.[14], on the other hand, covers several relation classes; however, it does not specify which arguments are shared between related predicates. Our database identifies shared arguments as well as fine-grained logical relations between PASs.

3. A database of logical relations between PASs

A PAS consists of a predicate and its arguments and is used as an unit for representing an event. Examples of PASs are shown below.

(2) a. wash [<X>$_{agent}$, <Y>$_{object}$]
b. give [<X>$_{agent}$, <Y>$_{theme}$, <Z>$_{goal}$]
c. be_interested_in [<X>$_{agent}$, <Y>$_{object}$]

Table 1 shows an overview of knowledge on Japanese PASs that we have been collecting for recognizing logical relations between statements. We focus on verbs, adjectives and predicative idioms as predicates. We are collecting knowledge on PASs from two aspects: argument structures and logical relations.

Pieces of knowledge on logical relations for PASs can be roughly classified into the following three classes:

Thesaurus A thesaurus is a basic structure that can provide synonyms among PASs. In Section 4.2, we will overview the thesaurus of PASs that we adopt to our database.

Relations between two events We defined the following nine types of logical relations between two PASs, with classification according to temporal connection and inevitability.

> near synonym, hypernym, inseparable, cooccur, means, antonym, presupposition, effect, goal

We describe these relations in detail in Appendix.

Other sophisticated relations Logical relations among more than two PASs, for example, the Perspective_on, Subframes and Precedes relations proposed in FrameNet[13].

4. Creating a database of relations between PASs

We have already carried out the following three tasks for making a database of relations between PASs.

1. Collection of basic argument structures for about 14,000 verbs and about 34,000 logical relations between two PASs.
2. Specification of a semantic class in a thesaurus to each of about 4,000 verbs.
3. Classification of constructions with sub-event of Japanese verbs.

Table 1. Overview of the current status of development of our database.

	Argument structure		Logical relation		
	Basic	With sub-event	Thesaurus	Between two	Otherwise
Verb	14,000	1,000	4,000	46,000	
i-Adjective	700 (ongoing process)			700 (ongoing process)	
na-Adjective	2,000 (ongoing process)			2,000 (ongoing process)	
Predicative idiom					

Table 2. Logical relations for the headword "*taosu* (put down)" from the definition sentence in a dictionary.

(Headword)	倒す (*taosu*) [<X> ガ (*GA*), <Y> ヲ (*WO*)] (put down [<X> (Subject), <Y> (Object)])
Presupposition	立つ (*tatsu*) [<Y> ガ (*GA*)] (stand [<Y> (Subject)])
Means	加える (*kuwaeru*) [<X> ガ (*GA*), 力 (*chikara*) ヲ (*WO*), <Y> ニ (*NI*)] (add [<X> (Subject), pressure (Direct object), <Y> (Indirect object)])
Means	傾ける (*katamukeru*) [<X> ガ (*GA*), <Y> ヲ (*WO*)] (add [<X> (Subject), <Y> (Object)])
Hypernym	する (*suru*) [<X> ガ (*GA*), <Y> ヲ (*WO*), 横 (*yoko*) ニ (*NI*)] (make [<X> (Subject), <Y> (Object), to lie down])

4.1 Extraction of logical relations from definition sentences in a dictionary

We have collected basic argument structures and logical relations for verbs from definition sentences in a dictionary.

For each sense of a headword verb in a dictionary, we carried out the following procedure:

1. Specify a PAS for the verb.
2. Extract all predicates from the definition sentence(s) of the word in the dictionary.
3. For each extracted predicate, do the following:
   (a) Specify a PAS to the predicate.
   (b) Choose a logical relation between the headword and the predicate.
   (c) Relate the corresponding argument in the former PAS to each argument in the latter PAS.

Let us take an example for the above procedure. Suppose that we have a headword "*taosu* (put down)". First, we specify the following PAS to the word.

(3) a. *taosu* [<X> *GA*, <Y> *WO*]
(put down [<X> (Subject), <Y> (Object)])

Next, we extract all predicates from the definition sentence of the word in a dictionary. As a dictionary of Japanese words, we used the *Iwanami* dictionary of Japanese[11]. In this dictionary, the definition sentence of the word "*taosu* (put down)" is the following.

tat te iru mono ni chikara wo kuwae te katamuke, yoko ni suru.

Literally, (To put down means to) make a standing objects lie down by adding pressure to it and tilting it.

This sentence includes the four predicates as shown with underlines: "*tat* (stand)", whose base form is *tatsu*, "*kuwae* (add)", whose base form is *kuwaeru*, "*katamuke* (tilt)", whose base form is *katamukeru*, and "*suru* (make)". We extract these four predicates for the headword.

For each extracted predicate, we perform the above procedure. Here, we take the last predicate "*suru* (make)" as an exmaple. First, we specify the following PAS to the predicate.

(4) a. *suru* [<?> *GA*, <?> *WO*, *yoko NI*]
(make [<?> (Subject), <?> (Object), to lie down])

In this PAS, *yoko* (lying) is a constant component, which means that *yoko* (lying) does not absolutely vary according to contexts, unlike other components. Next, we judge a logical relation between the headword and this predicate as hypernym because the latter is more abstract word representing the same event that the former does. Finally, we relate the corresponding argument in the PAS of the word "*taosu* (put down)" to each argument in the PAS of the predicate "*suru* (make)", with the result of obtaining the following PAS for the latter:

(5) a. *suru* [<X> *GA*, <Y> *WO*, *yoko NI*]

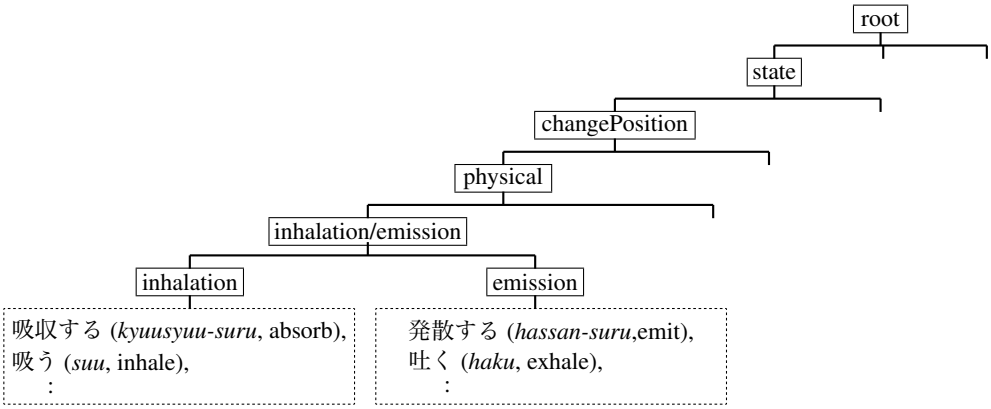

Figure 2. A part of the thesaurus made by Takeuchi et al.[15].

(make [<X> (Subject), <Y> (Object), to lie down])

We perform the above procedure for the other predicates similarly, and obtain logical relations shown in Table 2.

For 14,082 verbs (normal verbs and Japanese verbal nouns) in the dictionary described above, we have collected 14,082 PASs and 33,770 logical relations between two PASs.

4.2 Augmentation of logical relations with a thesaurus of verb argument structures

Takeuchi et al.[15] made a thesaurus of verb argument structures for about 4,000 verbs in Lexeed[9] that were the most frequently used. Their thesaurus has five levels: the top level has three classes, and the bottom level consists of about 1,000 classes. Figure 2 shows a part of the thesaurus. In this thesaurus, verbs belonging to the same semantic class at the bottom level can be considered as near synonym. For example, verbs "*kyuusyuu-suru* (absorb)" and "*suu* (inhale)" can be judged as near synonym because they belong to the same class as shown at the bottom in the left of Figure 2.

The thesaurus made by Takeuchi et al. has the remarkable advantage, among others, that it explicitly deals with antonymy for verbs. In this thesaurus, a forward-slash (/) in the fourth level class name means that the class has two antonymous classes of verbs in the bottom level. For example, the fourth-level class "inhalation/emission" has two sub-class "inhalation" and "emission". So, a verb belonging to the class "inhalation", such as "*kyuusyuu-suru* (absorb)" and "*suu* (inhale)", can be judged as an antonym for a verb belonging to a class "emission", such as "*hassan-suru* (emit)" and "*haku* (exhale)".

For each verb in our database, we specified a semantic class at the bottom level in the thesaurus, if any. These semantic classes augment logical relations between PASs in our database, because they provide near synonym and antonym of verbs through the thesaurus.

As described in the previous subsection, our database has adopted word senses in the *Iwanami* dictionary of Japanese[11]. On the other hand, Takeuchi et al. followed the word sense distinctions in Lexeed[9]. In the case that multiple corresponding senses of a verb are found in Lexeed for one sense of the verb in the *Iwanami* dictionary, we reproduced the entry in our database as much as the former senses are, and for each of these entries, we specified one of the semantic classes that the senses of the verb in Lexeed belonged to. As a result, our database has 29,555 entries, including 9,582 entries with semantic classes, and 45,905 logical relations between PASs.

4.3 Specification of PASs with sub-events

Some verbs take complicated constructions with complementizers, where an event referred to by the matrix clause embeds another event referred to by the subordinate clause. We call the former event super-event and the latter sub-event. For example, Sentence (6a) has two events (6b) and (6c). The former is the super-event and the latter the sub-event.

(6) a. *Ken wa ashita Kyoto ni ikou to ketsui-shi ta.*
(Ken decided to go to Kyoto tomorrow.)
b. *Ken ga aru koto wo ketsui-shi ta*
(Ken decided something)
c. *Ken ga ashita Kyoto ni iku*
(Ken will go to Kyoto tomorrow)

Such a PAS with a sub-event is often used in RTE. In this case, Statement (6a) entails Statement (6c) as well as State-

Table 3. Number of verbs for each types.

Type	Number	Example
I	25	*ketsui-suru* (determine), *kesshin-suru* (make up my mind)
II	28	*yakusoku-suru* (promise), *ukeou* (undertake)
III	93	*meirei-suru* (order), *yousei-suru* (request)
IV	1	*iu* (say)
V	16	*kyoka-suru* (permit), *kinshi-suru* (prohibit)
VI	3	*teian-suru* (propose), *hatsuan-suru* (suggest)
VII	170	*hatsugen-suru* (state), *houkoku-suru* (report)
VIII	124	*omou* (think), *mitomeru* (admit)
IX	54	*miru* (see), *kikoeru* (hear)
X	143	*odoroku* (be surprised), *kanshin-suru* (admire)
XI	71	*shikaru* (scold), *tetsudau* (help)
Total	728	

ment (6b). Variety of constructions with complementizers in Japanese makes it necessary to specify PASs with sub-events.

By investigating control phenomena in Japanese and constructions of verbs related to them, we classified PASs with sub-events into eleven types according to possible constructions with a sub-event and identity of the subject of a sub-event. For example, we classified a verb "*ketsui-suru* (determine)" into Type I, whose verb can take constructions with markers of a sub-event "*koto wo*", "*wo*", "(a base-form of a verb +)*to*" and "(a *u*-form of a verb +)*to*", where the subject of a sub-event is always equal to the subject of the main verb. Verbs with Type I roughly correspond to subject-control verbs in English, such as "promise" and "try". Another example is a verb "*meirei-suru* (order)". We classified it into Type III, whose verb can take constructions with markers of a sub-event "*koto wo*", "*wo*", "*you ni*" and "(an imperative-form of a verb +)*to*", where the subject of a sub-event is always equal to the object of the main verb. Verbs with Type III roughly correspond to object-control verbs in English, such as "order", "persuade", and "permit".

We have already specified one of these types to 728 verbs in our database. The number of verbs for each types is shown in Table 3.

4.4 The current status of our database

As mentioned in Section 4.2, our database has 29,555 entries and 45,905 logical relations between PASs. Table 4 shows an entry in our database. For each entry, we have specified the following seven items.

Table 5. Numbers of logical relations in our database.

Relation	Num
near synonym	17,816
hypernym	11,487
inseparable	174
cooccur	4,274
means	5,532
antonym	540
presupposition	3,037
effect	2,163
goal	882
Total	45,905

ID ID in this database

Headword A headword in *hiragana* spelling.

Spellings Various spellings of the headword, including *kanji* spellings and *katakana* spellings.

Semantic class A semantic class that the headword belongs to in the thesaurus described in Section 4.2.

Linking IDs This item includes IDs of the following two dictionaries: *Iwanami* dictionary of Japanese and Lexeed dictionary.

Argument structure A basic predicate argument structure that the headword takes, and the type of the verb described in the previous subsection, if any. Each surface case particle has the following information:

- **Deep case** A semantic role represented by the surface case.
- **Alternatives** Alternative case-marking particles that can be substituted for the surface case particle, if any.
- **Case component** A variable for identifying the shared argument between related two PASs, or the noun (or noun phrase) that always appears to the left of the particle.

Logical relations between PASs A list of logical relations between the target PAS and other PASs. Table 5 shows kinds and numbers of relations between PASs in our database.

5. Experiment

In a preliminary experiment with the database described in the previous section, we applied it to recognizing synonymy and antonymy between PASs in Web documents.

Table 4. An entry for "*kyuusyuu-suru* (absorb)" in our database.

Item	Value
ID	04992
Headword	きゅうしゅうする (*kyuusyuu-suru*, absorb)
Spellings	吸収する (*kyuusyuu-suru*, absorb)
Semantic class	state → changePosition → physical → inhalation/emission → inhalation
Linking IDs	IwanamiID: 0011538-0-0-0-x0, LexeedID: 06027950-4
Argument structure	[<X>$_{causer}$ ガ (*GA*), <Y>$_{direct\ object}$ ヲ (*WO*)]
Relation #1 (near synonym)	吸い込む (*suikomu*) [<X> ガ (*GA*), <Y> ヲ (*WO*), <X> ニ (*NI*)] (swallows [<X> (Subject), <Y> (Object), into <X>])
Relation #2 (near synonym)	吸い取る (*suitoru*) [<X> ガ (*GA*), <Y> ヲ (*WO*)] (suck [<X> (Subject), <Y> (Object)])
Relation #3 (cooccur)	取り入れる (*toriireru*) [<X> ガ (*GA*), <Y> ヲ (*WO*)] (take in [<X> (Subject), <Y> (Object)])
Relation #4 (hypernym)	する (*suru*) [<X> ガ (*GA*), <Y> ヲ (*WO*), 自分のもの (*zibun'nomono*) ト (*TO*)] (make [<X> (Subject), <Y> (Object), to be mine])

5.1 Methodology

We used 4,347 and 5,989 PASs in Web documents about the two topics of "*steroids*" and "*smoking*," respectively. First, we asked an annotator to judge synonymy and antonymy between them for each topic. Next, we implemented a system that recognized synonymy and antonymy between PASs using our database. This system receives a set of PASs and outputs a statement map only with "antonym" edges. We evaluated performance of the system for recognizing each relation by precision and recall.

We used the following seven relations in our database and synonymy from the thesaurus described in Section 4.2 as "synonymy":

> near synonym, hypernym, inseparable, cooccur, means, effect, goal

We also used the antonym relations in our database and antonymy from the thesaurus described in Section 4.2 as "antonymy".

5.2 Results

Tables 6 and 7 show the result for recognizing synonymy between PASs for each topic. In these tables, "◯" indicates the number of PASs judged as having at least one synonymous PAS and "×" indicates the number of PASs judged otherwise: that is, we counted the number of PASs in the corpus for each of which the system found a synonymous PAS in the same corpus. For the topics "steroids" and "smoking", precisions of the system are 80.1%(822/1026) and 79.5%(501/630), respectively, and recalls of the system are 63.2%(822/1300) and 51.1%(501/980), respectively. We think that these results are high enough for the first step of generating statement maps. Examples of pairs of PASs that the system successfully judged as synonyms include: the pair (7a) and (7b) as well as the pair (8a) and (8b).

Table 6. Result for the topic "steroids".

		Annotator ◯	Annotator ×	Total
System	◯	822	204	1,026
	×	478	2,843	3,321
	Total	1,300	3,047	4,347

Table 7. Result for the topic "smoking".

		Annotator ◯	Annotator ×	Total
System	◯	501	129	630
	×	479	4,880	5,359
	Total	980	5,009	5,989

(7) a. *takamaru* [*risuku GA*, *zyudou kitsuen DE*] (increase [risk (Subject), because of second-hand smoke])

b. *zyoushyou-sa-seru* [*zyudou kitsuen GA*, *risuku WO*] (increase [second-hand smoke (Subject), risk (Object)])

(8) a. *yobikakeru* [ϕ *GA*, *kin'en WO*, *kitsuensya NI*] (promote [ϕ (Subject), quitting smoking (Object), among smokers])

b. *uttaeru* [ϕ *GA*, *kin'en WO*, *kokumin NI*] (appeal [ϕ (Subject), quitting smoking (Object), to the public])

For the system that recognized antonymy between PASs, precisions are 45%(14/31) and 59%(20/34) and recalls are

26%(14/54) and 13%(20/158) for the topics "steroids" and "smoking", respectively.

Low recall in this experiment results mainly from the fact that human beings can use logical relations between nouns for recognizing synonymy and antonymy between PASs but the above systems cannot. Lack of the following kind of knowledge on synonyms between PASs, i.e., between a verb and "become *adjective*", in our database is another reason for low recall of the system:

(9) a. *takamaru* [*nikochin noudo GA*, *kitsuen DE*]
(increase [nicotine concentration (Subject), because of smoking])
b. *takaku naru* [*nikochin noudo GA*, *kitsuen DE*]
(become higher [nicotine concentration (Subject), because of smoking])

6. Conclusion and future work

In this paper, we presented a database of logical relations between predicate argument structures in Japanese for recognizing logical relations between statements.

We have been collecting knowledge on logical relations between PASs using the following two methods. One is to apply the method proposed in Section 4.1 to adjectives and predicative idioms. The other is to manually validate a huge scale of knowledge collected from a corpus by Abe et al.'s method[1] and organize the result into logical relations among more than two PASs, for example, Perspective_on, Subframes and Precedes relations proposed in FrameNet[13].

Acknowledgment

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Appendix: Nine types of logical relations between PASs in Japanese

To recognize logical relations between statements, we defined the following nine types of logical relations between two PASs.

near synonym, hypernym, inseparable, cooccur, means, antonym, presupposition, effect, goal

We describe these relations, with classification according to temporal connection and inevitability. In this paper, for a logical relation "A ⇒ B", we call A the antecedent event (or the antecedent PAS) and B the consequent event (or the consequent PAS).

Simultaneous connection Near synonym, hypernym, inseparable, cooccur, means and antonym are logical relations between two events (PASs) that happen simultaneously.

near synonym When two events can be paraphrased each other, we judge the relation between these to be near synonym. For example, "(10a) ⇔ (10b)" is a near synonym relation.

(10) a. *akeru* [<X> *GA*, <Y> *WO*]
(open [<X> (Subject), <Y> (Object)])
b. *hiraku* [<X> *GA*, <Y> *WO*]
(open [<X> (Subject), <Y> (Object)])

hypernym, inseparable When a proposition "the consequent event happens whenever the antecedent event happens" holds and the reverse does not always hold, we judge the relation between these events as hypernym. In the case that the predicate in the antecedent event literally includes the predicate in the consequent event, we judge the relation between these as inseparable. For example, "(11a) ⇒ (11b)" is a hypernym relation, and "(12a) ⇒ (12b)" is an inseparable relation, where the verb "*agesage-suru* (move up and down)" in (12a) literally includes the verb "*ageru* (move up)" in (12b).

(11) a. *tsukaikonasu* [<X> *GA*, <Y> *WO*]
(master [<X> (Subject), <Y> (Object)])
b. *tsukau* [<X> *GA*, <Y> *WO*]
(use [<X> (Subject), <Y> (Object)])

(12) a. *agesage-suru* [<X> *GA*, <Y> *WO*] (move up and down [<X> (Subject), <Y> (Object)])
b. *ageru* [<X> *GA*, <Y> *WO*]
(move up [<X> (Subject), <Y> (Object)])

cooccur, means When one of two events that happen simultaneously is the main event and the other is a peripheral activity or occurrence, we judge the relation between these two events as cooccur. Especially, in the case where the peripheral event indicates a means for the main event, we judge the relation between them to be means. For example, "(13a) ⇒ (13b)" is a cooccur relation, where (13b) is a peripheral event for (13a), and "(14a) ⇒ (14b)" is a means relation, where (14b) is a means for realizing (14a).

(13) a. *hayaru* [<X> *GA*]
(be popular [<X> (Subject)])
b. *tsutawaru* [<X> *GA*, *tsugitsugi TO*]
(travel [<X> (Subject), widely])

(14) a. *wakasu* [<X> *GA*, <Y> *WO*]
(boil [<X> (Subject), <Y> (Object)])
b. *kuwaeru* [<X> *GA*, <Y> *NI*, *netsu WO*]
(apply [<X> (Subject), <Y> (Indirect object), heat (Direct object)])

antonym When two events are antonymous, we judge the relation between these as antonym. For example, "(15a) ⇔ (15b)" is a antonym relation.

(15) a. *akeru* [<X> *GA*, <Y> *WO*]
(open [<X> (Subject), <Y> (Object)])

b. *shimeru* [<X> *GA*, <Y> *WO*]
(close [<X> (Subject), <Y> (Object)])

Happens-before connection Goal and effect are logical relations between two events where the antecedent event happens before the consequent event.

goal, effect When the antecedent event can cause the consequent event to happen, we judge the relation between these two events as goal, which implies that the agent of the antecedent event aims for the realization of the consequent event but the antecedent event may fail to cause the consequent event to happen. In the case that the antecedent event inevitably causes the consequent event to happen, we judge the relation between these as effect. For example, "(16a) ⇒ (16b)" is a goal relation, and "(17a) ⇒ (17b)" is a effect relation.

(16) a. *memo-suru* [<X> *GA*, <Y> *WO*, <Z> *NI*] (write down [<X> (Subject), <Y> (Object), on <Z>])
b. *wasure-nai* [<X> *GA*, <Y> *WO*]
(not forget [<X> (Subject), <Y> (Object)])

(17) a. *okosu* [<X> *GA*, <Y> *WO*]
(raise [<X> (Subject), <Y> (Object)])
b. *chokuristu-suru* [<Y> *GA*]
(stand [<Y> (Subject)])

Happens-after connection Presupposition is a logical relation between two events where the antecedent event happens after the consequent event.

presupposition When causing the antecedent event to happen requires the realization of the consequent event, we judge the relation between these two events as presupposition. For example, "(18a) ⇒ (18b)" is a presupposition relation.

(18) a. *iinogareru* [<X> *GA*, <Y> *WO*]
(dodge [<X> (Subject), <Y> (Object)])
b. *toitsumera-reru* [<X> *GA*, <Y> *WO*]
(be blamed [<X> (Subject), for <Y>])

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