# Linking Japanese FrameNet with Kyoto University Case Frames Using Crowdsourcing

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**Abstract**

We report on an ongoing project to link Japanese FrameNet (JFN) annotated sentences and Kyoto University Case Frames (KCF) example sentences that share the same meaning of a Japanese predicate (i.e., a verb, an adjective, or an adjectival noun), by way of crowdsourcing. JFN assigns a "cognitive frame" (a script-like conceptual structure that describes a particular type of situation, object, or event along with its participants and props, assumed in the theory of Frame Semantics) to each sense of Japanese words (mostly verbs, adjectives, adjectival nouns, and nouns). On the other hand, each "case frame" in KCF is a predicate-argument structure. Whereas JFN has been constructed manually so far, KCF was automatically constructed from 10 billion Japanese sentences taken from Web pages. By linking JFN annotated sentences and KCF example sentences that share the same meaning of a predicate, we can ultimately increase the size of JFN and also add semantic information to KCF. We use JFN cognitive frames to link the sentences in the two resources. We crowdsourced this task to ensure rapid and large-scale mappings between the two. Our preliminary results suggest that the proposed crowdsourcing method for linking the resources via cognitive frames is promising.

**Keywords:** Kyoto University Case Frames, Japanese FrameNet, Crowdsourcing

## 1. Introduction

We report on a project to link Japanese FrameNet (JFN) annotated sentences and example sentences in Kyoto University Case Frames (KCF) that share the same meaning of a Japanese predicate (i.e., a verb, an adjective, or an adjectival noun), by way of crowdsourcing.

There are two types of so-called frame knowledge. The first type concerns dividing what speakers know about the world into "cognitive frames," that is, script-like conceptual structures that describe a particular type of situation, object, or event along with its participants and props, in a top-down manner. The second type of frame knowledge involves predicate-argument structures and describes, in a bottom-up fashion, what kinds of arguments individual predicates (mostly verbs, including copulas, and adjectives) take, i.e., "case frames."

Both kinds of frame knowledge, that is, cognitive frames ("top-down frame knowledge") and case frames ("bottom-up frame knowledge"), have been organized into language resources and have become fundamental to text understanding. An example of the former is FrameNet (FN), an English language resource that relates cognitive frames to individual English words (mostly verbs, nouns, and adjectives) (Fillmore and Baker, 2010; Ruppenhofer et al., 2016). FN also includes corpora annotated with information about cognitive frames that words evoke. Resources similar to FN have also been built for languages other than English by manual elaboration or translation. However, they often have a problem in coverage, since most of them use a partial set of the cognitive frames defined in FN. For example, JFN, which has been constructed manually, has a smaller set of cognitive frames and smaller numbers of Lexical Units (LUs) and annotated sentences than the original FN, as shown in Table 1.

KCF is an example of the latter type of language resources, which has been automatically acquired from a large raw corpus of Japanese (Kawahara et al., 2014). It has a wide coverage and statistical information. However, although KCF applies a clustering algorithm to generate case frames with different usages, it does not contain semantic information.

| | FN | JFN |
|---|---|---|
| # of Cognitive Frames | 1223 | 979 |
| # of Lexical Units (LUs) | 13638 | 5029 |
| # of Annotated Sentences | 202229 | 7899 |

Table 1: Comparison of FrameNet (FN) and Japanese FrameNet (JFN)

This paper proposes a method to link JFN and KCF to exploit the advantages of both resources. There have been no attempts to combine a resource containing top-down frame knowledge (i.e., cognitive frames) with bottom-up frame knowledge (i.e., case frames). By using our method, it is possible to build a wide-coverage knowledge resource of cognitive frames using statistical information.

Our method links an automatically acquired case frame in KCF with one of the JFN cognitive frames associated with each verb, adjective, or adjectival noun (hereafter "predicate") in Japanese. To conduct this task fast and on a large scale, we employ the crowdsourcing technique. Specifically, for each predicate, we ask crowdworkers to link an example sentence of a KCF case frame with an example sentence of a JFN cognitive frame. One reason for using example sentences is to facilitate the linking task for crowdworkers. Another is to enable the reuse of the linking knowledge for newly reconstructed case frames. In fact, KCF case frames are often reconstructed by improving the clustering algorithm and by expanding the size of a source corpus.

Our method seems to be promising in the following three aspects:

- To scale up the size of sentences annotated with cognitive frames in JFN;
- To facilitate identifying missing cognitive frames in JFN;

- To add new LUs to existing cognitive frames in JFN.

Our ultimate goals include: increasing the size of JFN; and adding semantic information to each case frame in KCF. Our first step, however, whose preliminary results are reported in this paper, involves matching JFN annotated sentences and KCF example sentences that share the same JFN cognitive frame, in other words, assigning a JFN cognitive frame to each KCF case frame.

The inherent difficulty and complexity of the FN annotation processes have prompted researchers in the FN community to look for ways to expand the database of annotated sentences. One idea is to reuse some of the work done by other projects. There are, however, few language resources that share some of the principles of Frame Semantics in general and of FrameNet in particular.[1] We will argue, however, that linking JFN and KCF is indeed possible, since KCF does not include semantic information incompatible with the principles of Frame Semantics and since cognitive frames may be used to describe meanings of predicates and sentences in both of the resources.

The organization of the rest of the paper is as follows. In Section 2, backgrounds to FN, JFN, and KCF will be discussed. Section 3 deals with the methodology we adopted. Section 4 discusses the experimental settings and the preliminary results. It will be shown that according to the accuracy of crowdworkers responses, the predicates used in our experiments can be classified into three categories. Section 5 gives conclusions and prospects.

## 2. Related Work

FN is based on the framework of Frame Semantics. Cognitive frames correspond to word meanings.[2] Each cognitive frame has its own frame elements (FEs), similar to semantic roles in other theories, except that FEs are specific to each cognitive frame. The `Sending` frame ("a SENDER plans the PATH of a THEME and places it in circumstances such that it travels along this PATH under the power of some entity other than the SENDER") is an example of a cognitive frame and SENDER, PATH, and THEME are its FEs. LUs are a pairing of a lemma with a meaning, i.e., with a cognitive frame. For example, the English lemma *express* has at least two distinct LUs, namely, `Sending`.*express*.v and `Encoding`.*express*.v. That is, the verb *express* may be used to mean "to send in the post with a short delivery time," that is, with the meaning of the `Sending` frame. In addition, the same lemma *express* may also be used in a situation in which "a PERSON encodes a MESSAGE or mental content, broadly understood, in a particular MANNER," that is, in the `Encoding` frame.

The FrameNet database contains: definitions of cognitive frames and of their FEs; annotated corpus example sentences of LUs; and **valence patterns** (combinatorial possibilities of arguments and adjuncts, in terms of FEs, phrase types (PTs), and grammatical functions (GFs)) of LUs (cf. Table 1). For example, the English LU `Sending`.*express*.v currently has 39 valence patterns in FN, including "[SENDER.NP.Ext] *send* [THEME.NP.Obj] [PURPOSE.VP*to*.Dep]"[3] as in "[<SENDER> member states of the Arab League] *sent* [<THEME> troops] [<PURPOSE> to help the Palestinian Arabs]."

JFN is compatible with FN: sharing definitions of cognitive frames and their FEs, database structures, methodologies and some of the tools (Ohara, 2014). As shown in Table 1, there are currently 5029 LUs in JFN, consisting of: 1136 verbs, 132 adjectives, 152 adjectival nouns, and 3307 nouns.

There have been studies that assign FN cognitive frames to sentences using crowdsourcing (Hong and Baker, 2011; Fossati et al., 2013; Chang et al., 2015). Their methods basically present crowdworkers with example sentences or simplified frame definitions and ask them to select one from several choices. Unlike previous studies, our method involves not only word sense disambiguation (cognitive-frame disambiguation) but also linking two different types of frame knowledge, namely, JFN (i.e., top-down frame knowledge) and KCF (i.e., bottom-up frame knowledge). Moreover, as will be discussed below, our crowdsourced task involves example sentence selection and thus requires no prior knowledge of Frame Semantics on the part of crowdworkers.

In KCF, each case frame is represented as a predicate and a set of its case slots (or case markers) with their instance words. KCF contains verbs, copulas, adjectives and adjectival nouns, but not nouns. Table 2 is a partial list of the case frames of the verb *okuru* 'send' in KCF.

| KCF Case Frame ID | Case Slots | Instance Words |
|---|---|---|
| *okuru* (1) | *ga* (NOM[4])<br>*o* (ACC)<br>*ni* (DAT) | *watashi* 'I':374, ...<br>*meeru* 'mail':211755, ...<br>*keitai* 'cell phone':30944, ... |
| *okuru* (2) | *ga* (NOM)<br>*o* (ACC)<br>*ni* (DAT) | *josei* 'women':489,...<br>eeru 'yell':70314, ...<br>*senshu* 'athlete':3478, ... |
| *okuru* (3) | *ga* (NOM)<br>*o* (ACC)<br>*ni* (DAT) | *watashi* 'I': 125, ...<br>*shinsei* 'application': 35477, ...<br>*kaisha* 'company': 1367, ... |
| ... | ... | ... |

Table 2: Examples of KCF case frames for the predicate *okuru* 'send.' The numbers denote frequencies.

Here, the case frame *okuru* (1) consists of: the case slot *ga* followed by its instance words *watashi* 'I,' *dare* 'who,' *hito* 'person' ...; the case slot *o* followed by *meeru* 'mail,' *messeeji* 'message' ...; and the case slot *ni* followed by

[1] We would like to thank an anonymous reviewer for pointing this out to us.

[2] In Frame Semantics literature, terms such as cognitive frames (Fillmore, 1982, p.117 (Geeraerts (Ed.), 2006, p.379)), Fillmore and Baker, 2010, p. 314), semantic frames (Ruppenhofer et al., 2010), linguistic frames (Fillmore and Baker, 2010, p.338) and frames (Fillmore and Baker, 2010, p.314) have been used to refer to the same notion. In this paper, in order to distinguish the notion from case frames, we will use "cognitive frames."

[3] NP: noun phrase, VP: verb phrase, Ext: External Argument (i.e., Subject), Obj: Direct Object, Dep: Dependent (i.e., anything other than subject and direct object)

[4] "NOM" stands for the nominative case; "ACC" the accusative; and "DAT" the dative.

*keitai* ‘cell phone,’ *hito* ‘person,’ *tomodachi* ‘friend.’ Here, even though the three case frames of *okuru,* namely, *okuru* (1) through *okuru* (3), contain the same set of case slots *ga* (the nominative), *o* (the accusative), and *ni* (the dative), the instance words that each of the case slots accompanies are different. In other words, each case frame in KCF represents a “usage” of a predicate. The number of KCF case frames of a predicate usually exceeds the number of JFN LUs of the same predicate (in other words, exceeds the number of JFN cognitive frames that the predicate is associated with), it may be possible to say that a “usage” that each KCF case frame represents is more fine-grained than a “meaning” that a JFN cognitive frame represents. Unlike JFN valence patterns, however, KCF case frames do not at all include semantic information about case filler words. That KCF does not contain semantic information at all means that it does not have semantic information incompatible with JFN. Also, JFN cognitive frames can be used to describe meanings of predicates in KCF. It is thus possible to link JFN annotated sentences with KCF case frame example sentences via cognitive frames.

We use the latest version of KCF, which was constructed by applying Chinese Restaurant Process-based clustering (Kawahara and Kurohashi, 2006; Kawahara et al., 2014) to 10 billion Japanese sentences. KCF has about 110,000 predicates and 5.4 case frames on average for each predicate.

## 3. Methods

We link each KCF case frame of a predicate with one of the JFN cognitive frames that corresponds to the same meaning of the predicate. We cast this linking process as a crowdsourced task of example sentence selection. Figure 1 shows a screenshot of the crowdsourced sentence selection task for the case frame (3) of *okuru* ‘send’ in Table 2.

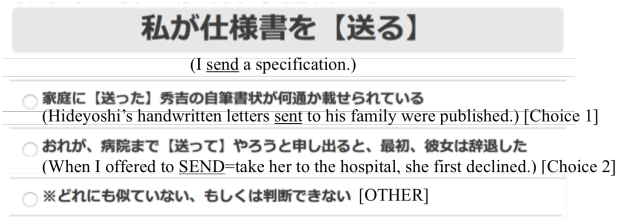


Figure 1: An example of crowdsourced sentence selection tasks

An example sentence for the case frame (3) from KCF was presented to crowdworkers and they were asked to select a JFN example sentence that is most similar to the presented sentence. The first two choices in Figure 1 are example sentences in JFN for `Sending.`*okuru*.v (Choice 1) and for `Bringing.`*okuru*.v (Choice 2) respectively. In addition to these two choices, we made another choice “No similar sentences exist or impossible to judge” (“OTHER”, hereafter), which is to be selected if the presented example sentence from KCF is not similar to either of the JFN example sentences or if it is impossible to judge from the presented sentence. We hypothesized that when “OTHER” was selected by many, there might be something to re-examine in the cognitive-frame assignment for the predicate in JFN (cf. Section 4.2).

We assumed that sentences shown to crowdworkers (both the presented sentence and the Choice 1 and Choice 2 sentences) should be short, so that it would be easy for them to understand their meanings. To generate such a sentence for each case frame in KCF, we selected a sentence that had the highest generative probability based on a language model from the set of example sentences that constitute the target case frame. By this method, we were able to select a sentence that was short and easy to understand. We adopted an RNN language model (Mikolov et al., 2010) to calculate the generative probability of a sentence. This RNN language model was trained on a web corpus consisting of 10 million Japanese sentences.

To generate an example sentence for a JFN cognitive frame, we manually selected the shortest example sentence from the set of example sentences that belong to the target JFN cognitive frame. The reason why we picked the shortest example sentences was to take into account the screen sizes of PCs and of smart phones and to make it easier for crowdworkers to read them. If a selected example sentence was longer than 60 characters, it was shortened by hand.

## 4. Experiments

### 4.1 Experimental Settings

There are currently 935 predicates that exist both in JFN and KCF. Among these predicates, we conducted experiments on 37 predicates (27 verbs, 5 adjectives and 5 adjectival nouns) that have two JFN cognitive frames and at least one example sentence for each in the JFN database. There were only 37 predicates that met the criteria above. These 37 predicates have 712 case frames in total in KCF.

The predicates that exist only in JFN are mostly complex prepositions (e.g. *ni_kansuru* ‘with respect to’) and compound nouns that may also be used as verb stems (e.g. *syookyaku_shori* ‘incineration’), which are not included in KCF.

There are approximately 110 thousand predicates that exist in KCF but not in JFN. This is because KCF distinguishes predicates with auxiliaries that cause case alternations. For example, in addition to *uru* ‘sell,’ a “bare” predicate, KCF has additional separate predicates with the same stem and an auxiliary verb beginning with *–te*, such as *ut-teiru, ut-tekuru, ut-tekureru*. There are 50 thousand predicates with a *–te* auxiliary verb in KCF. Furthermore, KCF distinguishes predicates with passivizing and causativizing suffixes, from the active predicates without such suffixes. There are 31500 predicates without passivizing/causativizing suffixes; 5300 predicates with the passivizing suffix *-(r)are*; and 1700 predicates with the causativizing suffix *-(s)ase*. In contrast, in JFN, uses of predicates with a *–te* auxiliary verb and uses of predicates with the passivizing/causativizing suffix are included in the same LUs and case alternations are recorded as different valence patterns of the same LUs (cf.

Section 2). KCF also contains many infrequent predicates (e.g. *nyuuzan_suru* 'go into a mountain,' *nikusyoku_da* 'carnivorous') that JFN does not contain.

We employed Yahoo! Crowdsourcing[5] to crowdsource the linking task. We asked 10 crowdworkers for the linking task of each case frame. Their answers were aggregated by majority voting. To alleviate the influence of malicious crowdworkers, we used gold questions, i.e., easy questions to which we had known the correct answers beforehand. We eliminated the crowdworkers who had not correctly answered the gold questions. As a result, in total 272 crowdworkers participated in the task, and it took approximately two hours to complete the task. The total cost was approximately 25,000 JPY.

### 4.2 Results and Discussions

We examined the responses of the crowdworkers for each case frame of each predicate, by manually checking whether their responses were correct or not. Specifically, we analyzed whether the JFN cognitive frame that got the largest number of votes was correct or not. Two JFN annotators evaluated the results of the crowdsourced task. After each of the two annotators individually evaluated the results, the principal JFN annotator compared the two evaluations (one by herself and another by the other JFN annotator) and gave the final evaluation.[6] There were inter-annotator agreements for the majority of the sentences.

| KCF Case Frame ID | KCF Target Sentence | JFN Cognitive Frame with the largest # of votes |
|---|---|---|
| *okuru* (1) | *watashi tachi ga iimeeru o okutta*<br>(We sent email) | ✔`Sending` |
| *okuru* (2) | *futari ga seien o okuru*<br>(Two people SEND cheers) | ✔"OTHER" |
| *okuru* (3) | *watashi ga shiyoosho o okuru*<br>(I send a specification) | ✔`Sending` |
| *okuru* (4) | *futari ga setsuyaku seikatsu o okuru*<br>(Two people SEND=live frugal lives) | ✔"OTHER" |
| *okuru* (5) | *watashi ga senga o okuru*<br>(I send specification) | ✔`Sending` |
| *okuru* (6) | *watashi ga tookyoo eki made sannin o okuru*<br>(I SEND =take three people to Tokyo Station) | ✔`Bringing` |
| *okuru* (7) | *jibun ga seishun jidai o okutta*<br>(I SENT=spent [my] youth) | ✔"OTHER" |
| *okuru* (8) | *watashi ga fakkusu de okuri mashoo ka*<br>(Shall I send [it] by fax?) | ✔`Sending` |
| *okuru* (9) | *boku no noo ga kiken shingoo o okuru*<br>(My brain sends a danger signal) | ×OTHER |

Table 3: Results of JFN cognitive frame assignments to KCF case frames for *okuru* 'send' by crowdworkers[7]

[5] https://crowdsourcing.yahoo.co.jp/

[6] The two annotators are both experienced JFN annotators, but whereas the principal annotator is formally trained in linguistics and in the theory of Frame Semantics, the other annotator is not.

[7] The symbols ✔ (correct) and × (incorrect) show the evaluation by JFN annotators.

Table 3 shows the result of evaluating the responses by crowdworkers for all the 9 case frames of the verb *okuru* 'send.' There were varying degrees of accuracy depending on the predicate. After evaluating the responses by the crowdworkers, we classified the 37 predicates into three categories based on two factors: the sematic closeness of the two relevant JFN cognitive frames; and whether the two JFN cognitive frames actually characterize the meanings of the predicate in question. The proposed three categories of predicates are the following:

Category I: None of the criteria for Categories II or III below applies. That is, the two JFN cognitive frames, which represent the two meanings of the predicate, are semantically distinct.

> e.g. *okuru* 'send' (The `Sending` frame, in which a SENDER does not travel with a THEME, is semantically distinct from the `Bringing` frame, in which an AGENT travels together with a THEME.)

Category II: The two meanings of the predicate are semantically close. There are two cases: the two JFN cognitive frames are related via JFN frame-to-frame relations; or not.

An example of the former is *iku* 'go.'

> e.g. *iku* 'go' (The `Motion` and `Self_motion` frames differ only in whether the entity that moves is a living being or not and the two cognitive frames are linked to each other via the Inheritance frame-to-frame relation.)

An example of the latter is *kaku* 'write.'

> e.g. *kaku* 'write' (The `Text_creation` frame, having to do with creating a TEXT that contains meaningful linguistic tokens, and the `Spelling_and_pronouncing` frame, pertaining to realizing a SIGN in some FORMAL_REALIZATION, are semantically close to each other but they are not related by any frame-to-frame relation.)

Category III: The cognitive frames assigned to the predicate in JFN do not correctly characterize its meanings. There are two cases: the predicate was incorrectly assigned a cognitive frame in JFN; or the predicate by itself (that is, not as a support predicate that accompanies a specific noun phrase) evokes another cognitive frame that has not been assigned to the predicate in JFN.

An example of the former is *tekisetsu-da* 'appropriate.'

> e.g. *tekisetsu-da* 'appropriate' (The `Suitability` and `Desirability` frames were assigned to this predicate in JFN. However, as the latter cognitive frame has to do with an EVALUEE being judged for its quality, i.e. how much it would be probably liked, it does not characterize the meaning of the predicate and thus should not have been assigned to the predicate in JFN.)

An example of the latter is *ataeru* 'give.'

> e.g. *ataeru* 'give' (In addition to the `Giving` and `Supply` frames that have been assigned to the verb in JFN, the `Objective_influence` and `Subjective_influence` frames should also be assigned to it.)

Table 4 summarizes the accuracy of the crowdworkers' responses for each of the three categories of the predicates. It shows that the predicates in Category I, namely, those having two semantically distinct meanings, achieved the highest accuracy. Category II predicates, with two semantically close meanings, followed Category I predicates in the accuracy. Category III predicates, with incorrect or incomplete cognitive-frame assignments, had the lowest accuracy.

| Predicate Category | # of Predicates | Accuracy |
|---|---|---|
| I | 9 | 83.9% |
| II | 11 | 57.9% |
| III | 17 | 26.3% |

Table 4: Micro Average of Accuracy

Our tentative hypotheses include the following:

1) When the two JFN cognitive frames assigned to a predicate are semantically close, it is difficult for crowdworkers to correctly distinguish between the two meanings (Category II);
2) When the assignment of a cognitive frame in the JFN database is incorrect, it is difficult for crowdworkers to make a distinction among the "correct" word meanings of the predicate (Categories III);[8]
3) When the predicate involves more than two meanings, it is difficult for crowdworkers to correctly make a distinction among them (Category III)

There are other possible causes for crowdworkers' mistakes. Some of the KCF sentences we presented to crowdworkers did not include all the syntactic arguments (i.e., all the case slots) and consequently the sentences were vague. It was thus impossible for crowdworkers to determine their meanings. In our future experiments we plan to use sentences with all the case slots filled.

Also, there are sentences in which a predicate constitutes a part of an idiom.[9] With such sentences, judgments by crowdworkers varied. Examples include:

(1) *chie* *o* *shiboru* 'rack one's brains'

wisdom ACC squeeze

(The whole phrase evokes the `Cogitation` frame.)

(2) *me* *o* *toosu* 'skim through'

eye ACC pass

(The whole phrase evokes the `Reading_perception` frame.)

(3) *sode* *o* *toosu* 'put on a shirt'

sleeve ACC pass

(The whole phrase evokes the `Drssing` frame.)

(4) *hooan* *o* *toosu* 'pass (a bill)'

bill ACC pass

(The whole phrase evokes the `Successfully_communicate_message` frame.)

Turning to the "OTHER" option in the crowdsourced task, it appears that crowdworkers resorted to this option when a support-predicate usage was involved in the presented sentence. For example, in Table 3, case frame (2) (*seien o okuru*: literally 'send cheers,' in other words, 'cheer'), case frame (4) (*seikatsu o okuru*: literally 'send a life,' in other words, 'live'), and case frame (7) (*seishun jidai o okuru*: literally 'send youth,' in other words, 'spend (one's) youth') involve such uses of the verb *okuru*. Therefore, the "OTHER" option may be used as a clue to finding support-predicate uses of predicates. We hope to investigate crowdworkers' uses of the "OTHER" option further.

## 5. Conclusion and Prospects

We proposed a method to crowdsource the assignment of JFN cognitive frames, that is, word meanings, to KCF case frames, by matching an example sentence from KCF and another from JFN that share the same meaning of a predicate. Our initial experiments with predicates that have two JFN cognitive frames yielded promising results, especially with regard to Category I predicates, namely, those having two meanings that are not semantically close to each other.

Our next step is to conduct experiments with the remaining 898 predicates that have been assigned three or more cognitive frames in JFN. For this task, we plan to use the frame-to-frame relations in JFN.

Although our ultimate goals include scaling up the size of annotated sentences in JFN, so far we have concentrated on the task of cognitive-frame disambiguation. The whole FN/JFN annotation process also involves assignments of FEs and thus our longer-term goals include assigning JFN FEs to individual case slots (i.e., case-marked NPs) of each KCF case frame as well. We estimate this task to be relatively easy for crowdworkers compared to the task reported in this paper, that is, compared to finding a JFN annotated sentence similar to an example sentence of a KCF case frame.

Furthermore, in order to increase the coverage of JFN, we plan to work on predicates that exist in KCF but not in JFN, by mapping each KCF case frame to a JFN cognitive frame. We will first focus on the "bare" predicates, which do not have passivizing/causativizing suffix or a *–te* auxiliary, in KCF.

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[8] We have yet to investigate whether correcting the assignment of JFN cognitive frames for these predicates would indeed improve the accuracy of responses by crowdworkers.

[9] In addition to having the "OTHER" option, it might be possible to add another choice of "IDIOM." However, following guidelines for crowdsourcing, we decided to keep each individual task as simple as possible for crowdworkers and thus did not make a choice of "IDIOM."

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