

# Emotion Reasoning Based on Valency Patterns

— a prototype annotation of causal relationships —

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**Abstract.** This paper proposes a valency-pattern-based method of emotion reasoning. To determine whether or not a sentence indicates an emotional situation, an attempt is made to annotate *causal relationships* for emotions to 14,819 valency patterns defined in the dictionary, 'Nihon-go Goi Taikai', which covers almost all Japanese verb senses. As a result, relationships for emotions were annotated to 5,606 patterns. The method was tested experimentally using a diary text, and was shown to have an accuracy of 63%. These results indicate that using valency patterns to determine causal relationships for emotions is a suitable method for emotion reasoning from text.

**Keywords:** emotion reasoning from text, semantic analysis, Japanese verb sense and emotion, emotion arousal feature, valency pattern, pattern based reasoning

## 1 Introduction

Affective reasoning from sentences has potential applications in the field of semantic analysis. Various verbal information has been used for this purpose, for example, the use of *beliefs* extracted from an understanding of a dialogue (Tokuhisa et al. 2000). This belief-based emotion reasoning theoretically infers emotions that depend on the context of the dialogue because the method infers the speaker's mental state from sentences. However, it is difficult to build an inference rule base or to describe a belief state using this system. (Rosis and Grasso 2000) included an emotion prediction function in their dialogue planning system. Since considerable emotion in the medical dialogue domain is annotated to the *effect slot of dialogue plan knowledge*, this method has a lower reasoning cost than the belief-based method. But high coverage of the plan knowledge is required for its use in wider areas. Focusing on verb level rather than discourse level, a deep-case-frame-based reasoning was proposed (Mera 2003). In this more widely applicable method, a formula for calculating emotion is assigned to each relationship between a verb and its deep case elements and an emotional value (e.g. pleasure/displeasure) is computed from it. However, it does not disambiguate verb senses nor dynamically solve the problem of context dependency for emotion arousal.

Valency patterns have been found to be very effective in analyzing Japanese verb senses in the field of machine translation (Kanadechi et al. 2004). These patterns have already been defined (Ikehara et al. 1997) with 14,819 patterns covering almost all Japanese verb senses. Since each pattern consists of a verb and surface case elements with semantic constraints, it is possible to disambiguate Japanese verb senses.

Therefore, this paper proposes a new emotion reasoning method based on valency patterns. This method uses *causal relationships* for emotions. The relationships are annotated to valency patterns to determine whether or not a sentence is describing an emotional situation. Even if the verb senses in two sentences are similar, the emotional states may be different. Therefore, a *precondition* is included in the relationships to support contextual understanding.

As the first trial, this paper tries to annotate the causal relationship to the pattern without using preconditions, because there is a large number of valency patterns and there are difficulties in clearly describing the preconditions. Section 2 introduces the principle of emotion reasoning and an ideal annotated pattern. In Sections 3 and 4 the annotation process and results are shown. Section 5 examines the feasibility of valency-pattern-based emotion reasoning.

## 2 How to reason emotion

### 2.1 Principle of emotion reasoning

(Tokuhsa and Okada 1997) regarded the emotion arousal process as a kind of pattern comprehension process, and defined “emotion arousal features” in terms of eight emotional concepts: *gladness/sadness, liking/dislike, expectancy, fear, surprise, and anger*. Figure 1 illustrates the feature frame for *gladness*. The highest level feature is “the after-state is better than the before-state.” This feature is conceptually decomposed into nine middle level features (MLFs) and 18 lowest level features (LLFs). Italic words in Figure 1 are LLFs.

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( gladness (  
  the after-state is better than the before-state (  
    physiological state ( inside pleasure; surface pleasure );  
    mental state (  
      goal achievement (  
        information acquisition ( confirmation; discovery; clarification );  
        planning ( plan creation );  
        result of execution ( achievement; acquisition; plan's effectiveness ));  
      human relationship (  
        fellowship ( agreement; sympathy; cooperation; reconciliation );  
        social rank ( superiority; acceptance of praise; request fulfillment; protection; hospitality));  
      others )))
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Figure 1. Feature frame for ‘gladness’

These features are suitable for emotion reasoning from sentences. Emotion reasoning from a sentence is aimed at determining whether or not the sentence means a specific situation, i.e., does it contain emotion arousal features? For example, if a sentence describes a situation in which *a boy has obtained theater tickets necessary for a date with his girl friend*, most people would assume that the boy would be glad. This situation matches the feature underlined in Figure 1.

### 2.2 Emotion reasoning based on valency patterns

As mentioned in Section 1, valency patterns have been defined (Ikehara et al. 1997) for almost all Japanese verbs. An example pattern of a Japanese verb “*nyushu-suru*(= acquire)” follows:

header:	<i>nyushu-suru</i>
valency pattern	
(Japanese):	N1- <i>ga</i> N2- <i>wo</i> N3- <i>kara nyushu-suru</i>
(English):	N1 get N2 from N3
constraint:	N1( <i>agent</i> ), N2( <i>organization, physical object, - - -</i> ), N3(*)
semantic attribute:	<i>possessive movement</i>

If this pattern matches a sentence, the sense of the sentence is analyzed as a *possessive movement*. Remind “acquisition,” is an LLF for *gladness*. If a person, N1, stated in the pattern has a *GOAL* and an object, N2, is necessary to achieve the *GOAL*, N1 may be glad in this situation. Therefore we add the following “causal relationship” to the pattern.

causal relationship of “ <i>nyushu-suru</i> ”	
feeler: N1	precondition: N1 has a <i>GOAL</i>
feel-to: N2	N2 is necessary to achieve the <i>GOAL</i>
cause: <i>acquisition</i>	
emotion: <i>gladness</i>	

The slot “feeler” and “feel-to” indicate whose emotion is aroused and which object receives the emotion, the slot “cause” represents the cause of the emotion, for instance, the feature name of the frame, and the slot “emotion” represents the type of emotion. For convenience, these three blocks are written separately, but in reality they are combined. It is difficult to describe preconditions because they include common sense. Therefore in this paper we investigate the feasibility of emotion reasoning using a valency pattern with causal relationships, initially without preconditions. Descriptions of preconditions will be developed in future work.

### 3 Annotation of causal relationships for emotions

#### 3.1 Conditions of annotation

The following conditions are applied in annotating causal relationships to the valency pattern:

- There is a variable  $N_n$  whose constraint includes human sense in the target valency pattern.
- When understanding the valency pattern from the person  $N_n$ 's viewpoint, the verb sense of the target pattern matches an emotion arousal feature<sup>1</sup>.

If there is more than one relationship in a valency pattern, duplicate the pattern and annotate each relationship to the duplicated pattern.

#### 3.2 Annotation steps

The annotation steps contain bottom-up and top-down steps. In the bottom-up step, the analyst reads every valency pattern, checks the annotation conditions, and annotates the relationships. In the top-down step, the analyst looks up the emotion arousal features in a thesaurus (Ono and Hamanishi 1981) and then checks whether the valency patterns of the synonym are correctly annotated. Note that subjective judgment is thus avoided because the emotion arousal features have been defined.

#### 3.3 Brief results

There are 14,819 valency patterns (Ikehara et al. 1997), and 5,606 valency patterns satisfy the annotation conditions. Since there were multiple annotations, 7,320 causal relationships were annotated.

Table 1 shows samples of verbs related to emotion arousal. The annotation targets Japanese verbs. To aid understanding, we added English verbs to the table.

Table 1. Samples of verbs related to emotion arousal

emotion	sample of Japanese verbs
gladness	( <i>position*-ga</i> ) <i>agaru</i> (= be promoted), ( <i>title*-wo</i> ) <i>ataeru</i> (= award), <i>atatamaru</i> (= get warmer), ( <i>occupation*-wo</i> ) <i>assen-suru</i> (= help one find), - - -
sadness	<i>tounan-ni au</i> (= be burglarized), <i>higai-wo ataeru</i> (= damage), ( <i>seafood*-ni</i> ) <i>ataru</i> (= be poisoned), ( <i>judgment*-wo</i> ) <i>ayamaru</i> (= err in), - - -
liking	<i>au</i> (= meet), ( <i>alcohol*-wo</i> ) <i>aogu</i> (= drink), <i>ajiwau</i> (= savor), ( <i>allocation*-ni</i> ) <i>azukaru</i> (= share), ( <i>right*-wo</i> ) <i>iten-suru</i> (= transfer), <i>nakama-ni ireru</i> (= include), - - -
dislike	<i>sitsurei-ni ataru</i> (= be impolite to), ( <i>fragment*-wo</i> ) <i>abiru</i> (= strike), <i>shian-ni amaru</i> (=be at wits' end for), <i>ayashimu</i> (= doubt), <i>aku-eikyou-suru</i> (= have bad influence upon), - - -
expectancy	( <i>material*-wo region*-ni</i> ) <i>aogu</i> (= depend), ( <i>plan*-wo</i> ) <i>atatameru</i> (= work on), <i>amaeru</i> (= fawn on), <i>kokoro-atari-ga aru</i> (= know of), <i>ishoku-suru</i> (= entrust), - - -
fear	<i>gai-ga aru</i> (= be bad for), <i>inpei-suru</i> (= conceal), <i>nigeba-wo ushinau</i> (= one's escape route be cut off), <i>shutai-wo enjiru</i> (= behave in a shameful manner), - - -
surprise	<i>battari au</i> (= run into), <i>te-no uchi-wo akasu</i> (= show one's hand to), ( <i>event*-ga</i> ) <i>okiru</i> (= happen to), <i>ura-wo kaku</i> (= outwit), - - -
anger	<i>azamuku</i> (= deceive), <i>ii-kaesu</i> (= retort), <i>ouryou-suru</i> (= embezzle), <i>kousoku-suru</i> (= restrain), <i>shokuhatsu-suru</i> (= influence), - - -

Asterisk words are semantic constraints for case elements, variables  $N_n$

### 4 Spread of emotional valency patterns

#### 4.1 Viewpoint of emotion arousal features

Table 2 shows the number of emotional valency patterns classified in terms of the emotion arousal feature. Parts of “-” mean that no LLF has been assigned to the emotion.

<sup>1</sup>If there is a need to annotate preconditions, the differential sense between the sense of the verb and the emotion arousal feature can be used.

There are a large number of patterns for *gladness* and *liking*. The opposite emotions, *sadness* and *dislike*, have fewer patterns. There are only a small number of patterns for *fear*, *surprise* and *anger*. The highest level features for these emotions are “a dangerous event/thing is found,” “an unexpected event happens, or an expected event doesn’t occur,” and “a rule/due is violated.” Because there are fewer verbs that have a sense of “danger”, “expectation”, or “rule/due”, this result is acceptable.

A large number of patterns are classified to *other* features of *liking*, *dislike*, and *expectancy*. We consider that the definition of the LLFs is not enough, because (Tokuhisa and Okada 1997) focused on children’s emotions.

The number of patterns for the *LLF of physiological state for surprise* is 0 because this paper assigns the annotation condition mentioned in Section 3.1. For instance, an event such as, “The floor vibrates”, would intuitively be expected to arouse *surprise*, but this expression does not contain a human subject and therefore does not satisfy the conditions.

Table 2. Spread of patterns in feature terms

	gladness	sadness	liking	dislike	surprise	expectancy	fear	anger
LLF of physiological state	32	79	117	245	0	4	34	2
LLF of goal	-	-	125	126	-	-	-	37
LLF of information	120	49	111	46	25	13	106	11
LLF of planning	99	69	-	-	-	127	54	-
LLF of result	759	323	352	136	12	-	1	41
LLF of fellowship	157	49	270	190	-	184	99	26
LLF of social rank	651	428	453	313	-	123	71	36
other	54	63	213	189	20	233	60	22
MLF	15	10	15	26	7	33	37	18
total	1,887	1,070	1,656	1,271	64	717	462	193

## 4.2 Viewpoint of verb sense

Thirty-six verb-sense attributes have been defined (Ikehara et al. 1997). The attribute system is a tree structure similar to a general thesaurus. Focusing on the second depth from the root, all the patterns (A) and annotated patterns (B) are summarized in Table 3. As the table shows, this system contains the modal of the verbs and these verbs have emotional patterns.

The density of the emotional patterns beneath terms of verb sense *state* and verb sense *action* are summarized in Table 4. We would expect a high number of *possessive movement* and *result*, but the number of *affective state* and *affective action* were higher than we expected.

Table 5 shows the spread of these patterns in terms of emotion arousal feature. The patterns of *affective state*, *affective action*, and *result* are distributed to all the features. For example, the following verbs belong to the *affective state/action*.

*LLF of physiological state*→*douki-ga suru*(= palpitate), *LLF of goal*→*shinbou-suru*(= endure), *LLF of planning*→*atama-wo kakaeru*(= be utterly perplexed at), *LLF of result*→*ki-ga chiru*(= be distracted by), *LLF of friendliness*→*shoutotsu-suru*(= conflict with), *LLF of social rank*→*jiman-suru*(= be proud of), - - -

This means that more specific verb-sense attributes may exist in these three attributes.

Taking Sections 4.1 and 4.2 into consideration, the emotional patterns can be spread to all the emotion arousal features and verb-sense attributes. We achieved a certain measure of success in the first trial of this annotation.

## 5 Experiment

### 5.1 Reasoning from diary text

This section evaluates the accuracy of the pattern knowledge base. We chose a diary text (Ishihara 2002) as a test set. This book is a lecture text for Japanese people who want to write a diary in English. There are 20 chapters and each of them has an emotional category. The category indicates the emotions that author wants to

Table 3. Spread of patterns in terms of verb-sense attributes

verb sense attribute	number of patterns under attribute(A)	number of emotional patterns under attribute(B)	density (B/A)
state	4,933	1,162	0.24
action	10,734	4,875	0.45
causative	16	15	0.94
potential	11	6	0.55
begining	99	24	0.24
ending	100	47	0.47

Table 4. Detailed spread of patterns under “state(left)” and “action(right)”

attributes of <i>state</i> verbs	density (B/A)	attributes of <i>action</i> verbs	density (B/A)
affective state	0.66 ( 181 / 275 )	affective action	0.75 ( 1,009 / 1,347 )
perceptive state	0.63 ( 38 / 60 )	possessive movement	0.73 ( 297 / 409 )
relativity	0.57 ( 203 / 356 )	result	0.68 ( 183 / 269 )
physiological state	0.52 ( 29 / 56 )	physiological change	0.59 ( 220 / 373 )
thinking state	0.52 ( 13 / 25 )	psychical movement	0.58 ( 597 / 1,023 )
possessive state	0.49 ( 38 / 78 )	thinking action	0.53 ( 726 / 1,374 )
mental state	0.33 ( 3 / 9 )	perceptive action	0.51 ( 98 / 193 )
attribute	0.17 ( 636 / 3,782 )	disappearance	0.43 ( 41 / 96 )
causality	0.12 ( 6 / 48 )	utilization	0.40 ( 48 / 121 )
existence	0.05 ( 3 / 61 )	attribute change	0.33 ( 845 / 2,588 )
natural state	0.03 ( 5 / 155 )	connecting action	0.30 ( 55 / 183 )
		generation	0.29 ( 79 / 276 )
		physiological action	0.28 ( 504 / 1,811 )
		physical movement	0.17 ( 88 / 511 )

Table 5. Spread of patterns in terms of features and attributes

feature	affective state	affective action	possessive movement	result	perceptive state
LLF of physiological state	2	27	0	18	34
LLF of goal	6	24	3	5	0
LLF of information	12	85	2	18	0
LLF of planning	26	46	5	6	0
LLF of result	11	113	99	81	1
LLF of friendliness	7	131	30	7	0
LLF of social rank	26	250	136	38	0

express. Therefore, these categories are available for decide the correct answer for the reasoning experiment.

We selected 12 titles (including 98 clauses) from the book and inferred emotions from them using the valency-pattern-matching method manually. Figure 2 shows one of the titles. The expression in clause (1) “*oubo-shita*(= entered)” matches the pattern “N1(*agent*)-*ga* N2(*human activity*)-*ni oubo-suru*.” Because this pattern has causal relationships, “feeler: N1,” “feel-to: N2,” “cause: others,” and “emotion: expectation,” the author’s *expectation* can be inferred. The next clause also leads to *gladness as a result of acquisition* in an identical manner. These emotions agree with the category of this title.

50 clauses, for example, clauses (4), (6), and (7) in Figure 2, did not require analysis, and leaving 48 clauses should be analyzed by our method. Since 30 clauses were correctly analyzed, the accuracy was 63%.

## 5.2 Error analysis

We classified the cases of error in the experiment in Table 6. Case (a) is an analyst’s error. It is difficult to solve case (b) formally. For example, from the sentence “We took a history test.” we should be able to reason the author’s emotion, perhaps based on the knowledge that “Most students hate tests.” Therefore, example-based reasoning may be required. Case (c) suggests that the precondition should take into account the informed contents, for instance, a *that-clause* followed by such verbs as “say, see, hear, know, etc.” For example, “I

1) <u>suu-kagetsu-mae-ni kenshou-ni oubo-sita.</u> <sub>(1)</sub> (I entered a prize competition in a magazine a few months ago <sub>(1)</sub> .)	(1) expectancy	correct
2) <u>kyou, maunten-baikyu-ga atatta</u> <sub>(2)</sub> <u>-toiu tsuchi-ga todoita.</u> <sub>(3)</sub> (and I got a notice that I've won a mountain bike! <sub>(2)(3)</sub> )	(2) gladness	correct
3) <u>majide? te kanji!</u> <sub>(4)</sub> (Unbelievable! <sub>(4)</sub> )	(3) no	incorrect
4) <u>konshu-matsu-ni haitatsu-site-kureru</u> <sub>(5)</sub> <u>-toiu koto-datta.</u> <sub>(6)</sub> (They said they'd deliver it to me this weekend. <sub>(5)(6)</sub> )	(4) no	don't care
5) <u>mechakucha ureshii!</u> <sub>(7)</sub> (I'm so happy! <sub>(7)</sub> )	(5) liking	correct
	(6) no	don't care
	(7) no	don't care

Since clauses (4) and (7) express the author's emotion directly, the emotion reasoner does not need to reason emotions from them.

Figure 2. Sample diary text and results of assessment

heard on TV that there was an earthquake in the area where my husband is on business." The speaker's emotion is depend on what she has heard. Case (d) presents a problem for the coverage of valency patterns.

In future work, we will therefore check all relationships according to case (a) and annotate preconditions, paying attention to case (c).

Table 6. Cases of error in valency-pattern-based reasoning

case	count
(a) The analyst missed annotating causal relationships.	6
(b) Action and state should be evaluated directly.	5
(c) Evaluation of the described information should be used for reasoning.	4
(d) More valency patterns are required.	3

## 6 Conclusion

This paper proposed a new emotion reasoning method based on valency patterns. We checked 14,819 previously defined valency patterns (Ikehara et al. 1997) that cover almost all Japanese verb senses, found 5,606 patterns that cause emotions, and annotated causal relationships to them. Next, the spread of emotional valency patterns was examined. Lastly, an emotion reasoning experiment from diary text showed an accuracy of 63%. Thus, we demonstrated the feasibility of our method. Future wok will focus on more accurate annotation and describing preconditions.

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