WRITING SUPPORT SYSTEM DEALING WITH NOTATIONAL VARIANT SELECTION

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Keywords: Writing support system, Dominant notational variant, κ values.

Abstract: In Japanese, there are a large number of notational variants of words. This is because Japanese words are written in three kinds of characters: Kanji (Chinese) characters, Hiragara letters, and Katakana letters. Japanese students study basic rules of Japanese writing in school for many years. However, it is difficult to learn which notational variant is suitable for official, business, and technical documents because the rules have many exceptions. From the viewpoint of information retrieval, a considerable number of studies have been made on notational variants, however, previous Japanese writing support systems were not concerned with them sufficiently. This is because their main purposes were misspelling detection. Nondominant notational variants are not misspelling, but often unsuitable for official, business, or technical documents. To solve this problem, we developed a writing support system which detects nondominant notational variants in students' reports and shows dominant ones to the students. This system is based on the idea that suitable notational variants are used dominantly in official, business, and technical documents. In this study, we first show the diversity of notational variants of Japanese words and how to develop notational variant dictionaries by which our system determines which notational variant is dominant in official, business, and technical documents. Finally, we conducted a control experiment and show the effectiveness of our system.

1 INTRODUCTION

In English, there are few words which are spelled in several different ways, such as, color and colour. In contrast, in Japanese, there are a large number of notational variants of words. This is because Japanese words are written in three kinds of characters:

- Kanji (Chinese) characters,
- Hiragara letters, and
- Katakana letters.

For example, *sakura* [cherry blossom], one of the symbols of Japan, is written in three ways, as shown in Figure 1. Basic rules of Japanese writing are announced by the Cabinet, and Japanese students study them in school for many years. However, it is difficult to learn the rules because they have many exceptions. In fact, we often find the confusion of notational variants in Japanese university students' reports, including unsuitable notational variants for official, business, and technical documents. As a result, it is important for students to learn which notational variant is suitable for official, business, and technical documents. To solve this problem, we developed a writing support system which detects unsuitable notational variants in students' reports and shows suitable ones to the students. In this study, we assumed that suitable notational variants are used dominantly in official, business, and technical documents, on the other hand, unsuitable ones are inferior or not found in these documents. If the assumption is proper, unsuitable notational variants can be detected by con-

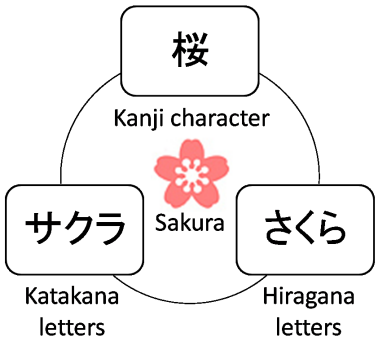

Figure 1: Notational variants of *sakura*.

Nishikawa A., Nishimura R., Watanabe Y. and Okada Y. (2009).
WRITING SUPPORT SYSTEM DEALING WITH NOTATIONAL VARIANT SELECTION.
In *Proceedings of the First International Conference on Computer Supported Education*, pages 73-80
DOI: 10.5220/0001973800730080
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names of plants	Hiragana	Katakana	Kanji+
sakura [cherry blossom]	184	39	736
bara [rose]	0	217	0
himawari [sun flower]	42	8	0
tsubaki [camellia]	9	25	83
tsutsuji [azalea]	5	15	0
ringo [apple]	8	71	10
mikan [orange]	66	37	2

Figure 2: The frequencies of notational variants of nouns (plant names) in the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].

firming whether they are used dominantly in official, business, and technical documents. In this study, we will use the term *dominant notational variant* of a word to refer to the most frequent notational variant of the word. Furthermore, our system shows the frequencies of notational variants to the students because they are objective and concrete measures. As a result, the system gives the students chances to consider the reasons why they used nondominant notational variants. There are two reasons why our system does not replace nondominant notational variants to dominant ones automatically.

- it is not appropriate to restrict the use of nondominant notational variants because the use of notational variants is one of the sources of the richness of Japanese expressions.
- it is important to consider the reasons why they used nondominant notational variants and choose suitable ones, especially, in educational institutions.

From the viewpoint of information retrieval, a considerable number of studies have been made on notational variants (Kubomura 03) (Kouda 06) (Bamba 08), however, spell checkers in Japanese word processor, such as Microsoft word 2007, and previous Japanese writing support systems were not concerned with notational variants sufficiently (Shimomura 92) (Araki 93) (Murata 01). This is because their main purposes were misspelling detection. Nondominant notational variants are not misspelling, but often unsuitable for official, business, or technical documents. In contrast, Yokoyama dealt with variants of Kanji characters (Yokoyama 06), but not with variants of words. Furthermore, he did not consider this variant problem from the viewpoint of document domains. Dominant notational variants may vary with document domains. For example, in newspaper articles, *sakura* is dominantly written in a Kanji character, on the other hand, in documents in biology, it is dominantly written in Katakana letters. Our system can deal with this problem flexibly by switching dictionaries of notational variants, which were developed by using official, business, and technical documents in several domains.

connection words	Hiragana	Kanji+
tatoeba [for example]	273	570
shitagatte [consequently]	21	26
tadasi [however]	343	0
ippou [on the contrary]	1	2879
mata [also, in addition]	4895	8
sarani [furthermore]	2677	24

Figure 3: The frequencies of notational variants of connection words in the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].

2 NOTATIONAL VARIANTS OF JAPANESE WORDS

In this section, in order to show the diversity of notational variants of Japanese words, we will show notational variants of nouns, connection words, and declinable words.

2.1 Notational Variants of Japanese Nouns

In case of Japanese nouns, notational variants can be classified into three types:

- words consist of Hiragana letters,
- words consist of Katakana letters, and
- words consist of Kanji characters and occasionally Hiragana and Katakana letters.

Figure 2 shows the frequencies of notational variants of plant names in the Mainichi newspaper articles (Jan. 2006 – June 2006). As shown in Figure 2, dominant ways of writing plant names are inconsistent.

2.2 Notational Variants of Japanese Connection Words

Connection words are important words in students' reports because they make the relationships between sentences and ideas smoother and clearer. In case of Japanese connection words, notational variants can be classified into two types:

- words consist of Hiragana letters, and
- words consist of Kanji characters and occasionally Hiragana letters.

Figure 3 shows the frequencies of notational variants of connection words in the Mainichi newspaper articles (Jan. 2006 – June 2006). As shown in Figure

declinable words	Hiragana	Katakana	Kanji+
yasashii [easy]	188	0	9
muzukashii [hard]	21	0	1524

(a) The frequencies of antonymous words: *yasashii* [easy] and *muzukashii* [hard].

declinable words	Hiragana	Kanji+ (1)	Kanji+ (2)
mijikai [short]	*mijikai*	**mijika**-*i*	**miji**-*kai*
	0	362	0
okonau [conduct]	*okonau*	**okona**-*u*	**oko**-*nau*
	15	9	2152
kawaru [change]	*kawaru*	**kawa**-*ru*	**ka**-*waru*
	15	9	2152
arawasu [show]	*arawasu*	**arawa**-*su*	**ara**-*wasu*
	7	283	1

(b) The frequencies of declinable words with declensional Kana ending. Declensional Kana endings of Kanji+(1) are shorter than those of Kanji+(2). Bold letters represent Kanji characters.

Figure 4: The frequencies of notational variants of declinable words in the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].

3, dominant ways of writing connection words are inconsistent.

2.3 Notational Variants of Japanese Declinable Words

In case of Japanese declinable words, notational variants can be classified into three types:

- words consist of Hiragana letters,
- words consist of Katakana letters with Hiragana letters "*suru*", and
- words consist of Kanji characters with declensional Kana (Hiragana) ending.

Figure 4 (a) shows the frequencies of notational variants of antonymous words, *yasashii* [easy] and *muzukashii* [hard], in the Mainichi newspaper articles (Jan. 2006 – June 2006). *Yasashii* [easy] is dominantly written in Hiragana letters, on the other hand, *muzukashii* [hard] is dominantly written in Kanji characters with declensional Kana (Hiragana) ending. In other words, the contrast between *yasashii* [easy] and *muzukashii* [hard] is broken from the viewpoint of the dominant way of writing. [1] Both *yasashii* [easy] and *muzukashii* [hard] have one type of declensional Kana ending: *-shii*. As a result, they have one variant with declensional Kana ending, **yasa**-*shii* and **muzuka**-*shii*, respectively. [2] However, considerable

[1] One of the authors dislikes this violation of the contrast and always writes *muzukashii* [hard] in Hiragana letters in his works.

[2] Bold letters represent Kanji characters.

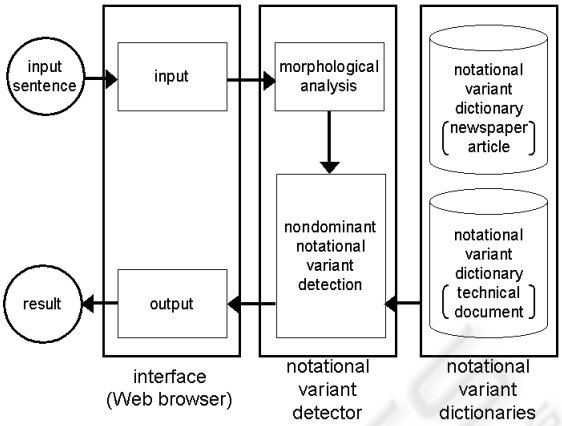


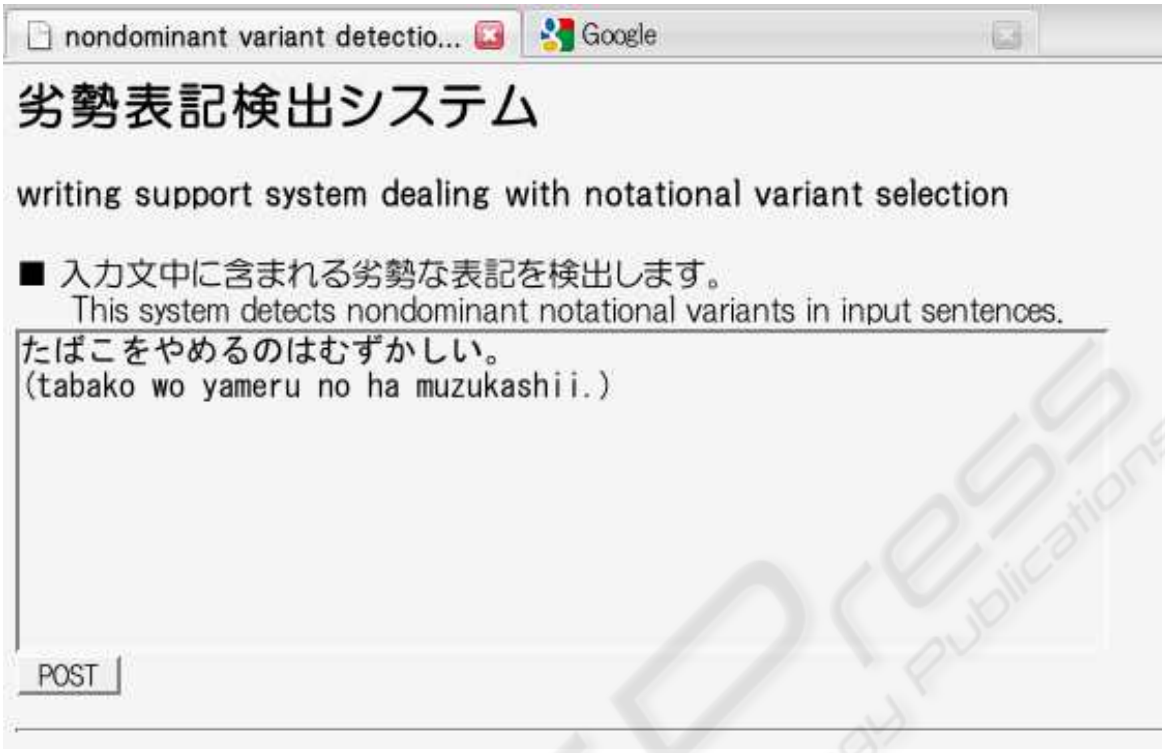
Figure 5: System overview.

number of declinable words have two types of declensional Kana ending, and as a result, two variants with declensional Kana ending. For example, *kawaru* [change] has two types of declensional Kana ending, *-ru* and *-waru*. As a result, *kawaru* [change] has two variants with declensional Kana ending, **kawa**-*ru* and **ka**-*waru*. Figure 4 (b) shows the frequencies of notational variants of declinable words with declensional Kana ending in the Mainichi newspaper articles (Jan. 2006 – June 2006). It also shows that dominant ways of writing declensional Kana ending are inconsistent. Declensional Kana ending is one of the most troubling aspect of notational variants. Japanese students often feel confusions about declensional Kana ending. As a result, we are often confronted with the confusion of declensional Kana ending in their reports.

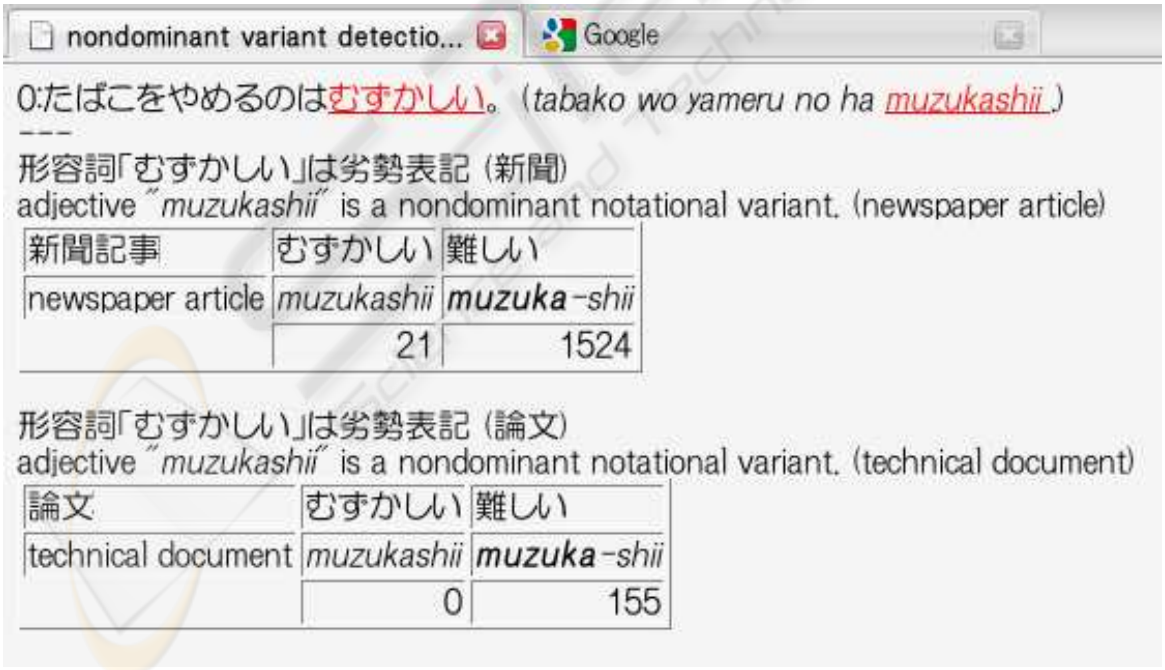
3 WRITING SUPPORT SYSTEM BASED ON NOTATIONAL VARIANT DICTIONARIES

3.1 System Overview

Figure 5 shows the overview of our system. Our system is based on the idea that suitable notational variants are used dominantly in official, business, and technical documents. Figure 6 shows an example of how to use our writing support system. As shown in Figure 6, users can access and send input sentences to the system via web browsers by using CGI based HTML forms. Input sentences are segmented into words by using a Japanese morphological analyzer, JUMAN (Kurohashi 05). Then, by using notational variant dictionaries, the system confirms whether notational variants of the words are used dominantly in official, business, and technical documents. When



(a) An input sentence, *tabako wo yameru no ha muzukashii* [it is hard to stop smoking], is given to the system.



(b) The system detects a nondominant notational variant, *muzukashii* [hard], in the input sentence and shows the frequency information of the word in the newspaper articles and technical documents.

Figure 6: An example of how to use our writing support system. English system messages are inserted ad hoc for convenience of non-Japanese readers of this paper.

the system detects a nondominant notational variant of a word in an input sentence, it is underlined and turns red, and the system shows the frequency information of notational variants of the word and gives users chances to consider the reasons why they used nondominant variants. In Figure 6 (a), a user gives an input sentence, *tabako wo yameru no ha muzukashii* [it is hard to stop smoking], to the system. Then, as shown in Figure 6 (b), the system detects a nondominant notational variant, *muzukashii* [hard], in the input sentence. *muzukashii* [hard] is underlined and turns red, and the frequency information is shown. In this way, the key to detecting nondominant notational variants is notational variant dictionaries. In section 3.2, we show how to develop notational variant dictionaries.

3.2 Development of Notational Variant Dictionaries

In this study, we assumed that suitable notational variants are used dominantly in official, business, or technical documents, on the other hand, unsuitable ones are inferior or not found in these documents. If the assumption is proper, unsuitable notational variants can be detected by confirming whether they are used dominantly in official, business, or technical documents. In order to confirm whether notational variants are used dominantly, we extracted examples of notational variants from

- 296364 newspaper articles published in the Mainichi Newspaper from January 2006 to June 2006 (Mainichi 07).
- 319 technical reports published in the 12th Annual Meeting of the Association for Natural Language Processing (2006).

and developed notational variant dictionaries. In this study, we used newspaper articles because we aimed to acquire notational variants of words which used in various domains. On the other hand, we used technical reports because we aimed to acquire notational variants of words in specific domains and develop domain specific dictionaries of notational variants. The reason why we developed domain specific dictionaries of notational variants was that dominant notational variants may vary with document domains. By switching domain specific dictionaries of notational variants, our system can confirm whether notational variants are suitable to compose documents in the specific domains. In this study, we acquired notational variants in a specific domain from technical reports published in the Annual Meeting of the Association for Natural Language Processing (2006). Some of the technical reports were given to the students, who took part in the experiment described in Section 4, as reference works. This is one reason why we extracted examples of notational variants from the technical reports. Sentences in these documents were segmented into words by using a Japanese morphological analyzer, JUMAN (Kurohashi 05). When JUMAN finds a notational variant, it gives a variant label to the variant. The same variant label is given to notational variants of a word. By using these variant labels, we extracted notational variants and developed two dictionaries of

- notational variants in newspaper articles, and
- notational variants in technical reports of natural language processing.

Table 1 shows the results of the notational variant extraction from newspaper articles and technical documents. The most frequent notational variant of each word was considered as the dominant notational variant.

As shown in Table 1, notational variants of 27988 and 9211 words were extracted from the newspaper articles and technical documents, respectively. These words can be classified into two types:

TYPE I a word of this type has actually two or more notational variants, however, only one of them was found in the newspaper articles or technical documents.

TYPE II a word of this type has two or more notational variants which were found in the newspaper articles or technical documents.

Table 2 shows the unique and total number of notational variants of TYPE II words in the newspaper articles and technical documents. In order to show how much the dominant notational variant of a word is used dominantly, we introduced *dominant degree*. Suppose that a word has notational variant i $(i = 1, \cdots, N)$. The dominant degree of the word is calculated as follows:

$$d = \frac{f_d}{\sum_{i=1}^{N} f_i}$$

where d is the dominant degree of the word, f_i and f_d are the frequencies of notational variant i and the dominant notational variant of the word, respectively. Figure 7 shows the histograms of the dominant degrees of TYPE II words in the newspaper articles and technical documents. In Figure 7, the broken lines show the histograms of the dominant degrees of all the TYPE II words in the newspaper articles and technical documents. On the other hand, the thick lines show

Table 1: The results of the notational variant extraction from the newspaper articles and technical documents.

part of speech	unique # of words (variant labels)	unique # of notational variants	total # of notational variants
noun	20603	26747	3656574
verb	3897	6403	1283024
adjective	2120	2830	280787
adverb	1125	1607	115609
conjunction	87	100	30850
interjection	80	97	2643
attributive	75	98	10946
prefix	1	3	10891
Total	27988	37885	5391324

(a) The results of the notational variant extraction from the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].

part of speech	unique # of words (variant labels)	unique # of notational variants	total # of notational variants
noun	6458	7154	310980
verb	1548	2093	101398
adjective	706	825	22952
adverb	376	459	13037
conjunction	60	71	4465
interjection	30	33	148
attributive	32	39	1192
prefix	1	3	302
Total	9211	10677	454474

(b) The results of the notational variant extraction from the technical documents [the Annual Meeting of the Association for Natural Language Processing (2006)].

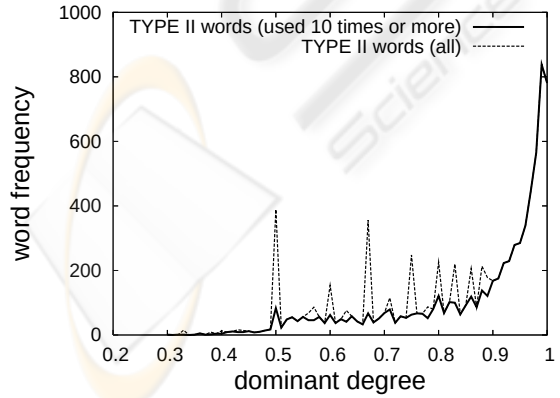
Table 2: The unique and total number of notational variants of TYPE II words in the newspaper articles and technical documents. A TYPE II word has two or more notational variants which were found in the newspaper articles / technical documents.

part of speech	unique # of words (variant labels)	unique # of notational variants	total # of notational variants
noun	5328	11472	1817055
verb	2135	4641	916302
adjective	628	1338	176374
adverb	440	922	72251
conjunction	13	26	12980
interjection	15	32	593
attributive	22	45	8853
prefix	1	3	10891
Total	8582	18479	3015299

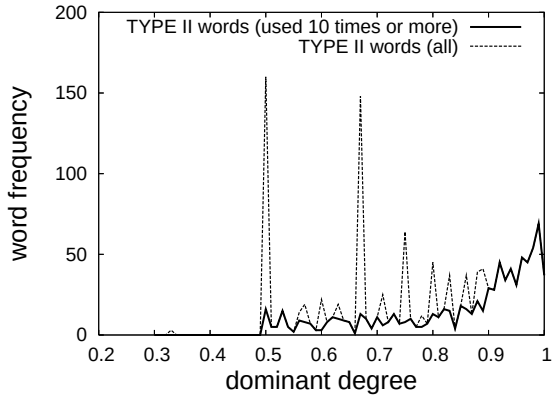
(a) The unique and total number of notational variants of TYPE II words in the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].

part of speech	unique # of words (variant labels)	unique # of notational variants	total # of notational variants
noun	644	1340	62848
verb	508	1053	56058
adjective	110	229	6253
adverb	78	161	5617
conjunction	11	22	1330
interjection	3	6	13
attributive	7	14	941
prefix	1	3	302
Total	1362	2828	133362

(b) The unique and total number of notational variants of TYPE II words in the technical documents [the Annual Meeting of the Association for Natural Language Processing (2006)].



(a) The histograms of the dominant degrees of TYPE II words in the newspaper articles [Mainichi Newspaper (Jan. 2006 – June 2006)].



(b) The histograms of the dominant degrees of TYPE II words in the technical documents [the Annual Meeting of the Association for Natural Language Processing (2006)].

Figure 7: The histograms of the dominant degrees of TYPE II words in the newspaper articles and technical documents.

the histograms of the dominant degrees of TYPE II words the notational variants of which were used 10 times or more in the newspaper articles and technical documents. The reason why we eliminated words the notational variants of which were used less than 10 times in the newspaper articles and technical documents is that it is difficult to confirm which notational variant is used dominantly because there were too few samples. As a result, we thought that dominant notational variants were credible when they satisfy the following conditions, and gave credibility labels to them.

- in case of a TYPE I word, the notational variant of the word was used 10 times or more in the newspaper articles or technical documents. 11825 and 2285 TYPE I words in the newspaper articles and technical documents, respectively, satisfied this condition.
- in case of a TYPE II word, the sum of frequencies of all the variants of the word was 10 or more, and the dominant degree was 0.8 or more. 5270 and 590 TYPE II words in the newspaper articles and technical documents, respectively, satisfied the above conditions.

4 EXPERIMENTAL RESULTS

To evaluate our method, we conducted a control experiment. We gave 10 problems of notational variant selection to 20 subjects, university students in computer science. Each problem consisted of two sentences. The differences between the two sentences were only notational variants. For example, the following sentences mean that it is hard to stop smoking:

- *tabako wo yameru noha muzukashii*
- *tabako wo yameru noha* **muzuka**-*shii*

the differences between the two sentences above are *muzukashii* and **muzuka**-*shii*. The former is written in Hiragana letters and the latter is written in Kanji Characters (in Bold letters) and Hiragana letters. The subjects were requested to choose one of the sentences, which seemed to be suitable for them to use in official, business, and technical documents. Subjects were classified into two groups, group A and B.

- subjects in group A were given only 10 problems and no more information.
- subjects in group B were given the same 10 problems and frequency information of the notational variants in the test materials.

The frequency information of the notational variants were retrieved by our experimental writing support system. As shown in Figure 6 (b), when our system detects a nondominant notational variant of a word in an input sentence, it shows the frequency information of notational variants of the word. For example, the frequency information of *muzukashii* and **muzuka**-*shii* was shown as follows:

newspaper articles	*muzukashii*	**muzuka**-*shii*
	21	1524
technical reports	*muzukashii*	**muzuka**-*shii*
	0	155

Table 3: Experimental results.

group	κ value	rate of choosing dominant notational variants
group A	0.261	74%
group B	0.623	87%

Table 4: Interpretation of κ values.

κ	Interpretation
< 0	no agreement
0.0 - 0.20	slight agreement
0.21 - 0.40	fair agreement
0.41 - 0.60	moderate agreement
0.61 - 0.80	substantial agreement
0.81 - 1.00	almost perfect agreement

To evaluate the experimental results, we introduced two measurement: κ values and the rate of choosing dominant notational variants (Table 3). κ values are statistical measures for assessing the reliability of agreement between subjects. κ values are generally thought to be more robust than simple percent agreement calculation, in this case, the rate of choosing dominant notational variants, because κ values take into account the agreement occurring by chance. Table 4 shows the interpretation of κ values (Landis 77). As shown in Table 3 and 4, in this experiment, there was fair agreement of notational variant selection in group A. In other words, we were confronted with the confusion of notational variants in their answers. In each problem, some students chose a nondominant (unsuitable) notational variant for no reason and they were totally unaware of doing it. It shows that the notational variant selection is a serious problem. On the other hand, there was substantial agreement in group B. In addition, we obtained 13 % increase of the rate of choosing dominant notational variants when the frequency information was given to subjects. It shows that the frequency information of notational variants is promising. It also implies that students do not have confidence in their notational variant selection and flexibly change their decisions when the reasons are given to them. Actually, three subjects in group B changed their decisions, and three other subjects did not change but felt sure of their decisions. Some of them said that they can obey sys-

tem's advices more simply than teacher's instructions without concrete evidences. The other four subjects in group B reported that the frequency information is not necessary. Actually, one of them could choose dominant variants correctly in all the problems, on the other hand, the others could not. This is because they obeyed a peculiar writing rule: they must use as many Kanji characters as possible in their official, business, and technical reports. This is the limitation of our writing support system, and where a human instructor comes in.

ACKNOWLEDGEMENTS

This research has been supported partly by the Grant-in-Aid for Scientific Research (C) under Grant No.20500106.

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