A Study on the Background Factors Involved in Kanji Writing Difficulty in Relation to Kanji Reading Difficulty and Low Vocabulary Attainment for Japanese Second to Sixth Graders

Hirohito Ozeki*, Chikaho Naka, Mito Mekaru, Yuri Yoshida and Toshihide Koike

The United Graduate School of Education, Tokyo Gakugei University, Japan

In the study, background factors involved in Kanji writing difficulty in Japanese second to sixth graders (N=1398) were investigated. Children with both Kanji reading and writing difficulties were grouped into those with low vocabulary attainment (Group A) and those without it (Group B). Children with only Kanji writing difficulty were classified into those with low vocabulary attainment (Group C) and those without it (Group D). Because of the small number of children, Group C was removed from the analysis. In Group A’s third and fourth graders, the contribution of verbal working memory was observed by employing multiple logistic analysis; Group A’s odds ratio values were larger than those of Groups B and D. In Group B, the contribution of fluent Hiragana reading was observed, which was not observed in Group D. These results reveal that background factors involved in Kanji writing difficulty might depend on a combination of Kanji reading difficulty and low vocabulary attainment.

Key Words: Kanji reading difficulty, Kanji writing difficulty, learning disabilities

Introduction

With the development of special needs education, research on background factors involved in low learning attainment among children in a normal class is becoming an urgent and important issue. The Japan Society for Educational Skill (2007) conducted research on the attainment of Kanji learning among elementary school children. The results of this study revealed that the percentage of correct answers in a Kanji writing test was very low in higher-grade students. This result indicated that specific background factors may be led to the encounter with writing difficulty in higher-grade. There are three types of representative writing systems: alphabet, syllabic, and morphosyllabic. Japanese Kanji characters belong to a morphosyllabic system (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). In a morphosyllabic system, the characters have semantic and syllabic aspects. Therefore, to clarify the characteristics of those children with low attainment of Kanji writing, it is important to consider not only their Kanji reading level, but also their ability to understand the meaning of words.

Okamoto (2014) reviewed 41 studies published between 1997 and 2012 that examined the instruction given to children in normal classes who experience Kanji writing difficulty. Okamoto (2014) noted that these studies found two groups of children: children with both Kanji writing and reading difficulties, and those with only writing difficulties. If distinctive background factors involved in Kanji reading difficulty are also involved in low vocabulary attainment, the background factors involved in Kanji writing difficulty may be dependent on the combination of Kanji reading difficulty and limited vocabulary. Therefore, to examine the background factors involved in Kanji writing difficulty, it might be imperative to clarify each group of children's back-
ground factors and subsequently, compare the groups based on the presence or absence of limited vocabulary and Kanji reading difficulty.

Gathercole and Baddeley (1989) examined background factors involved in limited vocabulary attainment and found through multiple regression analysis that the short-term phonological storage component of working memory is related to vocabulary acquisition. In their study, the term, working memory was used to indicate the memory process involving both the process of short-term memory and that of manipulating the information stored in memory. The present study employed this terminology. Gathercole and Baddeley (1989) evaluated vocabulary acquisition by measuring receptive vocabulary. Snowling, van Wagendonk, and Stafford (1988) compared expressive vocabulary and receptive vocabulary performance in children with reading disorders. Snowling et al. (1988) used a picture-naming task to test expressive vocabulary and a choosing-picture task for aurally presented names to test receptive vocabulary. The children with reading disorders scored lower on the picture-naming task than the CA-matched control group. However, for the choosing-picture tasks, their scores were on the same level as the control group. Snowling et al. (1988) demonstrated that expressive vocabulary testing may underestimate the vocabulary of children with reading disorders. Therefore, receptive vocabulary testing can be used to evaluate vocabulary development.

Onda, Sato, Takimoto, Mekaru, Naka, Kumazawa, and Koike (2015) examined Kanji reading difficulty. They found that for second to fourth graders, low Hiragana reading fluency contributes to Kanji reading difficulties. Furthermore, they showed that for fifth and sixth graders, low verbal working memory contributes to reading difficulties and that children with Kanji reading difficulty in these grades displayed the imageability effect: the reading score of Kanji words with low imageability was lower than that of words with high imageability. Duyck, Szmalec, Kemps, and Vandierendonck (2003) revealed that low imageability, which may be defined as a low degree of visual image formation of words, interferes with the acquisition of paired associate learning under the condition of restrained working memory. The results of this study suggest that the impairment of working memory in Japanese children at higher grades may result in a low performance of reading Kanji words with low imageability. Accordingly, the imageability effect should be examined to determine the contribution of working memory as a background factor involved in Kanji reading difficulty.

Naka, Yoshida, Kumoi, Ozeki, Igarashi, and Koike (2014) found that second graders who attained scores below the 10th percentile values of Kanji reading and special morae tests tend to exhibit a severely low attainment of Kanji writing. Naka et al. (2014) revealed that the low attainment of special morae may be related to a background factor involved in Kanji reading difficulty.

Nakamura, Naka, Mekaru, and Koike (2017) conducted research on second to sixth graders in a normal class. They showed that verbal working memory is related to Kanji writing difficulty in children without low attainment of Kanji reading. However, Nakamura et al. (2017) did not examine the influence of vocabulary. Therefore, further studies are needed.

From these studies, it was inferred that children with Kanji writing difficulty that had both low attainment of vocabulary and Kanji reading would score lower on a verbal working memory test than those without low vocabulary attainment and Kanji reading difficulty. Furthermore, low attainment of Hiragana reading and in special morae tests might be background factors for lower-grade students with difficulties in Kanji reading and writing. The higher-grade students with both Kanji writing and reading difficulty are expected to have lower scores for the reading test of low imageability Kanji words than for the reading test of high imageability Kanji words. The low performance of verbal working memory might also be related to such an imageability effect, regardless of the vocabulary attainment level. Consequently, a consideration of the background factors for each group of children might reveal typical background factors involved in Kanji writing difficulty that are common between groups and specific to each group and lead to discussions on effective teaching to support those with difficulties.

The aim of the present study was to investigate the background factors involved in Kanji writing difficulty. First, children were classified in groups depending on their attainment of vocabulary and Kanji reading. Thereafter, odds ratios were examined for low attainment of Hiragana reading fluency, special morae, and verbal working memory in each group of children. By comparing each group of chil-
The Background Factors of Kanji Writing Difficulty

dren, the background factors involved in Kanji writing difficulties are discussed in this study. Prior to the main investigation, the validity of the newly developed vocabulary test, which consists of a choosing-picture task for printed words was examined in a preliminary study.

**Methods of the Preliminary Investigation**

**Participants**
The study was carried out in three elementary schools in the Tokyo metropolitan area. The participants included 496 children in normal classes from the second to sixth grades: there were 112, 89, 90, 83, and 99 in the second, third, fourth, fifth and sixth grades, respectively. All the participants’ parents were informed about the purpose of the study through a document provided by the principal of each school; permission for participation was collected in each class.

**Materials**

*The vocabulary test.* Sixty words that consisted of two Kanji characters were selected for each grade from the list of fundamental vocabulary for learning (Kai, 2002) and a textbook of social studies for the third to sixth grades (Sasaki, Iwata, & Tanigawa, 2008). Two teachers of a resource room for children with linguistic disorders discussed and selected 45 words that are necessary to understand classroom lessons from these words.

Each test paper consisted of three Kanji words and six pictures. The children were asked to select the picture that expressed the meaning of the 45 Kanji words. Hiragana was written beside the Kanji characters to assist them in their reading. The number of correct answers was calculated. The difficulty level was examined through Item Response Theory (IRT) analysis. The words with a fixed range of difficulty were selected as test items. The total number of selected test items was 24, 21, 27, 24, and 24 for the respective grades; second to sixth.

_Kyoken-shiki Reading Test._ The vocabulary subtest of the Kyoken-shiki Reading Test (KRT) (Fukuzawa & Hirayama, 2015) was administered.

**Procedure**
The tests were conducted simultaneously in each classroom by a class teacher in April (first term). It took approximately 15 minutes to complete all the tests. The procedure and exercise session of the vocabulary test were explained before the test session.

**Analysis**
The number of correct answers for the vocabulary test and the vocabulary subtest of KRT were calculated.

To examine the content-related validity of the newly developed vocabulary test, the relationship between the number of correct answers for the vocabulary test and the children who scored below the fifth percentile value for the vocabulary subtest of KRT were evaluated. Accordingly, receiver operating characteristic (ROC) analysis was applied: the cutoff points identified those children who scored below the fifth percentile value for the vocabulary subtest of KRT. To perform this analysis, Ekuseru‐Toukei 2012 was used. For the IRT analysis, Easy Estimation Vol. 1.6.1 (Kumagai, 2009) was utilized.

**Method of the Main Research**

**Participants**
The study was conducted in nine elementary schools of Y ward in the Tokyo metropolitan area. The participants included 1398 children in normal classes from the second to sixth grades: 333 second graders, 290 third graders, 288 fourth graders, 220 fifth graders, and 267 sixth graders. All the participants’ parents were informed of the study’s purpose by means of document distribution by the principal. Consent to participate was collected through each school.

**Materials**

*Kanji reading and writing tests.* Kanji reading and writing tests, based on research conducted by Nakamura et al. (2017), were administered. In Nakamura et al.’s (2017) study, 16 words consisting of Kanji characters that were taught during the previous school year were included in each test. The test items comprised eight words with high imageability and eight with low imageability in order to examine the imageability effect. The same tests were adopted in the present study. In the Kanji reading test, the children were required to read 16 Kanji words in Hiragana. In the Kanji writing test, the children were required to translate 16 words written in Hiragana
into Kanji characters.

**Vocabulary test.** A vocabulary test, developed in the preliminary investigation, was conducted.

**The fluent Hiragana reading test.** This test required the students to read Hiragana words fluently and to select one correct word out of three alternatives, which consisted of two pseudo words and one real word. Each word consisted of four Hiragana characters. The students were given 30 seconds to complete each of the 36 test items.

**The special morae test.** This test, based Iyonaga, Naka, Mekaru, Nakamura, and Koike’s (2017) research, required students to select one correct word from three items, which included the special morae. The test, which comprised 18 items, was administered to the second and third graders.

**The digit recall test.** In this test, the sequence of digits was presented aurally. The participants were instructed to write down the digits in the order presented. Two trials for each sequence of four, five, and six digits were conducted.

**The digit recall test of ascending order.** This test, based on Iyonaga et al.’s research (2017), was administered to third to sixth graders. The sequence of digits was presented aurally. The participants were instructed to write down the digits in ascending order. Two trials for each sequence of four, five, and six digits were conducted.

**Procedure**

The participants were administered all the tests in their classes during June and July (first term). Instructions were given by a teacher. It took approximately 40 minutes to complete all the tests.

**Analysis**

**The Kanji reading test, Kanji writing test, and the vocabulary test.** For the Kanji reading test, Kanji writing test, and the vocabulary test, the correct answers were counted and converted to scores, with a total possible score of 100.

Based on the results of the three tests, the participants were divided as follows (Table 2): Group A consisted of the participants with low attainment of Kanji reading, Kanji writing, and vocabulary; Group B comprised those with low attainment of Kanji reading and writing; Group C included those with low attainment of Kanji writing and vocabulary; and Group D consisted of those with low attainment of Kanji writing. In addition, the participants with low attainment of Kanji reading and/or vocabulary formed Group E and those without any low attainment constituted Group F. The differences among groups between the Kanji reading test, Kanji writing test, and the vocabulary test scores were examined by means of the Kruscal–Wallis and Scheffe tests.

**The basic skills test of Kanji learning.** The number of correct answers of the special morae test was counted and converted as a score; the highest possible score was 100. The number of correct answers of the fluent Hiragana reading test was also calculated. The scores of the two types of digit recall tests were totaled to obtain the verbal working memory test score for the third to sixth graders. The score of the digit recall test was used as the score of the verbal working memory test for the second graders. The scores for each test were compared among groups by means of the Kruscal–Wallis and Scheffe tests.

**The background factors for low attainment of Kanji writing.** To investigate the background factors involved in the low attainment of Kanji writing, the odds ratio was calculated by means of multiple logistic analysis. The occurrence of each group was set as the object variable. For the Kanji learning basic skills, occurrences of scores below the 10th percentile value of each test were set as the explanatory variables.

**The relation between low attainment of Kanji writing and imageability.** The imageability effect was measured for fourth to sixth graders. The imageability effect value was calculated by subtracting the Kanji reading score with high imageability from the Kanji reading test score with low imageability. First, the difference of imageability effect values was examined by means of the Kruscal–Wallis and Scheffe tests. Subsequently, logistic regression analysis was conducted to determine the imageability effect factor. The object variable was defined as the occurrence of children whose imageability effect value was below the 10th percentile, and the explanatory variable was the occurrence of each group. Ekuseru–Toukei 2012 (Social Survey Research Information, 2012) was employed for the analysis.

**Results**

**Preliminary Investigation**

To examine the reliability of each test item for the vocabulary test, Cronbach’s $\alpha$ was calculated. The
results were as follows: 0.82, 0.81, 0.83, 0.80, and 0.83 for the second, third, fourth, fifth, sixth grade, respectively. The results confirmed the internal consistency of each word and the reliability of the vocabulary test. To define the cutoff value, which identifies children who scored below the fifth percentile value for the KRT vocabulary subtest, ROC analysis was conducted. The results of the ROC analysis are presented in Fig. 1. The vertical axis indicates true positive fraction (TPF) and the horizontal axis false positive fraction (FPF). The areas under the curve (AUC) were above 0.82 for each grade. Accordingly, the vocabulary test of the present study could set an adequate cutoff value; therefore, the validity of the test was confirmed. The cutoff values of correct answers for each grade were as follows, with TPF and 1-FPF values in parentheses: below 16 correct answers (0.67, 0.91) for the second grade; below 12 correct answers (1.00, 0.94) for the third grade; below 18 correct answers (0.67, 0.86) for the fourth grade; below 20 correct answers (1.00, 0.68) for the fifth grade; and below 19 correct answers (1.00, 0.76) for sixth grade.

In the present study, low attainment was defined as a score below the cutoff value.

**The Main Research**

**The results of the Kanji writing test, Kanji reading test, and the vocabulary test.** In Table 1, the average scores (SDs) of the Kanji writing test, Kanji reading test, and the vocabulary test for each grade are presented. The number of correct answers, blank answers, and wrong answers were calculated for every 10th percentile value for the Kanji writing test. The proportion of answers for every 10th percentile record was examined by means of Fisher’s exact test. Compared to children in other sections, children in the 0–10th percentile section had the highest proportion of blank answers. Consequently, the scores below the 10th percentile value were defined as low attainment on the Kanji writing test. The scores of the 10th percentile value for each grade were as follows: 83.3, 80.5, 50.0, 31.2, and 53.7 for the second, third, fourth, fifth, and sixth grade, respectively.

For the Kanji reading test, low attainment was defined as scores below the 10th percentile value; this was based on Nakamura et al.’s (2017) research. The 10th percentile values for each grade were as follows: 87.5 for second, third, and fourth grade, and 81.2 for fourth and sixth grade.

Low attainment on the vocabulary test was defined by the cutoff value determined by the results of ROC analysis in the preliminary investigation: 67 (10th percentile value) for the second grade, 57 (10th percentile value) for the third grade, 63 (20th percentile value) for the fourth grade, 83 (30th percentile value) for the fifth grade, and 79 (15th percentile value) for the sixth grade. Scores below these cutoff values were defined as low attainment.

Based on whether the participants also obtained low attainment scores for the Kanji reading test and the vocabulary test, the Kanji writing test scores were

![Fig. 1 Results of the ROC Analysis in the Preliminary Investigation](image)

**Table 1 Average Scores (SD) in the Kanji Reading Test, Kanji Writing Test, and Vocabulary Test**

| Grade    | Kanji reading test | Kanji writing test | Vocabulary test |
|----------|--------------------|--------------------|-----------------|
| Second   | 96.7 (8.4)         | 94.8 (11.2)        | 82.5 (14.6)     |
| Third    | 95.9 (10.0)        | 91.2 (17.7)        | 78.4 (17.8)     |
| Fourth   | 93.9 (15.1)        | 80.9 (24.3)        | 78.3 (16.9)     |
| Fifth    | 94.5 (12.8)        | 74.7 (26.3)        | 84.8 (17.6)     |
| Sixth    | 94.5 (10.9)        | 84.3 (21.0)        | 88.1 (13.1)     |
classified into six groups: A to F. In Table 2, the number of children in each group is presented. In Group C, there were less than five participants for all the grades. The expected value, which was calculated, was less than five for Group C. This result indicated that there were a small number of children in Group C; consequently, Group C was eliminated from the following analysis.

The scores of the basic skills test. The average score and SD of the fluent Hiragana reading test, special morae test, digit recall test, and verbal working memory test for each group in each grade are presented in Table 3. A comparison of the scores of each test between Group F and the other groups was conducted by means of the Kruscal–Wallis and Scheffe tests. A significant difference was found between Group F and Groups B and E in the second to sixth grades for the fluent Hiragana reading test. With the exception of the third grade, differences between Groups A and F were found in all the grades. For the special morae test, significant differences were found between Group F and Groups A, B, and E in the second grade, and between Group F and Groups A and E in the third grade. For the digit recall test, a significant difference was found between Group F and Groups B, D, and E in the second grade. For the verbal working memory test, significant differences were found between Group F and Groups A and E in the third and fifth grade, and between Group F and Groups A, B, D, and E in the fourth and sixth grade.

Table 2 The Number of Children in Each Group in the Second to Sixth Grades

| Group   | Kanji writing | Kanji reading | Vocabulary | Second grade | Third grade | Fourth grade | Fifth grade | Sixth grade |
|---------|---------------|---------------|------------|--------------|-------------|--------------|-------------|-------------|
| A       | ×             | ×             | ×          | 8            | 8           | 15 (2)       | 13 (2)      | 11 (1)      |
| B       | ×             | ×             | ○          | 7 (2)        | 9 (1)       | 10 (1)       | 5           | 6           |
| C       | ×             | ○             | ×          | 3            | 3           | 3            | 5           | 5           |
| D       | ×             | ○             | ○          | 17 (1)       | 9           | 11           | 3           | 11 (1)      |
| E       | ○             | ×             | ×          | 35 (1)       | 44 (1)      | 31 (1)       | 62          | 40          |
| F       | ○             | ○             | ○          | 263 (3)      | 217         | 218 (4)      | 132 (3)     | 194 (1)     |

Note: The cross mark (×) indicates poor attainment and the circle (○) indicates attainment. The number in parentheses is the number of children using special support services in resource rooms.

Table 3 The Average Score (SD) of Each Basic Skills’ Test and the Result of Multiple Comparisons

| Test                        | The result of multiple comparison | A  | B  | D  | E  | F  |
|-----------------------------|----------------------------------|----|----|----|----|----|
| Fluent Hiragana reading     | Second grade                     |    |    |    |    |    |
|                             | ABE<F***                         | 6.8(3.1) | 6.3 (2.2) | 9.4 (2.8) | 9.0 (3.9) | 10.7 (3.6) |
|                             | Third grade                      |    |    |    |    |    |
|                             | BDE<F***                         | 11.6(9.4) | 10.4 (4.2) | 10.9 (3.8) | 11.5 (4.1) | 13.8 (4.0) |
|                             | Fourth grade                     |    |    |    |    |    |
|                             | Ac<F*, BDE<F***                  | 11.3 (4.2) | 9.3 (2.6) | 10.7 (2.5) | 11.7 (3.8) | 14.2 (4.5) |
|                             | Fifth grade                      |    |    |    |    |    |
|                             | AE<F***, B<E*                    | 12.0 (4.4) | 11.2 (3.9) | 15.0 (2.9) | 15.3 (3.6) | 16.7 (3.6) |
|                             | Sixth grade                      |    |    |    |    |    |
|                             | ABE<F**                         | 13.9 (6.5) | 11.2 (3.3) | 16.3 (4.7) | 15.5 (3.0) | 17.6 (3.9) |
| Special morae               | Second grade                     |    |    |    |    |    |
|                             | ABE<F**                         | 67.3 (22.1) | 90.4 (5.7) | 95.7 (10.5) | 94.9 (8.2) | 97.8 (67.9) |
|                             | Third grade                      |    |    |    |    |    |
|                             | A<F**, E<F*                      | 72.8 (26.0) | 98.7 (2.3) | 96.2 (3.7) | 89.5 (17.2) | 92.4 (15.5) |
| Digit recall                | Second grade                     |    |    |    |    |    |
|                             | BE<F**, D<E*                     | 2.4 (1.9) | 1.4 (0.9) | 2.5 (1.3) | 2.6 (1.6) | 3.4 (1.4) |
| Verbal working memory       | Third grade                      |    |    |    |    |    |
|                             | AE<F**                          | 2.9 (2.0) | 6.6 (2.1) | 6.6 (2.3) | 5.2 (3.1) | 7.4 (2.5) |
|                             | Fourth grade                     |    |    |    |    |    |
|                             | ABDE<F**                        | 4.9 (2.0) | 5.5 (2.2) | 6.7 (1.8) | 7.9 (2.3) | 9.4 (2.0) |
|                             | Fifth grade                      |    |    |    |    |    |
|                             | AE<F**                          | 5.2 (3.0) | 8.0 (2.6) | 8.7 (2.1) | 8.7 (2.4) | 10.1 (1.8) |
|                             | Sixth grade                      |    |    |    |    |    |
|                             | ABE<F*, D<F**                    | 8.5 (2.3) | 8.7 (1.2) | 8.4 (2.0) | 9.2 (2.3) | 10.2 (1.5) |

*p<.05, **p<.01
Note. A significant difference is indicated with asterisks. The magnitude of relation is indicated with the less than sign.
The background factors involved in low attainment of Kanji writing test. All the participants in Groups B and D of the third grade did not achieve low attainment of special morae. Therefore, for the third grade, Groups A and E was set as the object variable, and low attainment on the special morae test was set as the explanatory variables for the multiple logistic analysis. The correlation coefficient between the explanatory variables was less than 0.5; thus, multicollinearity was not found. For all grades, the \( p \)-value calculated by chi-squared analysis was less than 0.01.

In Table 4, the odds ratios for the occurrences of Groups A, B, D and E are presented. For Group A, significantly large odds ratios were found for the special morae test in the second and third grades. For the fluent Hiragana reading test and the verbal working memory test, significant odds ratios were found in the third to sixth grades. For the verbal working memory test, the values of the odds ratios of Group A were larger than those of Group B or Group D in the third to sixth graders.

For Group B, a significant odds ratio was found for the special morae test in the second graders. For the fluent Hiragana reading test, significantly large odds ratios were found in the second to sixth grades. For the verbal working memory test, with the exception of the third grade, significant large odds ratios were found in the second to sixth grades. The odds ratio values for the verbal working memory test were larger than those of Group D.

For Group D, significant large odds ratios were found for the fluent Hiragana reading test in third and sixth graders. For the verbal working memory test, significant large odds ratios were found in the second and fourth to sixth grades.

The imageability effect for the low attainment of Kanji writing. In Fig. 2, the average imageability effect value for each group is depicted. The difference of the imageability effect values among the groups was examined by means of the Kruscal–

|                  | Fluent Hiragana reading | Digit recall | Special morae |
|------------------|-------------------------|--------------|---------------|
| **Second grade** |                         |              |               |
| A                | 2.6 (0.5–14.0)           | 3.1 (0.6–17.0)| 91.1 (10.3–810.1)** |
| B                | 14.0 (2.4–83.8)**        | 7.6 (1.4–41.3)*| 11.4 (2.0–64.6)** |
| D                | 1.7 (0.5–6.6)            | 3.3 (1.1–10.2)*| 1.8 (0.4–9.1)   |
| E                | 3.1 (1.3–7.2)**          | 2.3 (0.9–5.5) | 3.5 (1.3–9.3)*  |
| **Third grade**  |                         |              |               |
| A                | 7.9 (1.6–39.8)*          | 17.5 (3.5–87.2)**| 4.8 (1.1–21.5)* |
| B                | 11.4 (2.7–48.1)**        | 1.2 (0.1–11.1) | —             |
| D                | 7.0 (1.6–31.8)*          | 1.4 (0.1–12.4) | —             |
| E                | 3.2 (1.3–8.1)*           | 6.1 (2.6–14.5)**| 1.2 (0.5–3.1)  |
| **Fourth grade**|                         |              |               |
| A                | 4.9 (1.3–18.1)*          | 22.5 (6.8–74.4)**| —            |
| B                | 10.3 (2.6–40.8)**        | 9.6 (2.3–40.8)**| —            |
| D                | 1.1 (0.1–8.7)            | 5.9 (1.4–25.0)*| —            |
| E                | 3.9 (1.6–9.7)**          | 3.9 (1.4–10.9)**| —            |
| **Fifth grade** |                         |              |               |
| A                | 17.7 (4.2–74.5)**        | 36.6 (7.5–178.0)**| —            |
| B                | 10.2 (1.4–73.5)*         | 21.0 (2.6–169.6)**| —            |
| D                | 7.7 (0.6–96.2)           | 15.8 (1.2–217.1)*| —            |
| E                | 2.4 (0.9–6.6)            | 7.7 (2.4–24.7)**| —            |
| **Sixth grade** |                         |              |               |
| A                | 21.7 (5.5–85.7)**        | 8.0 (1.6–39.8)*| —            |
| B                | 64.6 (6.8–618.0)**       | 11.8 (1.6–89.2)*| —            |
| D                | 4.8 (1.1–20.7)*          | 10.4 (2.6–41.9)**| —            |
| E                | 2.6 (1.0–6.6)*           | 5.0 (2.0–12.6)**| —            |

\*\( p < .05 \), \**\( p < .01 \)

Note. Confidence intervals are indicated in parentheses. Significant odds ratios are indicated with asterisks.
Wallis and Scheffe tests. A significant difference was found between Group A and Groups D, E, and F ($p < .01$) in the fourth grade. A difference was also found between Group B and Group F ($p < .01$). A significant difference was found between Group A and Groups F and E ($p < .01$) in the fifth grade. The differences between Groups B and F and between B and E were shown to be marginally significant ($p < .10$). In the sixth grade, a significant difference was found between Group F and Groups A, B, D, and E. A difference was also found between Group A and Group E ($p < .01$), and between Group B and Group E ($p < .05$). The participants whose imageability effect values were below the 10th percentile were regarded as those who demonstrated an imageability effect.

Subsequently, regression logistic analysis was conducted. The occurrence of participants who showed an imageability effect was set as the object variable and the occurrence of each group as the explanatory variable. All the six graders in Group B showed an imageability effect value below the 10th percentile record; therefore, they were eliminated from the analysis. In addition, the correlation coefficient between Group E and Group F was above 0.5 in all grades; thus, Group E was eliminated from the analysis. The correlation coefficient among Groups A, B, D, and F was less than 0.5; therefore, multicollinearity was not found. In Table 5, the odds ratios for the occurrence of children whose imageability effect values were below the 10th percentile are presented. The $P$-value calculated by the chi-squared analysis was less than 0.01. The significant odds ratio was calculated for Group A in all grades. Fourth graders in Group B showed a marginally significant odds ratio.

### Table 5  The Odds Ratio for the Occurrence of Children Who Showed an Imageability Effect

| Grade     | Group | Odds Ratio (95% CI) |
|-----------|-------|---------------------|
| Fourth    | A     | 11.1 (2.5–48.7)**   |
|           | B     | 4.2 (1.0–18.2)$^*$  |
|           | D     | 1.0 (0.2–4.8)       |
|           | F     | 0.1 (0.0–0.3)       |
| Fifth     | A     | 19.0 (4.4–81.4)**   |
|           | B     | 8.6 (1.3–57.8)$^*$  |
|           | D     | 2.9 (0.2–34.4)      |
|           | F     | 0.3 (0.1–0.8)       |
| Sixth     | A     | 5.3 (1.3–22.7)$^*$  |
|           | B     | —                   |
|           | D     | 0.8 (0.2–3.2)**     |
|           | F     | 0.1 (0.0–0.2)       |

$^*p < .10, ^{**} p < .05, ^{***} p < .01$

Note. Confidence intervals are indicated in parentheses. Significant odds ratios are indicated with asterisks.

Fifth graders in Group B also demonstrated a significant odds ratio.

### Discussion

#### Validity and Characteristics of the Vocabulary Test

Before the main investigation, the newly developed vocabulary test was evaluated in the preliminary investigation. The KRT vocabulary subtest, which was employed to evaluate receptive vocabulary, has been widely used in normal classrooms. In this test, words are matched to descriptions of the meaning of the words. To identify participants whose performance was below the fifth percentile score in the KRT vocabulary subtest, ROC analysis was performed on the vocabulary test of the present study. AUC showed values above 0.82. Since AUC values above 0.8 are evaluated as an index of good discrimination, cutoff values were used in the vocabulary test of the present study. This cutoff value for each grade was utilized to define low attainment in the vocabulary test.

Hiragana and Kanji words were presented in the KRT vocabulary subtest; alternatives were descriptions of the meanings of Hiragana and Kanji words. In the description, Kana letters that explained how to read were not attached to the Kanji characters. Therefore, children with Kanji reading difficulties...
might have difficulty in choosing alternatives in the KRT vocabulary subtest. In contrast, in the vocabulary test of the present study, Kana letters were attached to all Kanji words. Furthermore, pictures of the meaning of words were provided in the alternatives so that Kanji reading difficulties would not interfere with the children’s ability to choose alternatives. Since the vocabulary test of the present study is useful for evaluating the level of vocabulary regardless of the presence or absence of Kanji reading difficulty, the vocabulary test could be employed to examine the relationship between Kanji reading difficulty and low attainment of vocabulary in children with Kanji writing difficulty.

Classification of Children with Kanji Writing Difficulty According to Low Attainment of Vocabulary and Kanji Reading

Okamoto’s review (2014) of research on children with Kanji writing disorders reveals that studies on children with both Kanji reading and writing disorders as well as those with only Kanji writing disorders have been conducted. Okamoto (2014) only reviewed studies that included children with Kanji writing difficulty whose FIQ was above 70, or whose nonverbal IQ or verbal IQ was above 85; in other words, they were the children without mental retardation. Occurrences of these children in normal classes have been reported, but not studied in detail. In the present study, children with Kanji writing difficulty without low attainment of vocabulary were found to correspond to children in Groups B and D; there were 8 to 24 of these children; their ratios ranged from 3 to 7% in each grade. ROC analysis revealed that low attainment in the vocabulary test corresponded to fifth percentile children of the KRT vocabulary subtest. Therefore, children in Groups B and D were classified as those without mental retardation. Consequently, the present study revealed that 3 to 7% of children have Kanji writing difficulties without mental retardation. To administer effective and individual teaching support, it is imperative that the background factors involved in Kanji writing difficulty of each group be clarified.

Background Factors in Each Group of Children with Kanji Writing Difficulties and Effective Teaching for Support

In the present study, Kanji writing difficulty was commonly found in children in Groups A, B and D, but there were different degrees of low attainment of Kanji reading and vocabulary among the groups. Therefore, by comparing the background factors involved in each group, it might be possible to identify common background factors involved in Kanji writing difficulty, irrespective of Kanji reading difficulty or low vocabulary attainment.

A comparison of the background factors involved in Groups A and B revealed that low performance of the special morae test contributed to Kanji writing difficulty in second graders in both Groups A and B. In the fourth to sixth graders of Groups A and B, the contributions of low verbal working memory performance and low Hiragana reading fluency were observed. This finding indicates that under the condition of combining writing and reading difficulties of Kanji, low performance of the special morae test in the second grade as well as low verbal working memory performance and low Hiragana reading fluency in the fourth to sixth grades contributed to Kanji writing difficulty, irrespective of low vocabulary attainment. With reference to verbal working memory, Group A’s odds ratios were above 15.0 and larger than those of Group B in the third and fourth grades. The imageability effect was observed distinctively in Group A. These results indicate that low verbal working memory might contribute more strongly to Kanji writing difficulty when Kanji reading difficulty and low vocabulary attainment co-occur. Furthermore, the restriction of working memory might result in low learning attainment of those Kanji words with low imageability. For Group A’s second and third graders, facilitating learning of special morae words might be effective. For third to sixth graders in Group A, interventions that take low verbal working memory and less fluent Hiragana reading into consideration are needed.

By comparing the background factors of Groups B and D, it was found that in third to sixth graders of these groups, low verbal working memory performance contributed commonly to Kanji writing difficulty. In the second and sixth graders in Groups B and D, the contributions of low Hiragana reading fluency were observed. These findings indicated that under the condition of good attainment of vocabulary, low verbal working memory in the third to sixth grades as well as low Hiragana reading fluency in the second and sixth grades might contribute to Kanji
writing difficulty, irrespective of Kanji reading difficulty. With reference to Hiragana reading fluency, Group B’s odds ratios were above 10.0 and larger than those of Group D in the third, fourth and sixth grades. This result suggests that low Hiragana reading fluency might contribute strongly to Kanji writing difficulty under the condition of Kanji reading difficulty with good attainment of vocabulary. For Group B’s third to sixth graders, intervention to compensate low verbal working memory as well as less fluent Hiragana reading might be an effective teaching support.

Children in Group D only showed low performance in the Kanji writing test. In the second and fourth to sixth graders in Group D, low performance of verbal working memory contributed to Kanji writing difficulty. In the third and sixth graders in Group D, the effect of low Hiragana reading fluency was observed. This result indicates that low verbal working memory might contribute consistently to Kanji writing difficulty under the condition of good Kanji reading and sufficient vocabulary. Therefore, for children in Group D, interventions to facilitate verbal working memory might be effective. For children with learning disorders, malfunction of visual cognition as well as visual memory has been indicated (Goto, Uno, Haruhara, Kaneko, Awaya, Kozuka, & Katano, 2010; Inomata, Uno, Izawa, Haruhara, Kaneko, & Awaya, 2011). The present study did not investigate low performance on visual cognition tests or visual memory as background factors. Accordingly, it is recommended future studies focus on these factors.

In previous studies, verbal working memory was found to be related to the background factors involved in the formation of verbal vocabulary (Gathercole & Baddeley, 1989). Hiragana reading fluency and verbal working memory were indicated as background factors involved in Kanji reading difficulty (Onda et al., 2015). The results of the present study revealed that the background factors involved in Kanji writing difficulty depend on a combination of Kanji reading difficulty and low vocabulary attainment. Since Kanji characters have semantic and syllabic aspects, a combination of a multiplicity of background factors exhibiting low attainments might be related to the diversity of Kanji writing difficulty. The most effective teaching support may result from interventions that are programed according to each child’s background factors. The effect of teaching support needs to be further studied in relation to the combination of Kanji reading difficulty and the low attainment of vocabulary.

References

Duyck, W., Szmalec, A., Kemps, E., & Vandierenodonck, A. (2003) Verbal working memory is involved in associative word learning unless visual codes are available. *Journal of Memory and Language, 48*, 527–541.

Fukuzawa, S. & Hirayama, Y. (2015) *Kyokenshiki Reading-Test*. Toshobunka, Tokyo (in Japanese).

Gathercole, S. E. & Baddeley, A. D. (1989) Evaluation of the role of phonological STM in the development of vocabulary in children: A longitudinal study. *Journal of Memory and Language, 28*, 200–213.

Goto, T., Uno, A., Haruhara, N., Kaneko, M., Awaya, N., Kozuka, J., & Katano, S. (2010) Visual function, visual perception and visual recognition in Japanese children with developmental dyslexia. *The Japan Journal of Logopedics and Phoniatrics, 51*, 38–53. (in Japanese)

Inomata, T., Uno, A., Izawa, Y., Haruhara, N., Kaneko, M., & Awaya, N. (2011) Relationship between long-term memory of non-verbal figures and Kanji character learning. *The Japan Journal of Logopedics and Phoniatrics, 52*, 246–253.

Iyonaga, S., Naka, C., Mekaru, M., Nakamura, R., & Koike, T. (2017) Risk factors for non-attainment of special notations in elementary 1st to 3rd graders: A study on Hatsu-on, Soku-on, Yo-on and Yo-chou-on. *Journal of Special Education Research, 55*, 63–73. (in Japanese)

Japan Society for Educational Skill (2007) Five points for the kanji acquisition shown by data. *Elementary school kanji acquisition situation survey*. Mitsumura Educational. (in Japanese)

Kai, M. (2002) *Vocabulary instruction method [Vocabulary table compilation]*. Mitsumura Tosho Publishing. (in Japanese)

Kumagai, R. (2009) Development of IRT analysis programs for beginners: Easy Estimation series. *The Japan Association for Research on Testing, 5*, 107–118. (in Japanese)

Naka, C., Yoshida, Y., Kumoi, M., Ozeki, H., Igarashi, Y., & Koike, T. (2014) A study on risk factors for difficulties of reading and writing Kanji in the 2nd grade of elementary school: Evaluation of risk factors by the CHAID analysis. *Journal of Special Education Research, 52*, 1–12. (in Japanese)

Nakamura, R., Naka, C., Mekaru, M., & Koike, T. (2017) Causal factors for difficulties of writing Kanji in children of the 2nd to 6th grades of Japanese elementary school. *Journal of Special Education Research, 55*, 1–13. (in Japanese)

Okamoto, K. (2014) Research trends investigating about teaching
for students with kanji-writing difficulties. *National Institute of Special Needs Research*, 41, 63–75. (in Japanese)

Onda, S., Sato, K., Takimoto, S., Mekaru, M., Naka, C., Kumazawa, K., & Koike, T. (2015) Risk factors for kanji word-reading difficulty in Japanese elementary school children. *Journal of Special Education Research*, 3, 23–34.

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001) How psychological science informs the teaching of reading. *Psychological Science in the Public Interest*, 2, 31–74.

Sasaki, T., Iwata, K., & Tanigawa, H. (2008) New edition of the textbook for social studies. Tokyo shoseki, Tokyo (in Japanese)

Snowling, M., van Wagtendonk, B., & Stafford, C. (1988) Object-naming deficits in developmental dyslexia. *Journal of Research in Reading*, 11, 67–85.