Original Article

Causal Factors Involved in Kanji Word-Reading Difficulty in Japanese Elementary Second to Sixth Graders

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In this study, causal factors involved in Kanji reading difficulty among second to sixth graders (N=4519) were examined by employing tests that comprised reading Kanji words, rapid searching of Hiragana words, writing special morae, verbal short-term memory, verbal working memory, and visual short-term memory. CHAID analysis showed that second to fourth graders with special morae test scores below the 10th percentile had the lowest Kanji reading ability in their grades. Furthermore, children with scores below the 10th percentile in the rapid searching of Hiragana words test had poor Kanji word-reading ability. Fifth and sixth graders with scores in the verbal short-term memory and/or verbal working memory tests below the 10th percentile had the lowest Kanji word-reading ability in their grades. The results suggest that the first causal factor among second to fourth graders may include low performance in phonological awareness. Furthermore, the first causal factor among fifth and sixth graders could be linked to poor verbal memory.

Key Words: Kanji word-reading difficulty, causal factors, learning disabilities, elementary school student

Introduction

With the development of inclusive education, it has become increasingly important to enhance educational support for children with learning difficulties. The National Curriculum (MEXT, 2008a) requires elementary school children to read Kanji characters equivalent to their grade. If the difficulties encountered when reading Kanji words were caused by specific causal factors, it would be difficult to overcome such difficulties through children's spontaneous efforts. To implement effective support so as to prevent Kanji reading difficulty, it is imperative to conduct an investigation on Kanji reading difficulty for children in normal elementary classes.

In order to examine the causal factors of Kanji reading difficulty, findings on Chinese characters may be informative for evaluating the reading process of Japanese Kanji. While Chinese characters are characterized by one-to-one correspondence between characters and sounds, this is not found in Kanji. Rather, Kanji characters have multiple pronunciations. Consequently, the demands involved in learning the association between characters and sounds in Japanese Kanji characters and Chinese characters are different. When the causal factors of Kanji reading difficulty are examined in relation to the findings on Chinese characters, common aspects as well as specific aspects of Kanji reading difficulty will be clarified in relation to their comparison with Chinese characters.

Studies on Japanese characters, namely, Hiragana and Kanji, have highlighted the contribution of phonological awareness in relation to Japanese children who experience reading difficulties in the lower grades. Studies on Chinese characters for Chinese children have revealed similar results. Huang and Hanley (1997) found that phonological awareness
predicts the attainment level of reading Chinese characters in the first grade. Amano (1986) demonstrated that the low attainment of special morae in Hiragana was the result of poor phonological awareness. Furthermore, by means of chi-square automatic interaction detector (CHAID) analysis, Naka, Yoshida, Kumoi, Ozeki, Igarashi, and Koike (2014) revealed that difficulties in reading Kanji characters were related to the low attainment of special morae in Hiragana.

Specific aspects of Kanji reading difficulty might be experienced by Japanese children in the higher grades. In Chinese higher graders, words in Chinese characters might be read by corresponding characters to sounds one-by-one (Leong & Tamaoka, 1998). On the contrary, almost all Japanese Kanji characters have multiple pronunciations (Leong & Tamaoka, 1998). Furthermore, the number of pronunciations that Japanese pupils have to learn increases as they advance through the grades (MEXT, 2008b). It is thought that Japanese children might acquire the ability to read Kanji words through associative learning, without having to rely on the one-to-one correspondence between characters and sounds. Duyck, Szmalec, Kemps, and Vandierendonck (2003) indicated that verbal short-term memory may play an important role in learning the association of a cue word and target word with low imageability. Many of the Kanji words learned in the higher grades tend to show low imageability (Onda, Sato, Takimoto, Mekaru, Naka, Kumazawa & Koike, 2015). Consequently, poor verbal short-term memory might interrupt learning the association between a Kanji word and its sound more intensively among higher graders than among lower graders. When higher graders have poor verbal working memory, the difficulty of reading Kanji inevitably leads to the difficulty of reading Kanji words with low imageability. Causal factors involved in Japanese middle and higher grade elementary children with reading difficulties have not been clarified.

Accordingly, the purpose of this study was to investigate the developmental properties of causal factors for Kanji reading difficulty. Elementary second to sixth graders were administered tests that comprised Kanji reading, the fundamental skills of Kanji reading including special morae of Hiragana and rapid Hiragana reading, verbal short-term memory, verbal working memory, and visual short-term memory. To examine the combined patterns of low attainment of the fundamental skills of Kanji reading as well as verbal and visual memory, CHAID analysis was conducted. Furthermore, multiple logistic analysis was performed to evaluate the combined patterns of causal factors.

**Method**

**Participants**

The participants included 4530 children in the normal classes of public elementary schools. They were enrolled in three schools in X ward, 13 in Y city, and four in Z city. Data of 11 participants were excluded because they either took less than three of the six tests and/or who did not indicate their gender. Consequently, 4519 children’s results were employed for the analysis: 927 (493 boys and 434 girls) 772 (400 boys and 372 girls), 869 (439 boys and 430 girls), 1019 (505 boys and 514 girls), and 932 (498 boys and 434 girls) second to sixth graders, respectively. Children who received special support services in resource rooms were included. The Board of Education and the principal of each school gave permission for the testing; their intention was to employ the results so as to improve classroom teaching. The principals informed all the participants’ parents of the purpose of the study in writing. Personal information and consent for participation was obtained through each school. The teachers of the students who experienced difficulties in the study were informed about the difficult content, the possible factors involved in the difficulties, and instructional recommendations to alleviate their difficulties.

**Material**

The following tests were conducted to assess the participants: Kanji reading test; fundamental skills tests for Kanji learning, that is, a Hiragana word search test and special morae test; and cognitive skills tests, namely, tests of verbal short-term memory, verbal working memory, and visual short-term memory. The content, instructions, and evaluation of each test are presented in Table 1. Onda et al. (2015) and Naka et al. (2014) asserted that children whose performances in fundamental skills tests and cognitive skills tests are below the 10th percentile are evaluated as children with low attainment scores.
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| Test                             | Contents                                                                 | Instruction                                                                 | Evaluation                                                                 |
|---------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Kanji reading test              | The test comprised 16 words: Each word had two Kanji characters taught in the previous grade. Eight words had high imageability, whereas the other eight with low imageability. The tests were based on the study of Onda et al. (2015). For second graders, there were only 16 high imagiability words. | Children were instructed to write the sounds of Kanji words in Hiragana. | The number of Kanji words that was answered correctly was counted, and the ratios of correct were calculated as full marks of 100. The children with a performance of 0–5th (6–10th) percentile were classified as those with reading Kanji difficulty 1 (reading Kanji difficulty 2). |
| Hiragana word search test       | The test was administered according to Fujii, Yoshida, Jo, Okano, Koike and Kumoi (2012). There were 14 lines in a page and each line had 14 randomized Hiragana letters. | Children were instructed to search for meaningful words from each line and to mark the words in 60 seconds. | The number of meaningful words that were marked correctly was counted as the score of this test. The children with performance below the 10th percentile were evaluated as those with low attainment score. |
| Special morae test              | The test was made based on the study of Naka et al. (2014). The illustrations that represent the words with special morae sounds were printed in a paper. Test included 5 items. | Children were instructed to write the names of the illustrations in Hiragana. | The number of items that were correctly written in Hiragana was counted as the score of this test. The children with performance below the 10th percentile were evaluated as those with low attainment score. |

Tests of fundamental skills

| Test of verbal short-term memory | A sequence of digits was presented aurally in Japanese. The numbers of digits range were four, five, and six. For each digit span, sequences of digits were presented in two trials. | Children were instructed to listen to the sequence of digits and write down the digits in the presented order. | The number of sequences that was correctly written in the presented order was counted as the score of this test. The children with performance below the 10th percentile were evaluated as those with low attainment score. |
| Test of verbal working memory   | A sequence of digits was presented aurally (spacing) in Japanese. The numbers of digits range were three, four, and five. For each digit range, the sequences of digits were presented in two trials. | Children were instructed to listen to the sequence of digits and write down the digits in the backward order. | The number of sequence that was correctly written in the backward order was counted as the score of this test. The children with performance below the 10th percentile were evaluated as those with low attainment score. |
| Test of visual short-term memory | In the answer sheet, a sequence of target complex figures was printed on the answer sheet. The numbers of target range were three and four. On the answer sheet, 30 complex figures with target figures were printed. The complex figures were selected from the abstract figures of Vanderplas and Garvin (1959). | At first, the children were instructed to look at the answer sheet and memorize the sequence of target complex figures within 10 seconds. Then, they were instructed to search and mark the target figures among the 30 different complex figures in the answer sheet within 30 seconds. | The number of figures that were correctly marked was the score of this test. The children with performance below the 10th percentile were evaluated as those with low attainment score. |

Procedure

The class teachers administered the tests simultaneously in each classroom in January and February 201X. The allotted time for each test was approximately 30 minutes. A practice session was conducted before the assessments of the Hiragana word search test and all the cognitive skills tests.

Analysis

Tests for Kanji reading. Indices of difficulty and discrimination were calculated using a two-parameter model of the item response theory (IRT) for each Kanji word. The average scores and SDs of these indices were calculated for each grade.

The answers were classified into three groups, namely, correct, wrong, and blank answers. The numbers for each type of answer were calculated in each
fifth percentile division of scores, and a contingency table was created. Chi-squared analysis and residual analyses were applied to this contingency table.

Based on the results of the analysis, Kanji reading difficulty was defined by occurrences of blank and wrong answers. The children in the percentile division who demonstrated significantly more blank and wrong answers than the expected values were defined as those with Kanji reading difficulty 1 while those in the percentile division who showed significantly more wrong answers than the expected values were defined as those with Kanji reading difficulty 2.

For Kanji difficulty 1 and 2, the prevalence rate of each difficulty was calculated for boys and girls. The male-to-female ratios of prevalence rates were calculated for all the grades.

The scores of the Kanji reading test were classified into four patterns according to the scores of low and high imageability words. Pattern A revealed that scores of low imageability words and high imageability words were below −2 SD. Pattern B revealed that scores of low imageability words were below −2 SD and scores of high imageability words were above −2 SD. Pattern C showed that scores of high imageability words were below −2 SD and scores of low imageability words were above −2 SD. Pattern D showed that scores of words of both high and low imageability were above −2 SD. The proportions of each pattern for the participants with Kanji reading difficulty 1 and 2 were examined by means of chi-squared analysis and residual analysis.

Tests of fundamental skills and cognitive skills. The scores of the fundamental skills and cognitive skills tests were compared among the grades by means of the Kruskal–Wallis and Scheffé tests so as to evaluate developmental properties.

Causal factors for low attainment of Kanji reading test. To investigate the combination of causal factors for Kanji reading difficulty, CHAID analysis was performed. CHAID analysis is a method employed to dissociate the distribution of a response variable by the combination of explanatory variables based on the chi-squared value. The proportion of children with Kanji reading difficulty 1 and difficulty 2, and those without these difficulties were calculated for each distribution by employing CHAID analysis (distributions of I, II-1, and II-2). The proportions were evaluated statistically by performing chi-squared and residual analyses. In addition, for the results distribution for the Kanji reading tests I, II-1, and II-2, the score rank was set at every 20 points, and the absolute frequency was sought. The display format of the horizontal axis for the distribution of achievement scores used in the public release of National Center for University Admission (2010) was used in the study. Furthermore, the occurrence of low attainment scores on each distribution of the CHAID analysis, tests of fundamental skills, and tests of cognitive skills were examined by performing multiple logistic analysis. All analyses were conducted using Ekuseru-Toukei 2012 (Social Survey Research Information, Japan) and SPSS for Windows ver. 23.0, Decision Tree (IBM).

Results

Kanji Reading Test

The average scores of the achievement tests for Kanji reading (scores in 10th and 5th percentile) were as follows: Second grade, 97.1 (93.8, 87.5); third grade, 95.2 (87.5, 75.0); fourth grade, 94.6 (81.2, 68.8); fifth grade, 96.0 (87.5, 81.2); and sixth grade, 95.0 (87.5, 75.0).

Cronbach’s α was 0.90, 0.83, 0.86, 0.82, and 0.83 for each grade, respectively. The difficulty in reading Kanji words for each grade was calculated by means of the IRT, and the differences between the grades were examined through a one-way analysis of variance. No significant differences were found (F(4,75)=0.86, n.s.).

The rate of answer types, namely, correct, wrong, and blank answers for each percentile record is presented in Table 2. The results of the chi-squared and residual analyses revealed that the participants in the 0-5th percentile record had a significantly higher rate of blank and wrong answers than the expected values in all the grades (p < .01). The children in the 6–10th percentile record in the third to sixth grade had a significantly higher rate of wrong answers than the expected values (p < .01). The rate of blank answers was the same as the expected value.

Accordingly, the participants in the 0–5th percentile record, who showed more blank and wrong answers than other percentile records, were regarded as experiencing relatively severe difficulty in Kanji reading; more specifically, Kanji reading difficulty 1. Those in the 6–10th percentile record were assumed to experience reading difficulty; more specifically,
Kanji reading difficulty 2. The criterion for Kanji reading difficulty 2 was the 6–15th percentile for the third and sixth graders because the values of the 15th percentile of the Kanji reading tests were the same as that of the 10th percentile. The participants in the 6–10th percentile record in the second grade showed the same rate of wrong answers as the expected value; thus, only second graders with relatively severe difficulty were examined. Therefore, the second graders had only Kanji reading difficulty 1, whereas the third to sixth graders had Kanji reading difficulty 1 and 2.

The following results reveal the number of children with Kanji reading difficulty 1; composition ratios within the same graders of the same sex are indicated in the parentheses: Second graders, 44 boys (8.9%) and 23 girls (5.3%); third graders, 24 boys (6.0%) and 16 girls (4.3%); fourth graders, 30 boys (6.8%) and 15 girls (3.5%); fifth graders, 42 boys (8.3%) and 26 girls (5.1%); and sixth graders, 42 boys (8.4%) and 21 girls (4.8%). The results reveal the ratio of boys and girls was 1.7:1 for second graders, 1.4:1 for third graders, 2.0:1 for fourth graders, 1.6:1 for fifth graders, and 1.8:1 for sixth graders. The results of the participants with Kanji reading difficulty 2 are as follows: third graders, 49 boys (12.3%) and 35 girls (9.4%); fourth graders, 32 boys (7.3%) and 17 girls (4.0%); fifth graders, 27 boys (5.3%) and 17 girls (3.3%); and sixth graders, 48 boys (9.6%) and 31 girls (7.1%). Furthermore, the results reveal the ratio of boys and girls was 1.3:1 for third graders, 1.8:1 for fourth graders, 1.6:1 for fifth graders, and 1.4:1 for sixth graders.

Low Attainment of Achievement Tests for Kanji Reading and the Effect of Word Imageability

The composition rates of the participants in the four patterns were calculated according to the types of words with low and high imageability (see Table 3). The results of the chi-squared analysis showed that the proportion of each pattern was significantly different among the participants with difficulty 1, difficulty 2, and no difficulty; consequently, residual analyses were applied. Significantly more participants with difficulty 1 revealed pattern A, and significantly more with difficulty 2 revealed pattern B than the expected values for the third and fourth graders (p<.01). In relation to the fifth and sixth graders, significantly more participants revealed patterns A and B than the expected value (p<.01).

Developmental Properties of Fundamental Skills and Cognitive Skills

The values of the average scores (SD, 10th percentile value) of the Hiragana word search test were 9.0 (3.6, 5), 9.9 (3.2, 6), 11.6 (4.2, 7), 13.6 (4.6, 9), and 14.2 (4.5, 9) for the second to sixth grades, respec-

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### Table 2 Rates of Answers in the Kanji Reading Achievement Test

| Grade   | Answer | 0–5%tile | 6–10%tile | 11–15%tile | 16–20%tile | 21–25%tile | 26–30%tile | 31–35%tile | 36–40%tile |
|---------|--------|----------|-----------|------------|------------|------------|------------|------------|------------|
| Second  | Correct| 62.5%    | ▼**       | 91.2%      | 93.8%      | ▲*         | 95.6%      | ▲**        | 100.0%     | ▲**        |
|         | Blank  | 22.5%    | ▲**       | 0.6%       | ▼**        | 0.6%       | ▼**        | 0.6%       | ▼**        | 0.0%       |
|         | Wrong  | 15.0%    | ▲**       | 8.2%       | 5.6%       | 3.8%       | ▼**        | 0.0%       | ▼**        | 0.0%       |
| Third   | Correct| 58.1%    | ▼**       | 82.6%      | ▼*         | 87.5%      | 92.5%      | 93.8%      | ▲*         | 93.8%      | ▲**        | 96.9%      | ▲**        | 100.0%     | ▲**        |
|         | Blank  | 22.5%    | ▲**       | 3.1%       | 1.3%       | 0.6%       | ▼*         | 0.6%       | ▼*         | 0.6%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |
|         | Wrong  | 19.4%    | ▲**       | 14.3%      | ▲**        | 11.3%      | 6.9%       | 5.6%       | 5.6%       | 3.1%       | ▼*         | 0.0%       | ▼**        | 0.0%       | ▼**        |
| Fourth  | Correct| 49.4%    | ▼**       | 78.8%      | ▼**        | 86.3%      | 91.3%      | ▲*         | 94.3%      | ▲**        | 94.3%      | ▲**        | 98.7%      | ▲**        | 100.0%     | ▲**        |
|         | Blank  | 30.0%    | ▲**       | 6.9%       | 3.8%       | 1.3%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |
|         | Wrong  | 20.6%    | ▲**       | 14.4%      | ▲**        | 10.0%      | 7.5%       | 5.7%       | 5.7%       | 1.3%       | ▼*         | 0.0%       | ▼**        | 0.0%       | ▼**        |
| Fifth   | Correct| 59.4%    | ▼**       | 85.0%      | ▼*         | 92.2%      | ▲*         | 93.8%      | ▲**        | 93.8%      | ▲**        | 95.6%      | ▲**        | 100.0%     | ▲**        |
|         | Blank  | 16.9%    | ▲**       | 1.2%       | 0.3%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |
|         | Wrong  | 23.8%    | ▲**       | 13.7%      | ▲**        | 7.5%       | 6.3%       | 6.3%       | 4.4%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |
| Sixth   | Correct| 55.3%    | ▼**       | 79.3%      | ▼**        | 87.5%      | 93.4%      | ▲**        | 93.8%      | ▲**        | 93.8%      | ▲**        | 96.3%      | ▲**        | 100.0%     | ▲**        |
|         | Blank  | 20.9%    | ▲**       | 2.5%       | 1.3%       | ▼*         | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |
|         | Wrong  | 23.8%    | ▲**       | 18.2%      | ▲**        | 11.3%      | 6.6%       | 6.3%       | 6.3%       | ▼*         | 3.8%       | ▼**        | 0.0%       | ▼**        | 0.0%       | ▼**        |

Note: Results of the residual analysis are indicated by the filled-in triangles (▲) and the open downward-pointing triangles (▼). The filled-in triangle indicates that the component ratio was significantly greater than the expected value. The open downward-pointing triangle indicates that the component ratio was significantly less than the expected value. **p<.01, *p<.05.
The values of the special morae test were 4.6 (0.9, 4), 4.8 (0.6, 4), 4.8 (0.6, 4), 4.9 (0.4, 5), and 4.9 (0.3, 5) for the second to sixth grades, respectively. The values of the verbal short-term memory test were 3.0 (1.5, 1), 3.7 (1.5, 2), 4.2 (1.4, 2), 4.5 (1.3, 5), and 4.7 (1.2, 3) for the second to sixth graders, respectively. The values of the verbal working memory test were 3.7 (1.5, 1), 4.5 (1.5, 2), 4.9 (1.3, 3), 5.1 (1.2, 3), and 5.3 (1.0, 4) for the second to sixth grades, respectively. The values of the visual short-term memory test were 4.2 (1.6, 2), 4.7 (1.6, 3), 5.0 (1.5, 3), 5.1 (1.5, 3), and 5.2 (1.4, 3) for the second to sixth grades, respectively.

To investigate the developmental properties, the scores of fundamental skills and cognitive skills tests were compared among the grades by employing the Kruskal–Wallis and Scheffé tests (see Table 4). The participants without Kanji reading difficulty showed a remarkable developmental change of scores in the fundamental skills and cognitive skills tests as they advanced through the grades while those with Kanji reading difficulty 1 did not demonstrate such a developmental change; rather, their developmental change was evident between the lower and higher grades.

Causal Factors of Low Attainment on Achievement Tests for Kanji Reading

The results of CHAID analysis are depicted in Figs. 1 and 2. A score below the 10th percentile value was regarded as low attainment for each test. The fifth and sixth graders above the 4th percentile scored full marks in the special morae test; thus, a score below the 3rd percentile was regarded as low attainment. The first factor that classified the distribution of the achievement tests for Kanji reading was the special morae test for the second, third, and fourth grades. The verbal short-term memory test and verbal working memory test were the first factors for the first and sixth grades, respectively. The Hiragana word search test was the second factor for the second, third, and fourth grades. The verbal short-term memory test and verbal working memory test were the first factors for the fifth and sixth grades, respectively. The Hiragana word search test was the second factor for the second, third, fifth, and sixth grades whereas the verbal short-term memory test was that for the fourth grade.

The number of participants with Kanji reading difficulty 1, difficulty 2, and those without difficulty among the distributions of I, II-1, and II-2, as determined from the results of CHAID analysis, is shown in parentheses in Figs. 1 and 2. The proportion of participants was examined through chi-squared and residual analyses. The results revealed significantly more participants with Kanji reading difficulty 1 than

Table 3 Rates of Four Patterns According to the Types of Words with Low and High Imageability

| Grade     | Patterns | Kanji reading difficulties 1 | Kanji reading difficulties 2 |
|-----------|----------|-------------------------------|-------------------------------|
|           |          | Rate | N  | Rate | N  |
| Third grade | Pattern A | 62.5% | 25 | 0.0% | 0  |
|            | Pattern B | 10.0% | 4  | 36.9% | 31 |
|            | Pattern C | 27.5% | 11 | 25.0% | 21 |
|            | Pattern D | 0.0%  | 0  | 38.1% | 32 |
| Fourth grade | Pattern A | 71.1% | 32 | 0.0%  | 0  |
|            | Pattern B | 17.8% | 8  | 42.9% | 21 |
|            | Pattern C | 11.1% | 5  | 22.4% | 11 |
|            | Pattern D | 0.0%  | 0  | 34.7% | 17 |
| Fifth grade | Pattern A | 52.5% | 31 | 0.0%  | 0  |
|            | Pattern B | 32.2% | 19 | 3.8%  | 8  |
|            | Pattern C | 15.3% | 9  | 4.8%  | 10 |
|            | Pattern D | 0.0%  | 0  | 91.4% | 191|
| Sixth grade | Pattern A | 31.7% | 20 | 0.0%  | 0  |
|            | Pattern B | 58.7% | 37 | 22.2% | 18 |
|            | Pattern C | 9.5%  | 6  | 2.5%  | 2  |
|            | Pattern D | 0.0%  | 0  | 75.3% | 61 |

*Note.* Refer to the note of Table 2. **p<.01, *p<.05
the expected values among distributions I and II-1 for all grades. The number of participants with Kanji reading difficulty 2 was significantly more than the expected values among distribution I for the third and fourth grades, and distribution II-1 for the fifth grade.

The results of multiple logistic analysis for distributions I and II-1 are presented in Table 5. The response variable was the occurrence of participants with difficulty in the achievement tests for Kanji reading. The correlation coefficients of the explanatory variables were all below 0.3. Thus, multicollinearity was not found. For the occurrence of reading Kanji difficulty 1, the odds ratios were in the range, 10.8 to 45.7 for distribution I between grades. For distribution II-1, the odds ratios were in the range, 4.1 to 11.0. For the occurrence of reading Kanji difficulty 2, the odds ratios were in the range, 3.6 to 6.9 for distribution I. For distribution II-1, the odds ratios were in the range, 2.1 to 3.7.

The odds ratio for the individual occurrence of each causal factor is presented in Table 6. For the occurrence of reading Kanji difficulty 1, with the exception of visual short-term memory, significant odds ratios were found in almost every causal factor in each grade. In relation to short-term memory, significant odds ratios were evident only for the third and fourth grades. The special morae test showed

ticsollinearity was not found. For the occurrence of reading Kanji difficulty 1, the odds ratios were in the range, 8.6 to 24.3. The odds ratios of the other causal factors were less than those of the special morae test in each grade. For the occurrences of reading Kanji difficulty 2, the special morae test and Hiragana word search test showed significant odds ratios in the third to fifth grades. The verbal short-term memory test and verbal working memory test showed significant odds ratios in the third, fourth, and sixth grades.

**Discussion**

**Characteristics of Kanji Reading Difficulty in Elementary School Students**

The JSES (Japan Society for Educational Skills, 2007) conducted a nationwide survey and researched acquisition ratios of reading Kanji characters in which they researched 1225 Kanji characters. The survey revealed that first to sixth grade children scored 92–94% in the reading test. In the present study, the children scored 2–3% higher than those in JSES’ (2007) report. While JSES (2007) conducted their survey at the end of the first academic term, the present study was conducted in the third academic term. Furthermore, even though the researched area and number of items were not the same as those of the present study, the rate of correct answers in the
JSES’ (2007) survey and the present study were similar. Consequently, the Kanji reading test of the present study is considered adequate to evaluate Kanji reading difficulty.

Kanji reading difficulty 1, that is, the 0–5th percentile record of the Kanji reading test had significantly more blank answers than the expected values. Blank answers reflected failure to form lexicon (Ishii, Son, Kasahara & Koike, 2004). Thus, children in the 0–5th percentile record can be regarded as having failed to form lexicon in Kanji reading. Although children classified as having Kanji reading difficulty 2, that is, the 6–10th percentile record in the fourth and fifth grade, and the 6–15th percentile record in the third and sixth grades, showed significantly more wrong answers than the expected values, they did not show significantly more blank answers than the expected values. Therefore, children with Kanji reading difficulty 2 may have incomplete lexicon compared to children without difficulty. DSM-5 (American Psychiatric Association, 2013) specifies that the prevalence of specific learning disorders across the academic domains of reading, writing, and mathematics is 5–15% among school-aged children across varying languages and cultures. Because the total proportion of Kanji reading difficulty 1 and 2 was within the range of the prevalence rate of specific learning disorders in DSM-5, the prevalence rate indicated in DSM-5 might be applicable to children with Kanji reading difficulty identified by significantly more occurrences of blank and wrong answers than expected values.

In the present study, male-to-female ratios of prevalence ranged from 1.4–2.0 : 1 for Kanji difficulty 1, and 1.3–1.8 : 1 for Kanji difficulty 2. Uno, Wydell, Haruhara, Kaneko, and Shinya (2009) found that male-to-female ratios of the prevalence rate for Kanji difficulty were 1.6 : 1. DSM-5 (American Psychiatric Association, 2013) specified that specific learning disorders are more common in males than in females (ratios range from about 2 : 1 to 3 : 1). It is suggested that male-to-female ratios of the prevalence rate for Kanji reading difficulty might be slightly lower than that of DSM-5 (American Psychiatric Association, 2013). In Japan, Hiragana reading disorder was also found in children with specific learning disorders. In relation to gender differences of Hiragana reading difficulty, Uno et al. (2009) reported that 495 second
to sixth grade children with Hiragana reading difficulty were all boys, which might suggest a high prevalence rate of Hiragana reading difficulty in boys in comparison with Kanji reading difficulty. In relation to gender differences in Hiragana and Kanji reading difficulty, further research is needed to examine the patterns of coexistence of these reading difficulties.

Causal Factors for Children with Kanji Reading Difficulty in the Low and Middle Grades

In relation to the causal factors involved in the acquisition of reading Chinese characters in the lower grades, Huang and Hanley (1997) conducted a follow-up study on first graders in Taiwan. Their results demonstrated that the scores in a phonological awareness test before entering school were a good
predictor of performance in reading Chinese characters after the first year.

In the present study, CHAID analysis revealed that, for the second to fourth graders, the first factor that dissociates the distribution of low scores in the achievement tests for Kanji reading was low attainment in the special morae test. Amano (1986) indicated that phonological awareness is related to attainment of reading special morae. Thus, Huang and Hanley (1997) as well as the present study indicated that phonological awareness might contribute to the acquisition of reading Chinese characters as well as Kanji.

Prior to learning Chinese characters in Taiwan, children are required to learn phonetic symbols, namely, Zhu-Yin-Fu-Hao. In mainland China, children learn Pinyin (Ho & Bryant, 1997). Zhu-Yin-Fu-Hao and Pinyin are used as supportive scripts for pronunciation (Chang & Inagaki, 1991; Kakihana, 2004). Before learning Kanji, Japanese children learn Hiragana because it supports the pronunciation of Kanji words. Therefore, hypothetically, it is possible that the children with low attainment of phonological awareness might experience obstacles in learning the supportive script for pronunciation. Furthermore, this restriction might interfere with their acquisition of reading Chinese words as well as Kanji words. Further research is needed to test this hypothesis.

Table 6  Odds Ratios of Occurrences of Children with Kanji Reading Difficulties

| Grade  | Tests               | Kanji reading difficulties 1 | Kanji reading difficulties 2 |
|--------|---------------------|------------------------------|------------------------------|
| Second grade | Hiragana word search | 3.7 (2.0–6.7)** | 1.9 (10–36)* |
|         | Special morae       | 8.6 (4.6–16.0)** | 5.5 (3.0–10.2)** |
|         | Verbal STM          | 2.5 (1.3–4.6)** | 1.7 (0.8–3.8) |
|         | Verbal WM           | 2.0 (1.0–3.9)* | 2.1 (1.1–4.1)* |
|         | Visual STM          | 0.9 (0.4–1.9) | 1.0 (0.4–2.2) |
| Third grade | Hiragana word search | 6.4 (2.9–14.0)** | 1.9 (10–36)* |
|         | Special morae       | 16.3 (7.2–36.7)** | 5.5 (3.0–10.2)** |
|         | Verbal STM          | 2.7 (1.0–7.4) | 1.7 (0.8–3.8) |
|         | Verbal WM           | 3.7 (1.5–9.0)** | 2.1 (1.1–4.1)* |
|         | Visual STM          | 2.8 (1.1–7.3)* | 1.0 (0.4–2.2) |
| Fourth grade | Hiragana word search | 4.2 (2.0–9.1)* | 3.4 (2.0–6.0)** |
|         | Special morae       | 6.8 (3.2–14.3)** | 2.5 (1.4–4.5)** |
|         | Verbal STM          | 5.4 (2.6–11.4)** | 1.8 (0.9–3.3) |
|         | Verbal WM           | 2.3 (1.1–4.9)* | 1.8 (1.0–3.1)* |
|         | Visual STM          | 3.4 (1.3–8.9)* | 1.3 (0.5–3.0) |
| Fifth grade | Hiragana word search | 4.0 (2.0–7.7)** | 3.3 (1.5–7.7)** |
|         | Special morae       | 10.2 (2.9–35.9)** | 6.3 (1.2–33.8)* |
|         | Verbal STM          | 5.2 (2.7–10.1)** | 2.3 (0.8–6.2) |
|         | Verbal WM           | 2.8 (1.5–5.4)** | 0.9 (0.3–2.6) |
|         | Visual STM          | 0.9 (0.3–2.2) | 0.2 (0.0–1.8) |
| Sixth grade | Hiragana word search | 3.9 (2.1–7.5)** | 1.7 (0.9–3.3) |
|         | Special morae       | 24.3 (5.6–105.2)** | 3.0 (0.3–29.6) |
|         | Verbal STM          | 3.7 (1.6–8.4)** | 3.0 (1.3–6.6)** |
|         | Verbal WM           | 6.0 (3.0–11.8)** | 0.9 (0.3–2.3) |
|         | Visual STM          | 1.4 (0.7–3.0) | 1.2 (0.6–2.3) |

Note. Significant odds ratios are shown. A 95% confidence interval is indicated within parentheses. Kanji reading difficulty 1 indicates children with a performance in the 0–5th percentile. Kanji reading difficulty 2 indicates children with a performance in the 6–11th percentile for fourth and fifth graders and in the 6–15th percentile for third and sixth graders. Low attainment scores of the fundamental skills tests and cognitive skills. ***p<.01, *p<.05
short-term memory test showed significant odds ratios for children with Kanji reading difficulty with scores below the 10th percentile among third and fourth graders. Lin and Uno (2015) studied third graders in Taiwan and indicated that a test of rapid naming of numbers and pictures, and a test of the immediate reproduction of complex figures were found to contribute significantly to Chinese character reading. Thus, it is suggested that visual memorizing processes that do not rely on verbal codes might contribute generally to reading Chinese characters as well as Kanji. Chinese characters are constructed from radicals, which are components that indicate meaning or pronunciation. The importance of teaching radicals has been demonstrated in the acquisition of meaning or pronunciation. The importance of teaching radicals has been demonstrated in the acquisition of reading Chinese characters (Ho, Ng, & Ng, 2003). In relation to the teaching of Kanji in Japan, bushu, which represent radicals of Kanji, is introduced in the third grade. Furthermore, children are instructed to learn the relationship between the parts of Kanji in order to learn it (MEXT, 2008b). Therefore, it is important to discriminate and memorize the parts of Kanji as well as Chinese characters in elementary reading learners. Thus, the dysfunction of the visual memorizing process without relying on verbal codes might be one of the causal factors of Kanji reading difficulty.

Causal Factors for Children with Kanji Reading Difficulty in the Higher Grades

To study the causal factors for difficulty in reading Chinese characters among children of higher grades in elementary school, Shu, McBride-Chang, Wu and Liu (2006) investigated fifth and sixth graders in mainland China. The participants included Chinese children with developmental dyslexia and age-matched control children. A logistic regression analysis revealed that dyslexic children were distinguished well from the age-matched control group in morphological awareness, rapid number naming and vocabulary tasks. In Shu et al.'s (2006) study in which verbal short-term memory was examined, results revealed that verbal short-term memory is not a distinguishing factor of dyslexic children.

In the present study of fifth and sixth graders, the first factor that dissociated the distribution of low scores in the achievement tests for Kanji reading was the low attainment in the verbal short-term memory test. Children with pattern B had scores below −2 SD for reading Kanji words with low imageability. The number of children with pattern B was significantly greater than the expected values for fifth and sixth graders with Kanji reading difficulty with scores below the 5th percentile. In the fifth grade, although there were significantly more children with pattern C, the number was half that of pattern B. Thus, the imageability effect was confirmed in the present study. Duyck et al. (2003) investigated learning the association of a cue word and a target word with low imageability and revealed that learning performance decreased when verbal short-term memory was disrupted by articulatory suppression. Many of the Kanji words learned in the higher grades of Japanese elementary schools are abstract words with low imageability. Almost all the Kanji characters that constitute Kanji words have multiple pronunciations. Thus, Japanese children with Kanji reading difficulty might acquire the reading of Kanji words through associative learning, without relying on one-to-one correspondence between characters and sounds. It is also suggested that restrictions of verbal short-term memory might impede the associative learning of reading Kanji words with low imageability in the higher grades. A consideration of Shu et al.'s (2006) results suggests that the involvement of verbal short-term memory might be a specific aspect of learning Japanese Kanji in the higher grades. It is recommended that further studies be conducted on methods of supportive teaching for the learning of reading Kanji words with low imageability in the higher grades.

In fifth and sixth grade Japanese children, the low attainment in the Hiragana word search test was the second factor that dissociated the distribution of low scores in the achievement tests for Kanji reading. In second and third grades, the same tendency was also shown. Shu et al. (2006) also found that the performances of rapid naming of number tests were effective for discriminating Chinese students with developmental dyslexia among general fifth and sixth graders in mainland China. Lin and Uno (2015) suggested that rapid processing of recalling and naming numbers or pictures has a similar aspect to that of rapid reading characters to sound. The Hiragana word search test is related to the process of rapid reading of both meaningful and meaningless words as well as the process of judging meaningful words, based on visual vocabulary. Thus, it is believed that the malfunction of rapid processing of converting
visual symbols to sound might be commonly related to the reading difficulty of Chinese characters as well as that of Kanji.

Developmental Change of Causing Factors of Kanji Reading Difficulty

The present study examined the developmental change of fundamental skills and cognitive skills in children with Kanji reading difficulty. Children without Kanji reading difficulty showed a remarkable developmental change for each skill as they advanced through the grades. However, children with Kanji reading difficulty with scores below the 5th percentile did not show such obvious developmental change. Rather, they demonstrated a mild developmental change between the lower and higher grades. The same developmental tendency was found in children with Kanji reading difficulty with scores in the 6–10th percentile. This suggests that the development of fundamental skills and cognitive skills might take a longer time and that developmental variability might be remarkably large in children with Kanji reading difficulty compared to children without Kanji reading difficulty. To establish effective support for Kanji reading, it is imperative to evaluate a combination of the low attainment of those skills and to facilitate the attainment of such skills through supportive teaching materials. With regard to the efficiency of supportive teaching materials, further research needs to be conducted on the typical profile patterns of basic skills.

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