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Relationship between reading/writing skills and cognitive abilities among Japanese primary-school children: normal readers versus poor readers (dyslexics)

Akira Uno · Taeko N. Wydell · Noriko Haruhara · Masato Kaneko · Naoko Shinya

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Abstract Four hundred and ninety-five Japanese primary-school children aged from 8 (Grade-2) to 12 (Grade-6) were tested for their abilities to read/write in Hiragana, Katakana, and Kanji, for their size of vocabulary and for other cognitive abilities including arithmetic, visuo-spatial and phonological processing. Percentages of the children whose reading/writing scores fell below the −1.5SD cut-off differ according to the scripts—Hiragana: 0.2% for reading and 1.6% for writing, Katakana: 1.4% and 3.8%, and Kanji: 6.9% and 6%, respectively. Further, for the normal children, the older the age, the better they performed on cognitive tasks, while the reading/writing disability (RWD) group (below −1.5SD) showed a weaker relationship between the age and the performance level. It was also revealed that for

A. Uno
Graduate School of Comprehensive Human Sciences, University of Tsukuba,
1-1-1, Tennohdai, Tsukuba, Ibaraki 305-8577, Japan
e-mail: uno@human.tsukuba.ac.jp

T. N. Wydell (✉)
School of Social Sciences, Brunel University, Uxbridge, Middlesex UB8 3PH, UK
e-mail: taeko.wydell@brunel.ac.uk

N. Haruhara
Faculty of Health Science, Mejiro University, 320, Ukiya, Iwatsuki-ku,
Saitama-shi, Saitama 339-8501, Japan
e-mail: haruhara@mejiro.ac.jp

M. Kaneko
Faculty of Medical Science for Health, Teikyo Heisei University,
2-51-4, Higashi-Ikebukuro, Toshima-ku, Tokyo 170-8445, Japan
e-mail: kaneko1234@hotmail.com

N. Shinya
Department of Rehabilitation Medicine, Kawakita Central Hospital,
1-7-3, Asagaya-Kita, Suginami-ku, Tokyo 166-8588, Japan
e-mail: n_shinya@tree.edn.ne.jp

the normal children, the “vocabulary size” was the most potent predictor variable in accounting for Kanji word reading performance for all grades except Grade-6, for whom nonword reading/repetition were also significant predictor variables. In contrast, for Kanji word writing, generally other writing related variables were better predictor variables. The RWD group however showed different patterns of results. Thus the data from the normal and RWD children in the current cohort were discussed in terms of the current theories of reading, and developmental dyslexia.

Keywords Hiragana · Katakana · Kanji · Reading and writing difficulties (Dyslexia and Dysgraphia respectively)

Abbreviations

RCPM	Raven’s Coloured Progressive Matrices
SCTAW	The Standardised Comprehension Test of Abstract Words
STRAW	Screening Test of Reading and Writing for Japanese Primary School Children

Introduction

In English, up to 10%–12% of children are said to suffer from developmental dyslexia (e.g., Shaywitz, Shaywitz, Fletcher, & Escobar, 1990; Snowling, 2000), and approximately 12% of adults have difficulties reading in Danish (e.g., Elbro, Moller, & Nielsen, 1995). In contrast, for languages such as Italian or German where orthography-to-phonology correspondence is consistent, the occurrence of developmental dyslexia is much lower (e.g., Landerl, Wimmer, & Frith, 1997; Paulesu et al., 2001; Paulesu et al., 2000).

Researchers (e.g., Landerl et al., 1997; Paulesu et al., 2000, 2001; Wydell & Butterworth, 1999) have argued that the discrepancy in the prevalence of reading impairments in the different languages might be primarily due to the differences inherent in the structure/characteristics of each orthography, in particular, the way in which phonology is computed from orthography. In the alphabetic languages where a finer ‘grain’ processing of the orthography-to-phonology mapping is required such as, for example, English or Danish, developmental dyslexia forms a large minority group.

Landerl et al. (1997), for example, comparing English and German, suggested that the different organisation of phonological recoding might be triggered by the key orthographic feature distinguishing the two orthographies, that is, the difference in the consistency/transparency of grapheme-phoneme relations for vowels. In German such relations are highly consistent, which allows for the immediate on-line assembly of syllables. In contrast, in English these relations are less consistent. Treiman, Mullenix, Bijeljac-Babic, and Richmond-Welty (1995) observed that for monosyllabic CVC-words with the same vowel graphemes in English, the consistency between the vowel graphemes and phonemes was only about 60% (e.g., ‘ea’ in beak/bread/learn). Therefore correct pronunciations of the vowels in English are determined by graphemic context, which prevents immediate on-line assembly of syllables.

Similarly, the hypothesis of granularity and transparency postulated by Wydell and Butterworth (1999) suggests that the way in which the phonology is computed from orthography determines the occurrence of developmental dyslexia, particularly, phonological dyslexia. Some orthographies are more prone to phonological dyslexia than others. This is because dyslexia is not a general deficit that will apply to any orthography, but that it is an interaction between a cognitive deficit and the specific demands of the orthography to be learned (Wydell, 2000, 2003; Wydell & Butterworth, 1999). A similar argument was made for Chinese behaviourally by Ho, Chan, Lee, Tsang, and Luan (2004) and neuronally (with fMRI) by Siok, Perfetti, Jin, and Tan (2004).

Gender and dyslexia

Dyslexia is said to be up to five times more common in boys than girls (e.g., Halpern, 1992). However, some argued that the same criteria for identifying dyslexia are not necessarily used to identify boys and girls with dyslexia and other learning disabilities (Vogel, 1990). With research-based criterion fewer numbers of boys are identified as being reading disabled than with the school teachers' ratings based on children's classroom behaviour. Shaywitz, Shaywitz, Feltcher, and Escobar (1990) followed 445 children in the USA through the second and third grade. In the second grade, their schools identified 13.6% of the boys and only 3.2% of the girls as being reading disabled; in the third grade, the school identified 10.0% of the boys and 4.3% of the girls as being reading disabled. However, when Shaywitz et al. tested the children on academic, cognitive and behavioural measures, they found that in the second grade, 8.7% of the boys and 6.9% of the girls, and in the third grade, 9.0% of the boys and 6.0% of the girls were considered as reading disabled if their reading test performance was below −1.5SD or below the level predicted from their IQs. A more recent large scale study involving 32,000 children in the USA revealed that the ratio between the boys and girls in the incidence of reading disability was closer to 2:1 (Flannery, Liederman, Daly, & Schults, 2000). These estimates are not substantially different from the figures found in the national data of students with dyslexia in UK higher education, this was 1.7:1 (Richardson & Wydell, 2003). Richardson and Wydell thus noted that dyslexia research based on school-identified samples is likely to be subject to a referral bias, and do not necessarily show a true prevalence of dyslexia.

Further Siegel and Smythe (2005)[1] argued that gender differences in the incidence of reading disability/dyslexia are very much influenced by how reading disability/dyslexia is defined. For example, Liederman, Kantrowitz, and Flannery (2005) defined reading disability/dyslexia as a discrepancy between IQ scores and measured achievement (e.g., reading). However, Siegel and Smythe noted that there appears to be no agreed measures of reading among researchers, which in turn leads to inconsistency in gender differences across different studies. Moreover, Liderman et al.'s definition also implies that disability is only confined to reading, and that

[1] We are grateful to one of the reviewers who drew our attention to Siegel and Smythe (2005) in terms of gender difference in the incidence of reading disability/dyslexia.

other cognitive functions are not impaired. According to Siegel and Smythe, however, children with reading disability/dyslexia often have many other problems over and above reading/writing. They see reading disability/dyslexia as one of the manifestations of any cognitive deficits that the children may have.

Siegel and Smythe analysed their own data from 984 children seen longitudinally from kindergarten until Grade-5, which allowed them to compare boys and girls at each age, and also the "stability of the development of these processes" (Siegel & Smythe, 2005, p. 475). They showed that there were no significant gender differences at all the grades except for at the Kindergarten (age 5). For the latter, Siegel and Smythe noted that girls tended to mature earlier than boys, but that the boys caught up by Grade-2. They thus asserted that "to make valid conclusions in comparing studies in this area, it is necessary to use appropriate and consistent definitions" (Seigel & Smythe, 2005, p. 476).

Dyslexia in Japan

In Japan it had been reported that the prevalence of dyslexia was low, and did not warrant special educational support. Also the concept of dyslexia was relatively unknown in Japan until recent years. Makita (1968) claimed that less than 0.1% of children had a reading disability in Japan. A more recent longitudinal nation-wide survey across 325 primary schools conducted by Kokuritsu Tokushu-Kyouiku Sougou Kenkyujyo [Japanese National Research Institute of Special Education] (1996) also revealed that less than 2% of the children showed reading delay/impairment by the time they reached the sixth and final grade in primary school education. The survey found that for reading, the percentage of children with reading delay (at least by 24 months) decreased as they progressed to higher grades —2.28%, 1.80%, 1.56%, 1.39% and 1.08% for the 2nd, 3rd, 4th, 5th and 6th grade, respectively. For writing, these were 4.45%, 3.13%, 2.85%, 2.19% and 1.81%, for the 2nd, 3rd, 4th, 5th and 6th grade, respectively. Thus more children had difficulty in writing than reading (cited by Wydell, 2003). These figures are higher than those found in the earlier studies, but still lower than that reported in the English-speaking world. It should however be pointed out that these studies lacked objectivity, because they were based on questionnaires on children's reading and writing attainments completed by their teachers.

There are studies, however, where reading ability in Japanese children was objectively measured. For example, Stevenson, Stigler, Lucker, and Lee (1982) tested fifth-grade primary school children's reading abilities in Japan, Taiwan, and America. The tests consisted of reading meaningful textural material presented in clauses, sentences and paragraphs. The children were asked to respond to true or false and multiple-choice questions. It was found that there were children in all three countries who were performing at least two grade levels below average fifth graders (5.4% in Japan, 7.5% Taiwan, and 6.3% USA, respectively). Further, the performance of the Chinese and Japanese children in these tests was consistently related to cognitive abilities, in particular, the common knowledge that a child has accumulated through everyday experience, and verbal memory. Similarly, Hirose and Hatta (1985) tested 250 children (aged 8.5–13.4) in Japan using Kitao's (1984) standardised test for the reading ability of 8–13 year old. The test items included word discrimination, sentence comprehension, sentence memory and reasoning. Hirose and Hatta found that 16.4% of them showed a 12-month delay, and 15.2% showed more than a 24-month delay.

These studies, however, typically concentrated on children's reading comprehension, and did not include any single-word reading tests where no contextual information can be utilised. Since single word reading tests are generally used as a diagnostic tool to identify children with reading impairments, these studies do not give conclusive evidence for the occurrence of dyslexia among Japanese children (see Wydell, 2003; Wydell & Butterworth, 1999 for a similar argument). Further, there has been no available study in Japan where the relationship between cognitive abilities and reading skills was systematically investigated.

Japanese orthography

The Japanese orthography consists of two qualitatively different scripts: logographic/ morphographic Kanji (derived from Chinese characters) and two forms of syllabic Kana, Hiragana and Katakana, which are derived from Kanji characters (see Sampson, 1985; Wydell, Patterson, & Humphreys, 1993 for further discussion). These three scripts are used to write different classes of words. Kanji characters are used for nouns (e.g., 学生 /GAKUSEI/ meaning 'students'), and for the root morphemes of inflected verbs (e.g., 食べる /TA-beru/meaning 'to eat'), adjectives (美しい /UTSUKU-shii/meaning 'beautiful') and adverbs (e.g., 忙しく /ISOGA-shiku/ meaning 'busily'). Hiragana is used mainly for function words and the inflections of verbs, adjectives, and adverbs, and for some nouns with uncommon Kanji representations. Katakana is used for the large number of foreign loan words (e.g., カメラ /kamera/meaning 'camera') in contemporary Japanese. Both forms of Kana have an almost perfect one-to-one relationship between character and pronunciation. This means that one character almost always represents one particular syllable or mora (syllable like unit) of the Japanese language, and its sound value does not change whether the character appears in the first, the middle or at the last position of a multi-syllable words. "This is different from English, where orthographic units not only map onto sub-syllabic phonological units, but also the mapping itself will depend on context, i.e., the location within the words" (Wydell & Butterworth, 1999, p. 277).

Because of the transparent nature of the relationship between a Kana and its pronunciation, it is known that children master both Kana scripts very quickly. Most children learn Hiragana script even before they start primary school education (Gibson & Levin, 1975; Makita, 1968; Muraishi, 1972; Sakamoto & Makita, 1973).

In contrast, the relationship between a Kanji character and its pronunciation is very opaque (Kaiho, 1983). "This is because each Kanji character is a morphographic element that cannot phonetically be decomposed in the way that an alphabetic word can be. There are no separate components of a character that correspond to the individual phonemes" (Wydell et al., 1993, p. 492). Most Kanji characters have one or more ON-reading (of Chinese origin: pronunciations were imported from spoken

Chinese along with their corresponding characters) and a KUN-reading (the original Japanese spoken language). Some characters have no KUN-reading, but for those which have, the KUN-reading is almost always the correct reading when this character constitutes a word on its own, e.g., the character, 花 /HANA /in KUN-reading is a single-character word meaning “flower”. Also, the same KUN-reading can be seen in two-character words, e.g., 花束 /HANA-TABA/meaning “bouquet”. However the same character is also pronounced as/KA/in ON-reading as in 花瓶 /KA-BIN/meaning “vase”.

Children are introduced to new Kanji characters in text. The Japanese children start their primary school education aged seven, which lasts for 6 years, and they are introduced to 996 different Kanji characters, which are prescribed in the List, GAKUNENBETSU KANJI HAITO HYO[2] by the Japanese Ministry of Education and Science. By the end of compulsory education (age 16 years), a total of 1,945 Kanji characters are taught. Note however that adults need some 3,000 Kanji characters for most every day activities (e.g., reading a national newspapers; Morton & Sasanuma, 1984).

It follows therefore that the most optimal way of learning Kanji is essentially by rote. An example of a primary school child repeatedly writing the same Kanji character in order to learn how to read and write character correctly can be seen in Naka and Naoi (1995). This is often accompanied by a child reciting the name of the character each time he/she writes the character.

The current study

In the current study, an objective research paradigm was employed and the Japanese primary-school children (Grade-2 to Grade-6) were tested not only for their abilities to read and write single characters and words in Hiragana, Katakana, and Kanji, as well as for their vocabulary, but also other cognitive abilities including arithmetic, visuo-spatial and phonological processing abilities. The aims of the study were to ascertain (1) the percentage of children who might be considered as reading/writing disabled within the current cohort, when a −1.5SD cut-off was used,[3] (2) gender differences in Kana and Kanji reading/writing disabilities, and (3) relationships between reading/writing abilities and other cognitive skills among the normal

[2] In Japan a common core curriculum is used during the first 9 years of compulsory education (primary and junior high schools). The Ministry of Education and Science in Japan prescribes 1945 Kanji characters/words that children learn during the compulsory education across Japan. This Ministry also prescribes which Kanji characters must be taught at each grade at primary schools in Japan. Further, there are at least two kinds of Kanji characters—pictographs and compound characters. A compound Kanji character has a phonetic radical and a semantic radical. However, primary school children are not made aware of this yet. This is partly because the consistency or congruency between the pronunciation of a phonetic radical and the pronunciation of the whole character containing that phonetic radical is very limited (approximately 30% and only applies to the ON reading; see Kaiho 1983).

[3] One of the reviewers rightly pointed out that cross-linguistic comparisons of the incidence of dyslexia are problematic, since they depend not only on the tests but also on the particular cut-off used. However, one of the main purposes of the study was not to compare directly the incidence of dyslexia across different languages. Rather, it was to establish a general picture of Kanji and Kana reading/writing disabilities among Japanese primary school children using a standardized test (which was developed and based on the results from individually testing over 1,000 Japanese primary school children) and a −1.5 SD cut-off.

readers and those with reading/writing disabilities (RWD), thus possibly revealing typical and atypical courses of reading/writing development in normal readers and those with reading/writing disabilities.

Method

Participants

Four hundred and ninety-five (263 boys and 232 girls) participated in the study aged between 8 (2nd grade) and 12 years old (6th grade) from a state-run primary school in a suburb of Tokyo, Japan, with a population of 463,000.

The Local Educational Authority approved of the study. Further, not only the participating children and their school teachers but also the parents/guardians of those participating children were informed of the study, and consent and approval was given by the headmaster of the school.

Material

The following test materials were used together with audio tape-recorders and stopwatches where necessary including RCPM–Raven's Coloured Progressive Matrices (Raven, 1976); Rey–Osterrieth Complex Figure Test (Osterrieth, 1993); SCTAW[4]—Standardised Test of Abstract Words (Uno, Haruhara, & Kaneko, 2002); STRAW—Screening Test for Reading and Writing for Japanese Primary School Children (Uno, Haruhara, Kaneko, & Wydell, 2006):

(a) Reading single Hiragana Characters (*n* = 20; STRAW)
(b) Reading single Katakana Characters (*n* = 20; STRAW)
(c) Reading Hiragana Words (*n* = 20; STRAW)
The stimuli consisted of Hiragana transcriptions of the Kanji words used in (e).
(d) Reading Katakana Words (*n* = 20; STRAW)
The stimuli consisted of Katakana transcriptions of the Kanji words used in (e).
(e) Reading Kanji Words (*n* = 20; STRAW)
The stimuli consisted of the Kanji words, which the children at each grade learned 24 months earlier (e.g., the 6th Grade children were asked to read the Kanji words which had been taught at their 4th Grade), except for the 2nd Grade children. They were asked to read the Kanji words which the children learned 12 month earlier.
(f) Writing (to dictation) Hiragana Words (*n* = 20; STRAW)
The stimuli were identical to those used in (c) STRAW)
(g) Writing (to dictation) Katakana Words (*n* = 20; STRAW)
The stimuli were identical to those used in (d) (STRAW)
(h) Writing (to dictation) Kanji Words (*n* = 20; STRAW; see sample items in Appendix)
The stimuli were identical to those used in (e).

[4] Kunishi et al. (International Journal of Pediatric Otorhinolaryngology (2007) 71, 1671–1679) demonstrated that the SCTAW was useful as an abstract lexical evaluation of hearing impaired children.

(i) Arithmetic (additions/subtractions from one digit to three digits, e.g., 2 + 4; 18 + 25; 324 + 163; 6–3; 38–19; 235–187; $n = 10$; STRAW)
(j) RCPM—(as an easily administered IQ test).
(k) SCTAW—(as a vocabulary test). This is a word-picture matching test with 45 abstract target words. In the present test, the target word was given orally, and a participant was requested to point to the correct picture depicting the target word, out of six pictures. The stimulus pictures consist of the target picture, two semantic-distracter (semantically related to the target word) pictures, two phonological-distracter (phonologically related to the target word) pictures, and one unrelated/neutral to the target word (see sample pictures in Appendix).
(l) Rey–Osterrieth Complex Figure Test—Copy Drawing
(m) Rey–Osterrieth Complex Figure Test—Immediate Recall
(n) Rey–Osterrieth Complex Figure Test—Delayed Recall (after 30 min)
(o) Nonword Reading ($n = 5$; STRAW)
The stimuli consisted of 3~5 morae pronounceable word-like nonwords (e.g., かたつむり /ka-ta-tsu-mu-ri/ (snail) → かたつとり /ka-ta-tsu-to-ri/).
(p) Nonword Repetition ($n = 5$; STRAW)
Each stimulus was a five-mora nonword presented aurally to each participating child by an examiner.

Procedures

For the reading tests—(a), (b), (c), (d), (e) and (o), (j)—RCPM, (k)—SCTAW, and (p) Nonword Repetition, each child was tested individually and the errors were recorded by his/her examiner. Also, each child's responses were audio-taped for later checking. For the writing tests—(f), (g), and (h), (i)—Arithmetic test, Rey's Complex Figure tests—(l)—Copying, (m)—Immediate Recall, and (n)—Delayed Recall were administered in the classrooms.

Twenty investigators (most of whom were Japanese speech therapists) including the authors spent a whole day for each grade at the school during July, 2003. Prior to the actual investigations, all the investigators went through a half-a-day training session so that every investigator knew how to conduct each test in the same manner. Children were told that these were not academic achievement tests, and only the investigators would see their results. The final check for all the collected data before and after the data input onto a PC was conducted by the authors.

Reading/writing disabilities and gender differences

Results

Table 1 shows the number of boys and girls in total who participated in the study as well as the number of boys and girls in the reading and writing disabled (RWD) Groups (with a −1.5SD cut off). Following Shaywitz et al. (1990) study, the children in this cohort ($n = 495$) whose reading or writing test scores [(a–h)] were

Table 1 Reading and writing disabled children and gender difference

	Total	Out of the total (%)	Boys	Out of the total (%)	Girls	Out of the total (%)
Total	495		263		232	
Normal	431		215		216	
RD (−1.5SD)	40	8.08	27	10.27	13	5.60
Hiragana	1	*0.2*	1	*0.38*	0	*0*
Katakana	7	*1.4*	7	*2.67*	0	*0*
Kanji	34	*6.87*	21	*7.98*	13	*5.60*
WD (−1.5SD)	43	8.69	36	13.69	7	3.02
Hiragana	8	*1.62*	7	*2.66*	1	*0.43*
Katakana	19	*3.84*	17	*6.46*	2	*0.86*
Kanji	30	*6.06*	24	*9.13*	6	*2.58*
RWD	64	12.9	48	18.25	16	6.9

Note: The total number of children in RWD (Reading and Writing Disabled) do not necessary match with the total number of children in RD and WD when they are added together. This is because some children were counted more than once (e.g., if a child made reading or writing errors both in Katakana and Kanji, he/she would be counted twice, once for Katakana and once for Kanji)

below −1.5SD (any of the tests) were considered as "Reading Disabled (RD)" or "Writing Disabled (WD)" children.

Because we used the −1.5 SD as the cut off, statistically speaking, 6.7% of the children in the cohort should be expected as RD or WD for any given reading/writing tests, when the data are normally distributed.

Reading disability (RD) in Hiragana, Katakana and Kanji, and gender differences

Hiragana: Table 1 shows that only *0.2%* of the total number of children in this cohort had reading difficulties in Hiragana (one boy in Grade-2)—0.38% of the total number of boys and 0% of girls, thus revealing that the girls had no reading impairment in Hiragana.

Katakana: The table shows that *1.4%* of the total number of children had reading difficulties in Katakana (7 boys in Grade-2, 4 and 5)—2.67% of the total number of boys and 0% of girls, thus again revealing that *girls had no reading impairment in Katakana*. These figures were much lower than those which would have statistically been expected (i.e., 6.7%).

Kanji: The table also shows *6.87%* of the total number of children had reading problem in Kanji (21 boys and 13 girls)—7.98% of the total number of boys, and 5.6% of the total number of girls. The ratio between boys and girls with a Kanji reading disability is *1.6:1*.

In total *8%* of the total number of children in this cohort had a reading disability (27 boys—10.3% of the total number of boys, and 13 girls—5.6% of the total number of girls). The ratio between boys and girls with reading disability in Japanese (including all three scripts) was *1.8:1*.

Table 2 Gender differences in reading and writing disabilities across different grades

Grade	RD			WD			R + W	
	Boys	Girls	Tot.	Boys	Girls	Tot.	Boys	Girls
2	5	2	7	6	3	9	***1***	***1***
3	1	5	6	6	1	7	***1***	***1***
4	9	3	12	9	1	10	***3***	***1***
5	10	2	12	9	2	11	***7***	***1***
6	2	1	3	6	0	6	***2***	***0***
Total	**27**	**13**	**40 (8%)**	**36**	**7**	**43 (8.8%)**	***14 (5.32%)***	***4 (1.72%)***
							18 (3.66%)	

These ratios showed greater similarities to the figures found in the dyslexia studies which used research-based criterion for identifying dyslexia (e.g., Shaywitz et al., 1990).

Writing disability (WD) in Hiragana, Katakana and Kanji and gender difference

Hiragana: Table 1 shows that *1.62%* of the total number of children had writing problem in Hiragana (7 boys and 1 girl)—2.66% of the total number of boys and 0.43% of the total number of girls. The ratio between boys and girls with writing disability in Hiragana is 6.8:1.

Katakana: The table shows that *3.84%* of the total number of children had a writing difficulty in Katakana (17 boys and 2 girls)—6.46% of the total number of boys and 0.86% of the total number of girls. The ratio between boys and girls with a writing disability in Katakana is *7:1*.

Kanji: Table 1 also showed that *6.06%* of the total number of children had a writing problem in Kanji (24 boys and 6 girls)—9.13% of the total number of boys, and 2.58% of the total number of girls. The ratio between boys and girls with a writing disability in Kanji is *3.5:1*.

In total *8.7%* of the total number of children in this cohort had writing disability (36 boys—13.7% of the total number of boys, and 7 girls—3.0% of the total number of girls). The ratio between boys and girls with a *writing disability* in Japanese (including all three scripts) was *5.2:1*.

Reading and/or writing disabilities (RWD) and gender difference

Table 1 further showed that *12.9%* of the total number of children, 64 in total (48 boys—18.3% of the total number of boys, and 16 girls—6.9% of the total number of girls) had reading and/or writing disabilities. The ratio between boys and girls is *2.7:1*, and this was statistically significant, $x^2 = 14.75$, $p < 0.01$.

Table 2 shows the further breakdowns of the data described in Table 1, revealing that out of 64 of the RWD Group, *3.66%* of the total number of children (14 boys—5% of the total number of boys, and 4 girls—1.7% of the total number of girls) had both reading and writing disabilities. It should be noted that a child in the RD (reading disability) or WD (writing disability) category was counted only once, that is, for example, even if a child had reading disabilities of Katakana and Kanji, he/she was counted only once for RD.

It was shown that the ratio between boys and girls with reading and writing disabilities was *3.5:1*. The data also indicated that the children with reading disability did not necessarily have a writing disability, and vice versa.

Discussion

The main findings from the descriptive data analyses can be summarised as follows: since −1.5SD cut off was used, statistically speaking, for any given tests 6.7% of the children in this cohort ($n = 495$) should be identified as being reading or writing disabled, however, (i) the percentage of children with *reading disability* in this cohort differed greatly across Hiragana, Katakana and Kanji, respectively—for *Hiragana 0.2%* of the children (only one boy), for *Katakana 1.4%* of the children (only seven boys), and for *Kanji 6.9%* of the children (both boys and girls) showed reading impairment. It was also revealed that in total 8.1% of the children in this cohort had a reading disability at least in one of the three scripts, and that the children who had a reading impairment in Katakana did not necessarily showed the impairment in Kanji. (ii) Similarly, the percentage of children in this cohort with *writing disability* also differed greatly across the scripts—for Hiragana *1.6%* of the children, for Katakana *3.8%* of them, and for Kanji *6.1%* of them had writing disabilities, respectively. It was also revealed that 8.7% of the children showed a writing disability at least in one of the three scripts, and that similar to reading, the children with writing impairment in Hiragana and/or Katakana did not necessarily have a writing disability in Kanji. (iii) For reading and writing disability together (RWD group), the ratio between the boys and girls in this cohort was *2.7:1*, (see Table 2), and this was statistically significant. That is, reading/writing disabilities were three times more common with boys than girls in this cohort.

Gender differences

The present data thus showed a gender difference in the occurrence of dyslexia and dysgraphia—more boys tended to be afflicted by these conditions than girls. This is also true with other dyslexia studies in English. Halpern (1992) for example reported that dyslexia was up to five times more common in men than women. Share, McGee, McKenzie, Williams, and Silva (1987) also pointed out that overall reading performance scores in English were lower in boys than girls when tested (see also van der Wissel & Zegers, 1985). However, studies on families with dyslexia in English revealed a more even distribution of dyslexic individuals between the sexes (e.g., Shaywitz et al., 1990). Some of these reported studies (Siegel & Smythe, 2005) thus imply that boys tend to be slower at acquiring literacy skills than girls. As discussed earlier, Siegel and Smythe argued that any interpretation of the results showing apparent gender differences in the incidence of reading disability/dyslexia needs caution.

Reading in Hiragana, Katakana and Kanji

The current study also revealed the different occurrence rate of RD according to the type of the scripts (Hiragana, Katakana and Kanji, respectively). For Kana, be it for Hiragana or Katakana, the occurrence of RD was still very low—0.4% and 1.4%, respectively. In contrast, for Kanji the occurrence of RD was 6.9%.

No other studies thus far revealed the occurrence of RD among Japanese children across the three different scripts used in Japan. The current data also indicated that reading Kanji may require different reading strategies or different cognitive skills to those required for reading Kana (this will be further discussed later in the paper).

The current data further revealed that the occurrence of reading disability in this cohort when the three scripts were put together was 8.1%, which was higher than the figure, 6.7%, statistically expected with the −1.5SD cut off and the figure, 5.4%, reported by Stevenson et al. (1982) who tested children in Grade-5. This could be due to the fact that Stevenson et al. only included older children (Grade-5) in their study, while the current study included the children from Grade-2 to Grade-6. The current data also indicated that in general maturation did contribute to a better performance on some of the tests (see below for more detailed analysis and discussion on maturation). Hirose and Hatta (1985) however reported that 15.2% showed more than a 24-month delay in reading when children aged 8.5–13.4 were tested on Kitao's test for reading ability, though Hirose and Hatta (1988) now claimed that the occurrence of developmental dyslexia in Japan is 11%. If the maturation is a key factor in children's reading abilities, then Hirose and Hatta's children who were on average older than the children in the current study should have shown a smaller prevalence rate than that that they reported. As described earlier Kitao's test is aimed to assess children's ability to read for meaning, and thus his test materials were very different from the ones used in the current study. This could be the reason why Hirose and Hatta's study revealed a higher incidence of children with reading impairments (which could be considered as a 'reading comprehension deficit').

Reading and writing in Hiragana, Katakana and Kanji

The current study also showed that the occurrence of both RD and WD, when putting reading and writing skills together, was 13% (see Table 1). This means that children who had RD did not necessarily have WD and vice versa. Only 3.7% of the total number of children (see Table 2) had both reading and writing disabilities. In 'reading' or 'literacy' research, especially in English, it is often assumed that if a child can read, he/she should also be able to write, and thus the majority of research seemed to concentrate only on children's reading skills (e.g., Snowling, 2000).

However, even in alphabetic languages, sometimes children's reading and writing skills can be dissociated—better reading skills than writing skills in German children (e.g., Wimmer, Mayringer, & Landerl, 2000) or Greek children (e.g., Nikolopoulos, Goulandris, & Snowling, 2003; Tzivinikou, 2002). This is partly to do with print-to-sound or sound-to-print consistency or regularity of a given orthography. In both German and Greek, for example, the grapheme-to-phoneme conversion is consistent but the phoneme-to-grapheme conversion is inconsistent.

In this sense, Kanji is inconsistent in both directions (see Wydell, Butterworth, & Patterson, 1995 for more details on characteristic of Kanji). Also it has been shown in any cognitive tasks generation or production (i.e., writing) is usually more cognitively demanding than recognition (i.e., reading). For Kanji, as stated by Morton and Sasanuma (1984), recognition vocabulary (i.e., reading) is often 30% greater than production vocabulary (i.e., writing) even for literate Japanese adults.

Interaction between gender and script-type

The current data further showed a kind of interaction between the gender and the scrip-type (i.e., Hiragana, Katakana or Kanji). The girls showed no problem with reading in Hiragana and Katana, and even for writing in Hiragana and Katakana they showed many fewer problems compared to the boys, who nevertheless made fewer errors in reading/writing in Kana, compared to reading or writing in Kanji. In contrast, for Kanji both boys and girls showed reading difficulties, though more boys still showed Kanji reading difficulties than girls. No other studies thus far have shown the interaction between the gender and the different scripts.

Interestingly, the rate of occurrence of RD in Kanji was very similar to that of writing disabilities in Kanji (8% vs. 8.7%) and yet there was little overlap between these disabilities—some children had RD without WD in Kanji, and others had WD without RD, thus showing a clear dissociation between reading and writing in Kanji. Again, no other studies have shown this dissociation between reading and writing abilities. This might also mean that reading and writing in Kanji may require different cognitive skills. Therefore it is possible only one of the skills, be it reading or writing, is affected.

Further, the two different types of scripts, syllabic Kana (Hiragana and Katakana) and logographic Kanji seem require Japanese children to use different learning strategies (see Sampson, 1985; Wydell & Butterworth, 1999 for more details). For instance, the relationship between a Kana character and its sound is almost perfect one-to-one and transparent, the children may use a simple script-to-sound translation in reading. In contrast, the relationship between a Kanji character and its sound is one-to-many, and the correct pronunciation is determined at the whole word level (Wydell et al., 1993). Therefore the Japanese children learn Kanji characters/words by rote, essentially by repeated writing (see Naka & Naoi, 1995 for more details on repeated writing when learning Kanji characters). These different learning strategies which were necessitated due to the characteristics of each script might have contributed to the different rate of reading/writing disabilities in different scripts.

Children's age and test performance (A)~(P) in normal and RWD groups

Results

Tables 3 and 4 show mean and SD for 16 tests—(a)~(p) for each Grade-2~6 for the Normal Group and RWD (all the children with reading and/or writing disabilities) Group.

Table 3 Mean and SD for 16 reading/writing/cognitive tests—normal readers

	Total ($N = 431$)	Grade-2 ($N = 88$)	Grade-3 ($N = 47$)	Grade-4 ($N = 100$)	Grade-5 ($N = 91$)	Grade-6 ($N = 105$)
(a) $n = 20$ R.Hira.1CHR	19.9 (0.30)	19.8 (0.48)	19.9 (0.28)	19.9 (0.27)	19.9 (0.21)	19.9 (0.17)
(b) $n = 20$ R.Kata.1CHR	19.8 (0.52)	19.6 (0.79)	19.8 (0.56)	19.9 (0.36)	19.9 (0.38)	19.9 (0.37)
(c) $n = 20$ R.Hira.Word	19.9 (0.14)	19.9 (0.18)	20	19.9 (0.10)	19.9 (0.11)	19.9 (0.17)
(d) $n = 20$ R.Kata.Word	19.9 (0.33)	19.8 (0.49)	19.8 (0.41)	19.9 (0.29)	19.9 (0.18)	19.9 (0.17)
(e) $n = 20$ R.Kanji.Word	19.1 (1.03)	18.1 (1.18)	19.0 (0.75)	19.6 (0.64)	18.8 (0.78)	19.6 (0.78)
(f) $n = 20$ W.Hira.Word	19.8 (0.49)	19.6 (0.73)	19.9 (0.25)	19.9 (0.35)	19.7 (0.51)	19.9 (0.32)
(g) $n = 20$ W.Kata.Word	19.2 (2.16)	17.6 (3.87)	19.6 (0.72)	19.7 (1.57)	19.4 (0.83)	19.7 (0.86)
(h) $n = 20$ W.Kanji.Word	17.7 (2.55)	17.7 (2.09)	19.8 (0.50)	18.1 (1.81)	17.1 (2.69)	16.8 (3.23)
(i) $n = 10$ Arithmetic	9.3 (1.22)	8.2 (1.72)	9.2 (1.28)	9.7 (0.78)	9.6 (0.80)	9.7 (0.68)
(j) RCPM	32.2 (3.03)	29.6 (3.97)	31.6 (3.13)	32.4 (2.60)	33.1 (1.74)	33.5 (1.81)
(k) % SCTAW	65.4 (15.80)	48.2 (10.25)	57.2 (10.88)	62.8 (12.19)	73.2 (11.09)	79.0 (10.87)
(l) RCFT Copy	27.4 (8.43)	18.6 (9.05)	24.3 (7.52)	29.0 (6.30)	30.3 (6.16)	32.3 (5.17)
(m) RCFT Immed	16.3 (8.67)	9.2 (5.79)	13.7 (6.68)	16.2 (7.79)	16.8 (8.51)	23.0 (7.21)
(n) RCFT Delay	17.1 (8.61)	8.9 (6.06)	14.7 (6.63)	17.0 (7.64)	18.8 (7.92)	23.5 (6.61)
(o) $n = 5$ R. NW	4.0 (1.16)	3.6 (1.34)	4.0 (1.20)	3.9 (1.10)	4.3 (1.11)	4.3 (0.97)
(p) $n = 5$ Rep. NW	4.4 (0.84)	4.1 (1.03)	4.3 (0.84)	4.5 (0.89)	4.6 (0.61)	4.5 (0.70)

In order to examine whether maturation would contribute to a better performance for each of the 16 tests from (a) to (p), a one-way ANOVA for each test per Grade was employed. These analyses were conducted on the data from the normal group and the RWD group separately. (Note that no analyses were conducted on the data from the RD and WD groups separately as the data sets were too small.)

Normal group

For the children in this group, the following eight tests—(h), (j), (k), (l), (m), (n), (o) and (p)—showed significant age difference:

(h) *Writing (to dictation) Kanji Words*, $F(4, 426) = 15.05$, Mse $= 5.75$, $p < .0001$. Post hoc Bonferroni multiple comparisons revealed that Grade-3 performed better than Grade-2 ($p < .0001$), Grade-4 ($p < .001$), Grade-5 ($p < .0001$) and Grade-6 ($p < .0001$), suggesting that Grade-3 was the best performer on this test. This was followed by Grade-4 performing better than Grade-5 ($p < .045$) and Grade-6 ($p < .001$). In general, the performance on Kanji writing was inversely related to age

Table 4 Mean and SD for 16 reading/writing/cognitive test—RWD group

	Total ($N = 64$)	Grade-2 ($N = 13$)	Grade-3 ($N = 11$)	Grade-4 ($N = 18$)	Grade-5 ($N = 15$)	Grade-6 ($N = 7$)
(a) $n = 20$ R.Hira.1CHR	19.7 (0.86)	19.0 (1.68)	20	19.9 (0.24)	19.9 (0.35)	19.9 (0.38)
(b) $n = 20$ R.Kata.1CHR	19.2 (2.09)	17.1 (3.93)	19.9 (0.30)	19.7 (0.77)	19.7 (0.49)	19.7 (0.76)
(c) $n = 20$ R.Hira.Word	19.8 (0.61)	19.6 (0.65)	19.9 (0.30)	19.9 (0.24)	20	19.4 (1.51)
(d) $n = 20$ R.Kata.Word	19.1 (2.41)	17.5 (4.84)	19.8 (0.41)	19.3 (0.83)	19.6 (0.63)	19.3 (1.89)
(e) $n = 20$ R.Kanji.Word	16.2 (3.65)	13.8 (4.97)	17.9 (1.14)	17.8 (1.62)	15.7 (1.22)	15.0 (7.0)
(f) $n = 20$ W.Hira.Word	19.1 (1.40)	17.8 (2.05)	19.5 (0.93)	19.3 (1.14)	19.1 (0.92)	20
(g) $n = 20$ W.Kata.Word	14.6 (6.04)	10.2 (7.80)	16.2 (5.85)	13.7 (6.25)	17.3 (2.29)	16.4 (2.99)
(h) $n = 20$ W.Kanji.Word	11.9 (5.45)	10.7 (4.85)	17.9 (1.93)	12.6 (5.28)	9.3 (3.77)	8.3 (6.53)
(i) $n = 10$ Arithmetic	8.6 (1.64)	7.2 (1.92)	9.1 (0.70)	8.8 (1.92)	8.7 (0.98)	9.3 (1.50)
(j) RCPM	31.0 (2.78)	29.2 (3.54)	29.7 (2.49)	31.2 (2.37)	32.8 (1.78)	31.9 (1.95)
(k) % SCTAW	56.5 (13.07)	43.0 (9.39)	50.9 (11.53)	59.0 (8.43)	65.6 (10.76)	64.3 (13.24)
(l) RCFT Copy	23.3 (9.07)	13.5 (7.45)	18.0 (7.44)	26.3 (6.58)	29.5 (5.54)	29.2 (6.30)
(m) RCFT Immed	14.3 (8.16)	7.2 (5.43)	9.7 (6.91)	16.3 (7.98)	18.6 (6.72)	20.3 (5.35)
(n) RCFT Delay	14.6 (7.57)	8.1 (4.99)	11.3 (6.22)	15.8 (8.11)	18.6 (5.99)	20.5 (4.58)
(o) $n = 10$ R. NW	3.2 (1.37)	2.2 (1.21)	3.6 (0.81)	3.5 (1.20)	3.3 (1.59)	3.0 (1.63)
(p) $n = 10$ Rep. NW	4.1 (1.22)	3.1 (1.50)	4.3 (0.91)	4.6 (0.70)	4.3 (0.88)	4.1 (1.86)

apart from Grade-2, i.e., the scores of the younger children were greater than those of the older ones.

(j) *RCPM (Raven's Coloured Progressive Matrices)*, $F(4, 426) = 29.00$, $\text{Mse} = 7.30$, $p < 0.0001$. Post hoc analyses showed that the performance of Grade-2 was significantly poorer than that of Grade-3 ($p < .0001$), Grade-4 ($p < .0001$), Grade-5 ($p < .0001$) and Grade-6 ($p < .0001$). Similarly, the performance of Grade-3 was significantly poorer than that of Grade-4 (though not significant, $p > 1$), Grade-5 ($p < .017$) and Grade-6 ($p < .001$). The performance of Grade-4 was poorer than that of Grade-5 (though not significant, $p > 1$), and Grade-6 ($p < .03$). On the whole there was a linear relationship between the performance on RCPM and age: performance was better with age.

(k) *SCTAW (the Standardised Test of Abstract Words)*, $F(4, 426) = 110.48$, $\text{MSe} = 123.65$, $p < 0.0001$. Post hoc analyses revealed that the performance of Grade-2 was significantly poorer than that of the rest of the Grades, 3, 4, 5, and 6 (all at $p < .0001$). Similarly the performance of Grade-3 was significantly poorer than that of Grade-4 ($p < 0.04$), Grade-5 ($p < .0001$) and Grade-6 ($p < .0001$). Grade-4 performed worse than Grade-5 and Grade-6 (both at $p < .0001$), and

Grade-6 performed better than Grade-5 ($p < .0001$). The results thus clearly showed a linear increase in SCTAW performance scores with age.

(l) *Rey–Osterrieth Complex Figure Test—Copy Drawing*, $F(4, 426) = 57.47$, MSe = 46.61, $p < 0.0001$. Post hoc analyses showed that the performance of Grade-2 was significantly poorer than that of the rest of the Grades, 3, 4, 5 and 6 (all at $p < .0001$). Similarly, Grade-3 performed worse than Grade-4 ($p < .001$) and Grade-5 and 6 (both at $p < .0001$). However, Grade-4 performed no worse than Grade-5 ($p > 1$), but worse than Grade-6 ($p < .006$). There was no difference in the performance between Grade-5 and 6 ($p > 1$). Children's performance on copy drawing got better with age until Grade-4, and then the performance levelled off at Grade-5 and 6.

(m) *Rey–Osterrieth Complex Figure Test—Immediate Recall*, $F(4, 426) = 43.76$, MSe = 53.77, $p < 0.0001$. Post hoc analyses revealed that the performance of Grade-2 was significantly poorer than that of the rest of the Grades, 3 ($p < .009$), 4, 5 and 6 (all at $p < .0001$). However, Grade-3 performed no worse than Grade-4 ($p > 1$) and 5 ($p > 1$), but worse than Grade-6 ($p < .0001$). The difference between Grade-4 and 5 was not significant ($p > 1$), but the difference between Grade-4 and 6 was ($p < .0001$). Grade-5 performed significantly poorer than Grade-6 ($p < .0001$). The results thus showed that Grade-6 performed better than the rest of the grades, and that there was no significant difference between Grades 3, 4 and 5 in this immediate recall task. Thus there was a sudden increase in the children's ability to perform this task when they were in Grade-6 (the oldest in this cohort).

(n) *Rey–Osterrieth Complex Figure Test—Delayed Recall*, $F(4, 426) = 53.68$, MSe = 49.72, $p < .0001$. Post-hoc analyses revealed that the performance of Grade-2 was significantly poorer than that of the rest of the Grades, 3, 4, 5 and 6 (all at $p < .0001$). Grade-3 performed no worse than Grade-4 ($p > 1$) but worse than Grade-5 ($p < .014$) and 6 ($p < .0001$). Grade-4 performed no worse than Grade-5 ($p > 1$) but worse than Grade-6 ($p < .0001$). Grade-5 performed significantly worse than Grade-6 ($p < .0001$). Thus, Grade-6 was the best performer in this task. There was no difference between Grade-3 and 4, and similarly Grade-4 and 5.

(o) *Nonword Reading (in Hiragana)*, $F(4, 426) = 5.08$, MSe = 1.29, $p < .001$. Post hoc analyses revealed that Grade-2 performed no worse than Grade-3 ($p > 1$) and Grade-4 ($p > 1$), but significantly worse than Grade-5 ($p < .002$) and Grade-6 ($p < .001$). No other comparisons were significant. The results clearly indicate nonword reading in Hiragana was an easy task for these children. The only significant difference relating to age or maturation was seen in the differences shown between young children (Grade-2) and older children (Grade-5 and 6).

(p) *Nonword Repetition*, $F(4, 426) = 5.84$, MSe = .673, $p < .0001$. Post hoc analyses revealed that Grade-2 performed similarly to Grade-3 ($p > 1$), but significantly worse than Grade-4 ($p < .012$), Grade-5 ($p < .0001$) and Grade-6 ($p < .002$). Otherwise there was no difference between any other Grades.

RWD group

For the RWD group, the following 12 tests—(e), (f), (g), (h), (i), (j), (k), (l), (m), (n), (o) and (p)—showed significant age difference:

(e) *Reading Kanji Words*, $F(4, 59) = 3.76$, MSe = 11.33, $p < .009$. Post hoc Bonferroni multiple comparisons revealed that the performance of Grade-2 was poorer than that of Grade-3 ($p < .039$) and Grade-4 ($p < .016$). Otherwise no other means comparisons were significant ($p > 1$).

(f) *Writing Hiragana Words*, $F(4, 59) = 4.93$, MSe = 1.57, $p < .002$. Post hoc analyses revealed that the performance of Grade-2 was poorer than that of Grade-3 ($p < .017$), Grade-4 ($p < .011$), Grade-5 (though only approaching significant, $p = 0.57$), and Grade-6 ($p < .004$).

(g) *Writing Katakana Words*, $F(4, 59) = 3.45$, MSe = 31.67, $p < .013$. Post hoc analyses showed that although the performance of Grade-2 was poorer than that of the rest of the grades, the only significant difference was observed between Grade-2 and Grade-5 ($0 < .013$) who was the best performer for this test.

(h) *Writing Kanji Words*, $F(4, 59) = 7.32$, MSe = 21.19, $p < .0001$. Post hoc analyses showed that the only significant difference was observed between Grade-2 and Grade-3 ($p < .003$), who scored the highest on this test.

(i) *Arithmetic*, $F(4, 59) = 3.33$, MSe = 2.35, $p < .016$. Post hoc analyses revealed that the performance of Grade-2 was poorer than that of Grade-3 ($p < .044$), Grade-4 (though only approaching significance, $p = .056$), Grade-5 (though statistically not significant $p > 1$) and Grade-6 (though only approaching significance, $p = .0.58$). Any other comparisons were not statistically significant ($p > 1$).

(j) *RCPM*, $F(4, 59) = 4.45$, MSe = 6.35, $p < .003$. Post hoc analyses revealed that there was no difference between Grade-2 and Grade-3, Grade-4 or Grade-6 (all at $p > 1$), however the performance of Grade-2 was significantly poorer than that of Grade-5 ($p < .004$). No other comparisons showed significance.

(k) *SCTAW*, $F(4, 59) = 10.58$, MSe = 10.88, $p < .0001$. Post hoc analyses showed that there was no difference between Grade-2 and Grade-3 ($p > 1$), but the performance of Grade-2 was poorer than that of Grade-4 ($p < .001$), Grade-5 ($p < .0001$) and Grade-6 ($p < .0001$). There was no difference between Grade-3 and Grade-4 ($p > 1$), but the performance of Grade-3 was poorer than that of Grade-5 ($p < .006$) and Grade-6 (though only approaching significance, $p = 0.09$). No other comparisons were significant.

(l) *Copying*, $F(4, 59) = 14.41$, MSe = 44.42, $p < .0001$. Post-hoc analyses showed that the performance of Grade-2 was poorer than that of Grade-3 (though not significant, $p > 1$), Grade-4 ($p < .0001$), Grade-5 ($p < .0001$), and Grade-6 ($p < .0001$). Similarly, the performance of Grade-3 was significantly poorer than that of Grade-4 ($p < .018$), Grade-5 ($p < .0001$) and Grade-6 ($p < .009$). However, no significant difference was found amongst Grade-4, 5 and 6.

(m) *Immediate Recall*, $F(4, 59) = 8.05$, MSe = 44.43, $p < .0001$. Multiple comparisons revealed that there was no difference between Grade-2 and Grade-3, however, the performance of Grade-2 was significantly poorer than that of Grade-4 ($p < .005$), Grade-5 ($p < .0001$), and Grade-6 ($p < .001$). Similarly, no significant difference was found between Grade-3 and Grade-4, however, the performance of Grade-3 was poorer than that of Grade-5 ($p < .017$), and Grade-6 ($p < .021$). There was no significant difference between, Grade-4, 5 and 6, indicating the performance levelled off at Grade-4.

(n) *Delayed Recall*, $F(4.\ 59) = 7.16$, MSe = 41.24, $p < .0001$. Post hoc analyses showed a very similar performance pattern to that of Immediate Recall: there was no difference between Grade-2 and Grade-3 ($p > 1$), however, the performance of Grade-2 was significantly poorer than that of Grade-4 ($p < .017$), Grade-5 ($p < .001$), and Grade-6 ($p < .001$). Similarly, no significant difference was found between Grade-3 and Grade-4 ($p > 1$), however, the performance of Grade-3 was poorer than that of Grade-5 (though only approaching significance, $p = .057$), and Grade-6 ($p < .042$). There was no significant difference between, Grade-4, 5 and 6, again indicating that the performance levelled off at Grade-4.

(o) *Nonword Reading*, $F(4, 59) = 2.7$, MSe = 1.70, $p < .039$. Post hoc analyses revealed that on average Grade-2 showed lower scores than Grade-3 ($p = .073$), Grade-4 ($p = .062$), Grade-5 ($p > 1$) and Grade-6 ($p > 1$), none of the differences were significant. Also no other significant differences were found in the a-priori means comparison tests between other grades.

(p) *Nonword Repetition*, $F(4, 59) = 3.74$, MSe = 1.27, $p < .009$. Post hoc analyses showed that the performance of Grade-2 was poorer than the other grades, but the only significant difference was found between Grade-2 and Grade-4 ($p < .004$), and the difference between Grade-2 and Grade-5 was only approaching significance ($p = .073$).

Discussion

The results of ANOVA for the normal and RWD groups are summarised separately below and each summary is followed by a discussion:

Normal group

For the normal group, the findings can be summarised as follows: (*1*) *age had a linear relationship with children's performance*—the older the age (i.e., higher the grade) the better the children performed on (j) RCPM (Raven's Coloured Progressive Matrices), (k) SCTAW—comprehension of abstract words, and (l) Copy Drawing; (*2*) *age had a greater impact on younger as well as oldest children's performance but not in the middle grade children's performance* on—(m) Immediate Recall—children's performance improved with age until Grade-4, and then the performance levelled off at Grade-4 and 5, and improved again at Grade-6, and (n) Delayed Recall—children's performance in general got better with age, but there was no difference between Grade-3 and 4, and similarly Grade-4 and 5, *(3) age had an impact only when younger children were compared with older children on performance* on (o) Nonword Reading—the only difference was seen between the group of younger children (Grade-2, 3 and 4) and that of the older children (Grade-5 and 6), and (p) Nonword Repetition—again the only difference was observed between younger children (Grade-2 and 3) and older children (Grades 4, 5, and 6); and *(4) age had an inverse relationship with children's performance* on (h)—Kanji Word Reading—the younger children (apart from Grade-2) scored higher than the older children.

In general, the current results from the normal group clearly demonstrated that maturation contributed to better performance on these tests. Some results showed a linear relationship between the age and performance level. For example, as children grew older, the size of their vocabulary for abstract words (SCTAW) and their IQ (RCPM) increased linearly. It was also witnessed that there was a sudden increase in the performance of Grade-6, the oldest children in this cohort (Immediate and Delayed Recall Tasks). In contrast, other results showed a significant difference between the younger and older children (e.g., Grade-2 and 3 versus Grade-4, 5 and 6 or Grade-2, 3, and 4 versus Grade-5 and 6). The data thus indicated that the cognitive skills necessary to perform these tests (at least above 5 out of 16 tests) developed with age and sometimes levelled off in the older children.

There was however one exception to this—for Kanji word reading, counter-intuitively the age had an inverse relationship with children's performance. This inverse relationship could be explained by the increase in the degree of complexity, both in terms of visual and phonological complexity of the Kanji characters that the children learned as they grew older. The Japanese children at primary schools initially learn simple Kanji characters especially at Grade-1, and at subsequent higher grades, they learn more complicated Kanji characters (e.g., greater number of strokes in a character, more complicated configuration of a character, different ways of pronouncing the same character (i.e., in ON-reading of Chinese origin or KUN-reading of Japanese origin). The current Grade-2 and Grade-3 children were tested on the Kanji characters that they had learned at Grade-1. Otherwise the children were tested on the Kanji characters that they had learned 24 months previously. Therefore, the Kanji reading performance might be reflecting the degree of difficulty in learning those Kanji word stimuli used in the study as the children became older.

RWD group

For the RWD group, the data can be summarised as follows: (i) compared to the normal readers, *a weaker linear relationship between the performance level and maturation* was seen in (m) Immediate Recall (Rey's Complex Figure), (n) Delayed Recall, and even a weaker trend was seen in (k) SCTAW, (j) RCPM, and (l) Copying; (ii) often *the performance of Grade-2 was poorer than that of the other higher grades*, but within the higher grades (Grade-3, 4, 5, or 6), there was no significant difference between their performance [e.g., (e) Reading Kanji Words, (g) Writing Hiragana words, (i) Arithmetic, and (p) Nonword Repetition] and (iii) compared to the normal readers, *a weaker inverse relationship* with maturation and the performance level was found for (h) Kanji word writing (apart from Grade-2).

On the whole, the data from the RWD group revealed that maturation had a smaller impact on the performance of these tests compared to the normal readers. This might imply that the cognitive development of the children in the RWD group might not be following a normal course of development. A visual inspection of the total scores of the normal group (see Table 5) and the RWD group (see Table 6) for all the tests revealed that there was no apparent difference between the two groups on their IQ—(j) RCPM, Reading Hiragana and Katakana Single Characters as well

Table 5 Results of multiple regression analyses for the *Normal Readers*—(e) reading Kanji words as a dependent variables

	R^2	($p < .05$)
TOTAL ($N = 431$)		
(k) SCTAW	0.23	
(g) W.Kata.Word	0.33	
(h) W.Kanji.Word	0.37	
(b) R.Kata.1CHR	0.39	
(f).W.Hira.Word	0.41	
(i) Arithmetic	0.42	
(c) R.Hira.Word	0.43	
GRADE-2 ($N = 88$)		
(h) W.Kanji.Word	0.22	
(b) R.Kata.1CHR	0.31	
(k) SCTAW	0.36	
(m) RCFT Immed	0.41	
GRADE-3 ($N = 47$)		
(k) SCTAW	0.38	
GRADE-4 ($N = 100$)		
(k) SCTAW	0.16	
(b) R.Kata.1CHR	0.22	
(c) R.Hira.Word	0.27	
(h) W.Kanji.Word	0.31	
GRADE-5 ($N = 91$)		
(k) SCTAW	0.17	
(h) W.Kanji.Word	0.25	
GRADE-6 ($N = 105$)		
(h) W.Kanji.Word	0.23	
(o) R. NW	0.30	
(9) Rep. NW	0.35	
(m) R.Hira.Word	0.39	

as Words, i.e., (a), (b), (c) and (d), respectively, (f) Writing Hiragana Words, and (p) Nonword Repetition.

It was particularly interesting to note that there was no statistically significant IQ difference between the normal readers and the children in the RWD group, as the most commonly accepted definition of developmental dyslexia often states that dyslexic children's unexpected reading problems cannot be attributed to low intelligence, and often these children have normal IQ (Ellis, 1993; Snowling, 1987, 2000).

It was also shown that on the rest of the tests the normal group performed better than the RWD group including (k) SCTAW—comprehension of abstract words (i) Arithmetic, (m) Immediate Recall, and (n) Delayed Recall. Dyslexia research in English revealed that short-term memory is often impaired in dyslexics, and Rack (1994) even argued that short-term memory deficit is one of the most reliable characteristics of dyslexia. The current data also indicated this. Further, some studies in English revealed that some dyslexic children also have problems with arithmetic

Table 6 Results of multiple regression analyses for the *Normal Readers*—(h) writing Kanji words as a dependent variables

	R^2	($p < .05$)
TOTAL ($N = 431$)		
(g) W.Kata.Word	0.08	
(e) R.Kanji.Word	0.11	
(k) SCTAW	0.14	
(m) RCFT Immed	0.16	
(f).W.Hira.Word	0.17	
(d) R.Kata.Word	0.18	
GRADE-2 ($N = 88$)		
(g) W.Kata.Word	0.37	
(e) R.Kanji.Word	0.43	
GRADE-3 ($N = 47$)		
(g) W.Kata.Word	0.13	
GRADE-4 ($N = 100$)		
(e) R.Kanji.Word	0.11	
GRADE-5 ($N = 91$)		
(g) W.Kana.Word	0.22	
(e) R.Kanji.Word	0.29	
(b) R.Kata.1CHR	0.33	
(f) W.Hira.Word	0.36	
GRADE-6 ($N = 105$)		
(e) R.Kanji.Word	0.22	
(b) R.Kata.1CHR	0.29	
(i) Arithmetic	0.34	
(g) W.Kata.Word	0.37	
(k) SCTAW	0.40	

(e.g., Lewis, Hitch, & Walker, 1994). It was assumed that those children with concurrent dyslexia and dyscalculia (arithmetic difficulty) might have some central cognitive deficit(s) such as a working memory deficit, which might affect both reading/writing and arithmetic abilities. The current data appear to lend support to this conjecture.

Relationships between reading/writing and other cognitive tests

Results

In order to ascertain which tests are more closely related to reading or writing performance, a series of multiple regression analyses were conducted on the data from the normal and the RWD groups separately.

Normal group

Table 5 shows the results of step-wise regression analyses indicating the contributing variables (tests) and their R^2 values (when p-values were greater than

$p < .05$) to explain the scores of (e) Reading Kanji Words across different Grades. Table 6 shows the same to explain the scores of (h) Writing Kanji Words across different Grades. Table 7 shows the same for (e) Reading Kanji Words when the data were dichotomized as younger children (Grade-2 and 3, and Grade-2, 3, and 4, respectively) and older children (Grade-4, 5, and 6, and Grade-5 and 6, respectively). Table 8 shows the same for (h) Writing Kanji Words.

Table 7 Results of multiple regression Analyses for the *Normal Readers—Younger versus Older Children*—(e) reading Kanji words as a dependent variable

Grade-2 and 3			Grade-4, 5 and 6		
($N = 135$)	R^2	($p < .05$)	($N = 296$)	R^2	($p < .05$)
(h) W.Kanji.Word	0.29		(h) R.Kanji.Word	0.14	
(k) SCTAW	0.43		(f) W.Hira.Word	0.19	
(b) R.Kata.1CHR	0.46		(k) SCTAW	0.22	
(f) W.Hira.Word	0.49		(c) R.Hira.Word	0.23	
(n) RCFT Immed	0.50				
Grade-2, 3 and 4			Grade-5 and 6		
($N = 235$)	R^2	($p < .05$)	($N = 196$)	R^2	($p < .05$)
(k) SCTAW	0.29		(k) SCTAW	0.13	
(g) W.Kata.Word	0.41		(g) W.Kata.Word	0.23	
(b) R.Kata.1CHR	0.45		(h) W.Kanji.Word	0.26	
(j) RCPM	0.48		(f) W.Hira.Word	0.27	
(h) W.Kanji.Word	0.49				
(f) W.Hira.Word	0.50				
(j) Arithmetic	0.51				

Table 8 Results of multiple regression analyses for the *Normal Readers—Younger versus Older Children*—(h) writing Kanji words as a dependent variable

Grade-2 and 3			Grade-4, 5 and 6		
($N = 135$)	R^2	($p < .05$)	($N = 296$)	R^2	($p < .05$)
(h) W.Kata.Word	0.41		(h) R.Kanji.Word	0.14	
(k) R.Kanji.Word	0.50		(g) W.Kata.Word	0.18	
(b) RCFT Copy	0.52		(i) Arithmetic	0.19	
			(d) R.Kata.Word	0.20	
			(f) W.Hira.Word	0.21	
Grade-2, 3 and 4			Grade-5 and 6		
($N = 235$)	R^2	($p < .05$)	($N = 196$)	R^2	($p < .05$)
(g) W.Kata.Word	0.21		(g) W.Kata.Word	0.15	
(e) R.Kanji.Word	0.24		(e) R.Kanji.Word	0.21	
			(o) R. NW	0.22	

RWD group

As with the normal readers, Table 9 shows the results of step-wise regression analyses illustrating the contributing variables (tests) and their R^2 values (with p-values greater than $p < .05$) to account for the scores of (e) Reading Kanji Words across different Grades. Table 10 shows the same to explain the scores of (h) Writing Kanji Words across different Grades. Table 11 shows the same for (e)

Table 9 Results of multiple regression analyses for the *RWD Group*—(e) reading Kanji words as a dependent variables

	R^2	(p < .05)
TOTAL (N = 64)		
(b) R.Kata.1CHR	0.20	
(i) Arithmetic	0.26	
GRADE-2 (N = 13)		
None		
GRADE-3 (N = 11)		
None		
GRADE-4 (N = 18)		
(d) R.Kata.Word	0.24	
GRADE-5 (N = 15)		
None		
GRADE-6 (N = 7)		
(i) Arithmetic	0.66	

Table 10 Results of multiple regression analyses for the *RWD Group*—(h) writing Kanji words as a dependent variables

	R^2	(p < .05)
TOTAL (N = 64)		
(b) R.Kata.1CHR	0.09	
(k) SCTAW	0.21	
GRADE-2 (N = 13)		
(g) W.Kata.Word	0.61	
(d) R.Kata.Word	0.76	
(j) RCPM	0.86	
(p) Rep. NW	0.93	
GRADE-3 (N = 11)		
(j) RCPM	0.46	
(n) RCFT Delay	0.71	
GRADE-4 (N = 18)		
None		
GRADE-5 (N = 15)		
None		
GRADE-6 (N = 7)		
None		

Table 11 Results of multiple regression analyses for the *RWD Group—Younger versus Older Children—* (e) reading Kanji words as a dependent variable

Grade-2 and 3			Grade-4, 5 and 6		
($N = 24$)	R^2	($p < .05$)	($N = 40$)	R^2	($p < .05$)
(b) R.Kata.1CHR	0.36		None		
Grade-2, 3 and 4			Grade-5 and 6		
($N = 42$)	R^2	($p < .05$)	($N = 22$)	R^2	($p < .05$)
(b) R.Kata.1CHR	0.37		(j) Arithmetic		0.30
			(f) W.Hira.Word		0.45

Table 12 Results of multiple regression analyses for the *RWD Group—Younger versus Older Children—* (h) writing Kanji words as a dependent variable

Grade-2 and 3			Grade-4, 5 and 6		
($N = 24$)	R^2	($p < .05$)	($N = 40$)	R^2	($p < .05$)
(b) R.Kata.1CHR	0.50		None		
(g) W.Kata.Word	0.68				
(n) RCFT Delay	0.75				
Grade-2, 3 and 4			Grade-5 and 6		
($N = 42$)	R^2	($p < .05$)	($N = 22$)	R^2	($p < .05$)
(g) W.Kata.Word		0.35	None		
(i) Arithmetic		0.43			

Reading Kanji Words when the data were dichotomised as younger children's data (Grade-2 and 3, and Grade-2, 3, and 4, respectively) and older children's data (Grade-4, 5, and 6, and Grade-5 and 6, respectively). Table 12 shows the same for (h) Writing Kanji Words.

Discussion

Normal group

With reading Kanji words as a dependent variable

Kanji reading performance (Table 5) was accounted for between 25% (Grade-5) and 41% (Grade-2), and 43% (total number of children) with different combinations of the variables (tests). Out of these variables, (k) SCTAW—comprehension of abstract words came out as a significant contributing variable for Kanji word reading performance for all the Grades, except for Grade-6. Instead, Grade-6 revealed the two variables, (o) Nonword Reading and (p) Nonword Repetition as significant, which were not seen in other grades. Similarly, all the grades showed (h) Writing Kanji Word as a significant variable, except for Grade-3. For Grade-3, (k) SCTAW was the only variable came out as significant, accounting for 38% of Kanji word reading scores.

When the children were divided into younger and older groups, Kanji word reading performance (see Table 7) accounted for 50% for the former, and 23% for the latter in one classification (Grade-2 and 3 versus Grade-4, 5, and 6), and 51% for the former, and 27% for the latter in the other classification (Grade-2, 3, and 4 versus Grade-5 and 6) with different combinations of the variables. For the first grouping, (h) Writing Kanji words performance accounted for the first 29% for the younger children's and the first 14% for the older children's performance on Kanji word reading. Other variables which were commonly significant for the younger and older children's performance on Kanji word reading were (k) SCTAW, and (g) Writing Katakana words.

For the second grouping, (k) SCTAW accounted for the first 29% for the younger children's, and the first 13% for the older children's performance on Kanji word reading. For the older children in the second grouping, by replacing (c) Reading Hiragana words (in the 1st grouping) by (g) Writing Katakana Words, R^2 was increased by 4%. For the younger children, replacing (n) RCFT Immediate by three other variables, (b) Reading Katakana Single Characters, (j) RCPM, and (f) Writing Hiragana Words, R^2 was increased by 1%.

The results thus demonstrated that vocabulary development seemed to be closely related to performance on reading Kanji words in general—an increase in vocabulary size lead to a better performance on Kanji word reading. This was in accordance with a view that reading is considered to be a secondary linguistic skill (e.g., Mattingley, 1972), and that reading is acquired through spoken language development (e.g., Bowey & Patel, 1988). Similarly, the results showed that reading Kanji words had a strong relationship with writing Kanji words. Snowling (2000) for example argued that "the spoken language system, and the child's awareness of it, influences the acquisition of spelling" in English (p. 75).

Further, the results also revealed that the children in Grade-6 showed a strong link between phonological processing skills and Kanji word reading. Many studies in English have established the strong link between phonological development and the acquisition of literacy—better phonological awareness leads to better literacy skills (e.g., Bradley & Bryant, 1983; Brady, Shankweiler, & Mann, 1983; Gathercole & Baddeley, 1996; Snowling, Goulandris, & Defty, 1998). This was also true with reading in Chinese—another logographic orthography similar to Kanji (e.g., Ho, 2003). Snowling (2000) further argued that "reading plays a reciprocal role in promoting phonological awareness ….. as soon as children start to learn to read, this experience alters the way in which they represent the speech sounds of spoken words" (p. 77). However, this relationship was only seen in the oldest children (Grade-6) in this current cohort. Interestingly, the data from the literate Japanese adults showed that phonological processing also takes place early on along with lexical and semantic processing during Kanji word reading (Sakuma, Sasanuma, Tatsumi, & Masaki, 1998; Wydell et al., 1993). It could therefore mean that the reading system in the Grade-6 children is maturing.

With writing Kanji words as a dependent variable

Kanji writing performance (see Table 6) was accounted for from 11% (Grade-4) to 43% (Grade-2) and 18% (total number of children) with different combinations of the variables (tests). Out of these variables, (g) Writing Katakana Words came out as a significant contributing variable for Kanji word writing performance for all the Grades. This was followed by (e) Reading Kanji Words for all the Grades except for Grade-3, whose Kanji writing performance was solely accounted for, though only by 13%, by the variable (g) Writing Katakana Words.

As with Reading Kanji Words, when the children were divided into younger and older groups, Kanji word writing performance (see Table 8) accounted for 52% for the former, and 21% for the latter in one classification (Grade-2 and 3 versus Grade-4, 5, and 6), and 24% for the former, and 22% for the latter in the other classification (Grade-2, 3, and 4 versus Grade-5 and 6) with different combinations of the variables. The two variables—(g) Writing Katakana Words and (e) Reading Kanji Words came out significant in the first and second groupings. Also, Kanji writing performance in the first grouping especially for the younger children was better accounted for than the second grouping. Compared to Kanji word reading, the performance on Kanji word writing in Grade-3 and 4 (see Table 6) was solely accounted for by single variables—(g) Writing Katakana Words, and (e) Reading Kanji Words, respectively, and the percentage that these variables could explain the performance of Kanji word writing was small—13% and 11%, respectively.

The results thus revealed that in general there was a strong link between Kanji writing and reading, and also that Kanji writing was closely linked to other writing related variables such as Writing Katakana Single Characters/Words, and Writing Hiragana Words. Only Grade-6 showed that the performance of Kanji word writing was related to the variables which were not related to writing, such as arithmetic or comprehension of abstract words. The latter results seemed to suggest that when the children came to Grade-6, cognitive activity such as writing Kanji words became part of general cognitive skills which develop with age.

RWD group

With reading Kanji words as a dependent variable

Possibly due to fewer numbers of children in this group, only few variables came out as significant. Kanji reading performance (see Table 9) accounted for between 0% (Grade-2, 3, and 5) and 66% (Grade-6) and 26% (total number of children) by different variables (tests). The performance of Kanji word reading in Grade-6 was solely accounted for by (i) Arithmetic (66%), while this in Grade-4 was again solely accounted for by (d) Reading Katakana Words (24%).

As with the normal readers, when the children in this group were divided into younger and older groups, Kanji word reading performance (see Table 11) accounted for 36% for the former, and 0% for the latter in one classification (Grade-2 and 3 versus Grade-4, 5, and 6), and 37% for the former, and 45% for the latter in the other classification (Grade-2, 3, and 4 versus Grade-5 and 6) with different combinations of the variables. For the younger children in the first and the second groupings, the performance of Kanji word reading was solely accounted for by the variable, (b) Reading Katakana Single-Character—36% for the former and 37% of the latter groups. In contrast, this was accounted for by none of the variables for the older children in the first group, and by the two variables, (i) Arithmetic and (c) Reading Hiragana Words (45%) in the second group.

The results thus showed a very different pattern to that seen in the normal readers (see Tables 5 and 9). None of the 16 variables (tests) could account for the performance of Kanji word reading for Grade-2, 3 and 5. Again the results might imply that the children in the RWD group were not following the normal course of cognitive development. Yet for Grade-6, arithmetic accounted for as high as 66% of the variance of the performance of Kanji word reading, suggesting a close link between reading and arithmetic skills particularly for the children in this group. This finding further lends support to the claim that dyslexia and dyscalculia (i.e., arithmetic difficulties) can co-occur in some children.

With writing Kanji words as a dependent variable

Kanji writing performance (see Table 10) accounted for between 0% (Grade-4, 5, and 6) and 93% (Grade-2) and 21% (total number of children) with different combinations of the variables (tests). For Grade-2, as high as 93% of the variance of the performance of Kanji writing was accounted for by (g) Writing Katakana Words, (d) Reading Katakana Words, (j) RCPM and (p) Nonword Repetition.

When the children in this group were further divided into younger and older groups, Kanji word reading performance (see Table 12) was accounted for 75% for the former, and 0% for the latter in one classification (Grade-2 and 3 versus Grade-4, 5, and 6), and 43% for the former, and 0% for the latter in the other classification (Grade-2, 3, and 4 versus Grade-5 and 6) with different combinations of the variables. Among the younger children, the common variable which came out as significant for the first and second groupings was (g) Writing Katakana Words.

Similar to the findings with Kanji Word Reading, the results showed a very different pattern to that observed with the normal readers (see Tables 6 and 10). None of the 16 variables (tests) could account for the performance of Kanji Word Writing for the older children (Grade-4, 5 and 6). Further, for Grade-2, the performance of Kanji Word Writing was accounted for as high as 93% by the combination of four tasks—(g) Writing Katakana Word, (d) Reading Katakana Word, (j) RCPM and (p) Nonword Repetition, while none of the tasks could explain the performance of Kanji Word Reading for the same children (0%). The data might thus imply that for these children at least reading and writing require different cognitive skills. The contrast between the normal children and the RWD children was striking, since in general the normal children's data revealed the involvement of common cognitive skills for reading and writing.

General discussion

Kanji versus Kana

One of the major findings that the current study revealed was that reading/writing difficulties in Japanese primarily arose from the Kanji script, and there was a clear dissociation between children's abilities to read/write Kanji and Kana (Hiragana and Katakana). One of the main reasons why only a few children were affected by reading/writing impairments in Kana could be that unlike English or Danish (Elbro et al., 1995; Jensen, 1973), but like German or Italian, the computation of phonology from Kana is so consistent/transparent that reading Kana is a relatively easy task. In English, on the other hand, often complex grapheme-to-phoneme translation including segmentation of the graphemes and blending the phonemes is required (Landerl et al., 1997; Paulesu et al., 2000, 2001; Wydell, 2000, 2003; Wydell & Butterworth, 1999), which makes reading in English more difficult. Even for writing to dictation in Kana because each moraic (syllable like unit) sound exists in the Japanese language has a corresponding Kana character, there is no ambiguity in transcribing a heard word into Kana except for a very limited number of exceptions (see Takebe, 1979 for more details on the Japanese orthography).

Thus for Kana and Kanji combined, the number of Japanese primary school children with reading and writing impairments in the current study was greater than those reported elsewhere (e.g., Kokuritsu Tokushu-Kyoiku Kenkyujyo, 1996; Makita, 1968; Stevenson et al., 1982), but still smaller than those typically reported in English (e.g., Shaywitz et al., 1990; Snowling, 2000), despite the fact that Kanji characters have visually more complex configurations and more inconsistent orthography-to-phonology correspondences than the English alphabet. This may be due to the different learning strategies being employed when learning Kanji, Kana or English. It is reasonable to assume that these learning strategies are constrained by the characteristics of a given orthography. As mentioned earlier, the learning strategy that is widely used and optimal for Kanji is repeated writing (e.g., Kusumi, 1992; Naka & Naoi, 1995) together with simultaneous reciting. Children in Japan are encouraged to write new Kanji characters repeatedly, while reciting them simultaneously, often page after page, until they also acquire almost automatic motor sequences of the character (see Wydell, 2003 for more details).

It is therefore assumed that different reading strategies must be used for Kana and Kanji. For Kana, where the orthography-to-phonology mapping is consistent/transparent, a simple on-line phonological processing (i.e., sublexical analytical reading) strategy may be used during reading (Wydell & Butterworth, 1999). In contrast for Kanji, because the character-to-sound relationship is often one-to-many and opaque, and the correct pronunciation is determined at the whole-word level, Japanese readers use a lexical whole-word reading strategy (e.g., Morton, Sasanuma, Patterson, & Sakuma, 1992; Wydell, 1998; Wydell & Butterworth, 1999; Wydell et al., 1993, 1995; however please also see Fushimi, Ijuin, Patterson, & Tatsumi, 1999 for a small but significant consistency effect in Kanji word reading).

Reading versus writing

Eight percent of the children in this cohort had reading difficulty only, while 8.7% of them had writing difficulty only. This was surprising since it was often assumed that writing is more difficult (i.e., cognitively more demanding) than reading. For example, case studies of Japanese children with reading and writing impairments often showed that writing was more of a problem than reading (e.g., Kaneko et al., 1997, 1998; Uno & Kambayashi, 1998; Uno, Kaga, & Inagaki, 1995).

Another surprising finding was that *only* 3.6% of the children had both reading and writing difficulties. This might imply that reading and writing skills require different cognitive processors. If this were the case, the dissociation between reading and writing abilities/impairments seen in these case studies of the Japanese children could also be explained by the different cognitive processes involved in reading and writing Kanji words. Maybe for these children, only the processors required for writing might have been affected rather than simply because writing is more cognitively demanding than reading (though these two factors interact with each other). However, a close inspection of the data also suggested that writing particularly in Kanji might be cognitively more demanding for all the children participated in the study than any other reading or writing tasks (see Morton & Sasanuma, 1984 for a similar argument for the Japanese adults). For the normal children, the accuracy in Kanji Word Reading Task was 95.5%, while this in Kanji Word Writing tasks was 88.5%. Similarly, for the RWD group children, the former was 81%, while the latter was 59.5%. This attenuates the argument for different cognitive processes involved in reading and writing but lends support for the argument that writing Kanji is more cognitively demanding than reading Kanji.

The question however still remains as to why only a small number children in this cohort who had both reading and writing difficulties in particular Kanji. The current data do not allow us to tease out which cognitive processors might be more involved in Kanji writing than reading.

Gender differences

The study showed that more boys had reading and writing problems than girls across different grades, and across different scripts with the ratios between boys and girls ranging from 1.6:1 (Kanji reading disability) to 7:1 (Katakana writing disability). Similar gender differences in children's reading (and writing) skills are also evident in the studies in English (e.g., Halpern, 1992). However, the gender difference in the prevalence of dyslexia seemed to become less apparent in young adults (e.g., Richardson & Wydell, 2003). More importantly, as discussed earlier in the paper, the gender differences found in the current study have to be interpreted with caution (see Siegel & Smythe, 2005).

Maturation on reading/writing and cognitive tests

It was shown that for the children in the Normal Group, the higher the Grade, the better the test scores became, in particular, on their IQ, their size of vocabulary, and their ability to copy drawing. Also it was found that there was a leap in the level of performance on their immediate and delayed recalls from Grade-3, 4 and 5 where the performance levelled off, to Grade-6. It was also witnessed that the older children when grouped together tended to perform better than the younger children on the nonword reading and nonword repetition tests. There was however one exception to this—there was an inverse relationship between the children's grades and Kanji word reading performance. This was thought to be largely due to the fact that the older children learn more complicated—in terms of visual and phonological processing demands—Kanji characters/words, hence the older children were faced with increasingly more difficult Kanji reading tests.

In the RWD group, however, the relationship between maturation and better performance was attenuated, showing a much weaker trend of this kind on the same tests revealed for the normal group. It was also true that Grade-2 performed consistently poorer than the rest of the grades (where the performance was levelled off) on Kanji word reading, Hiragana word writing, arithmetic and nonword repetition. Further, the inverse relationship between age and performance on kanji word reading was also attenuated in this group. In the RWD group, however, the relationship between maturation and better performance was attenuated compared to the data from the normal group. This in turn suggests that the children in this group might not be developing normally as far as reading/writing and sometimes arithmetic skills are concerned.

Relationships between reading/writing and other tests

A series of regression analyses revealed that for the Kanji Word Reading performance of the normal children in this cohort, the most potent predictor variable was vocabulary size (SCTAW) for all grades except for the oldest children (Grade-6). The Kanji word reading scores for these children were better accounted for by their phonological skills (Nonword Reading and Repetition). This is interesting since the data from the literate Japanese readers also showed a significant phonological effect in Kanji word reading (Sakuma et al., 1998; Wydell et al., 1993). These Japanese adults showed similar homophony effects in Kanji to those found in English (Van Orden, 1987) during semantic category judgements (e.g., the target, "ROWS" was erroneously responded as correct for the category name 'a flower'). Further research needs to be conducted in order to ascertain why phonological skills become important only for older children and adults when reading in Kanji. In contrast in English many studies have shown that phonological skills can predict children's reading skills at a younger age (sometimes even at pre-school age; e.g., Stanovich & Siegel, 1994).

In contrast the Kanji Word Writing scores were in general better explained by other writing related variables (e.g., Writing Katakana Words) and also Reading Kanji Words. However, for the Grade-6 children, the Kanji word writing scores were more related to arithmetic or vocabulary size (SCTAW). This suggests that the skills involved in Kanji word writing develop along with other cognitive skills.

For the RWD group, the analyses revealed a very different picture to that seen in the normal readers. Often none of the variables explained the scores of Reading or Writing Kanji Words. As has been mentioned, this could be largely due to the fact the number of children who fell into this group was much smaller. However, this could also be due to the fact that the children in this group did have problems with Reading and Writing particularly in Kanji, and that they might not be following a normal course of literacy development.

Further, it should also be noted that the interpretation of the data in the RWD group needs some caution, since the difficulties that the children in this group are experiencing are diverse—some only have a reading difficulty in one script, while others have difficulty in many areas. Detailed case studies of these children in the RWD group may shed light into what factors make certain children exceptionally vulnerable to reading and or writing difficulties.

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Appendix 1

Examples of stimuli for Kanji dictation

For grade 2 and 3		For grade 6	
右(right)	男(boy)	束(bunch)	卒業(graduation)
雨(rain)	町(town)	粉(powder)	完全(perfect)
青(blue)	学校(school)	芽(bud)	努力(effort)
赤(red)	先蔟(teacher)	梅(plum)	山脈(mountain range)
空(sky)	出口(exit)	鏡(mirror)	反省(conscience)
左(left)	正月(New year)	種(seed)	風景(landscape)
糸(thread)	火山(volcano)	巣(nest)	健康(health)
耳(ear)	天気(weather)	孫(grandchild)	目標(target)
車(wheel)	夕立(shower)	仲間(group)	歴史(history)
草(grass)	日本(Japan)	機会(opportunity)	散歩(a walk)

Examples of SCTAW pictures

References

Bowey, J. A., & Patel, R. K. (1988). Metalinguistic ability and early reading achievement. *Applied Psycholinguistics, 9*, 367–383.

Bradley, L., & Bryant, P. E. (1983). Categorising sounds and learning to read–a causal connection. *Nature 30*, 419–421.

Brady, S. A., Shankweiler, D., & Mann, V. (1983). Speech perception and memory coding in relation to reading ability. *Journal of Experimental Child Psychology, 35*, 345–367.

Elbro, C., Moller, S., & Nielsen, E. M. (1995). Functional reading difficulties in Denmark. A study of adult reading of common text. *Reading and Writing: An Interdisciplinary Journal, 7*, 257–276.

Ellis, A. W. (1993). *Reading, writing and dyslexia: A cognitive analysis* (2nd ed.). Hove: Lawrence Earbaum Associates.

Flannery, K. A., Liederman, J., Daily, L., & Schultz, J. (2000). Male prevalence for reading disability is found in a large sample of black and white children free from ascertainment bias. *Journal of the International Neuropsychological Society, 6*, 433–442.

Fushimi, T., Ijuin, M., Patterson, K., & Tatsumi, I. (1999). Consistency, frequency, and lexicality effects in naming Japanese Kanji. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 382–407.

Gathercole, S. E. & Baddeley, A. D. (1996). *The children's test of nonword repetition*. London: The Psychological Corporation.

Gibson, E. J. & Levin, H. (1975). *Psychology of reading*. Cambridge, MA: MIT Press.

Halpern, D. (1992). *Sex differences in cognitive abilities*. 2nd ed. Hillsdale, NJ: Erlbaum.

Hirose, T., & Hatta, T. (1985). Reading disabilities in Japan: Evidence against the myth of rarity. *International Journal of Neuroscience, 26*(3–4), 249–252.

Hirose, T., & Hatta, T. (1988). Reading disabilities in modern Japanese children. *Journal of Research in Reading, 11*, 152–160.

Ho, C.S.-K. (2003). Reading acquisition and developmental dyslexia in Chinese: A cognitive perspective. In N. Goulandris (Ed.), *Dyslexia in different languages: Cross-linguistic comparisons*. London: Whurr Publishers.

Ho, C. S.-K., Chan, D. W.-O., Lee, S.-H., Tsang, S.-M., & Luan, V. H. (2004). Cognitive profiling and preliminary subtyping in Chinese developmental dyslexia. *Cognition, 91*, 43–75.

Jensen, A. R. (1973). Spelling errors and the serial-position effect. *Journal of Educational Psychology, 53*, 105–109.

Kaiho, H. (1983). Ningen wa kanji o doo shori shite iruka [How do people process kanji?] In H. Kaiho (Ed.), *"Kanji o kagaku suru"* [*Sciencing Kanji*] (pp. 35–66). Tokyo: Yuhikaku.

Kaneko, M., Uno, A., Kaga, M., Matsuda, H., Inagaki, M., & Haruhara, N. (1997). Developmental dyslexia and dysgraphia—a case report [in Japanese]. *NO TO HATTATSU (Brain and Child Development), 29*, 249–253.

Kaneko, M., Uno, A., Kaga, M., Matsuda, H., Inagaki, M., & Haruhara, N. (1998). Cognitive neuropsychological and regional cerebral blood flow study of a developmentally dyslexic Japanese child. *Journal of Child Neurology Brief Communications, 13*, 9.

Kitao, N. (1984). *Reading ability test TK-1*. Tokyo: Taken Press.

Kokuritsu Tokushu-Kyoiku Sougou Kenkyujyo [Japanese National Research Institute of Special Education] (1996). *Report C-28*: Kyouka-gakushuu-ni tokuina-konnan-wo shimesu jidou-seito-no ruikeika-to shidouhou-no kenkyu [Categorisation of Primary School Children with L.D. and a Study on Remediation Methods].

Kusumi, T. (1992). Meta-memory. In Y. Anzai, S. Ishizaki, Y. Otsu, G. Hatano, & H. Mizoguchi (Eds.), *Handbook of cognitive science*. Tokyo: Kyoritsu Shuppan.

Landerl, K., Wimmer, H., & Frith, U. (1997). The impact of orthographic consistency on dyslexia: A German-English comparison. *Cognition, 63*, 315-334.

Liederman, J., Kantrowitz, L., & Flannery, K. (2005). Male vulnerability to reading disability is not likely to be a myth: A call for new data. *Jorunal of Learning Disabilities, 38*(2), 109–129.

Lewis, C., Hitch, G. J., & Walker, P. (1994). The prevalence of specific arithmetic difficulties and specific reading difficulties in 9- to 10-year-old boys and girls. *Journal of Child Psychology & Psychiatry, 35*, 283–292.

Makita, K. (1968). The rarity of reading disability in Japanese children. *American Journal of Orthopsychiatry, 38*, 5990614.

Mattingley, I. G. (1972). Reading, the linguistic process, and linguistic awareness. In J. F. Kavanagh & I. G. Mattingley (Eds.), *Language by ear and by eye*. Cambridge: MA: MIT Press.

Morton, J., & Sasanuma, S. (1984). Lexical access in Japanese. In L. Henderson (Ed.), *Orthographies and reading: Perspectives from cognitive psychology, neuropsychology and linguistics* (pp. 25–42). London: Lawrence Erlbaum Associates.

Muraishi, S. (1972). Acquisition of reading Japanese syllabic characters in pre-school children in Japan. Paper presented at Twentieth International Congress of Psychology, Tokyo.

Morton, J., Sasanuma, S., Patterson, K., & Sakuma, N. (1992). The organisation of lexicon in Japanese: Single and compound Kanji. *British Journal of Psychology, 83*, 517–531.

Naka, M., & Naoi, H. (1995). The effect of repeated writing on memory. *Journal of Memory and Cognition, 23*(2), 201–212.

Nikolopoulos, D., Goulandris, N., & Snowling, M. J. (2003). Developmental dyslexia in Greek. In N. Goulandris (Ed.), *Dyslexia in different languages: Cross-linguistic comparisons*. London: Whurr Publishers.

Osterrieth, P. A. (1993). The complex figure copy test. *The Clinical Neuropsychologist, 7*(1), 3–21.

Paulesu, E., Demonet, J. F., Fazio, F., McCrory, E., Chanoine, V., Brunswick, N., Cappa, S. F., Cossu, G., Habib, M., Frith C. D., & Frith, U. (2001). Dyslexia—cultural diversity and biological unity. *Science, 291*, 2165–2167.

Paulesu, E., McCrory, E., Fazio, F., Menoncello, L., Brunswick, N., Cappa, S., Cotelli, M., Cossu, G., Corte, F., Lorusso, M., Pesenti, S., Gallagher, A., Perani, D., Price, C., Frith, C., & Frith, U. (2000). A cultural effect on brain function. *Nature Neuroscience, 3*, 91–96.

Rack, J. P. (1994). Dyslexia: the phonological deficit hypothesis. In: Fawcett, A., Nicolson, R. (Eds.), *Dyslexia in Children: Multidisciplinary Perspectives*. London: Harverster Wheatsheaf.

Raven, J. C. (1976). *Coloured progressive matrices: SETS A, A_B, B*. Oxford: OPP.

Richardson, J. T. E., & Wydell, T. N. (2003). The representation and attainment of students with dyslexia in higher-education. *Reading and Writing: An Interdisciplinary Journal, 16*, 475–503.

Sakamoto, T., & Makita, K. (1973). Japan. In: Downing, J. (Ed.), *Comparative Reading*. New York: Macmillan.

Sakuma, N., Sasanuma, S., Tatsumi, I. F., & Masaki, S. (1998). Orthography and phonology in reading Japanese Kanji words: Evidence from the semantic decision task with homophones. *Memory and Cognition, 26*, 75–87.

Sampson, G. (1985). *Writing systems*. Stanford, CA: Stanford University Press.

Shaywitz, S. E., Shaywitz, B. A., Feltcher, J. M., & Escobar, M. D. (1990). Prevalence of reading disability in boys and girls: Results of the Connecticut longitudinal study. *Journal of the American Medical Association, 264*, 998–1002.

Share, D. L., McGee, R., McKenzie, D., Williams, S. M., & Silva, P. A. (1987). Further evidence relating to the distinction between specific reading retardation and general reading backwardness. *British Journal of Developmental Psychology, 5*(1), 35–44.

Siegel, L. S., & Smythe, S. (2005). Reflections on research on reading disability with special attention to general issues. *Journal of Learning Disabilities, 38*, 473–477.

Siok, W. T., Perfetti, C. A., Jin, Z., & Tan, L. H. (2004). Biological abnormality of impaired reading is constrained by culture. *Nature, 431*, 71–76.

Snowling, M. (1987). *Dyslexia: A cognitive developmental perspective*. Oxford: Basic Blackwell.

Snowling, M. (2000). *Dyslexia*. Oxford: Blackwell.

Snowling, M. J., Goulandris, N., & Defty, N. (1998). Developmental and variation in developmental dyslexia. In C. Hulme & R. M. Joshi (Eds.), *Reading and spelling: Development and disorders* (pp. 201–217). Mahwah, NJ: Lawrence Erlbaum Associates.

Stanovich, K. E., & Siegal, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 66*, 24–53.

Stevenson, H. W., Stigler, J. W., Lucker, G. W., Lee, S., In collaboration with Hsu, C., & Kitamura, S. (1982). Reading disabilities: The case of Chinese, Japanese, and English. *Child Development, 53*, 1164–1181.

Takebe, T. (1979). *NIHONGO NO HYOKI* (The Japanese Orthography, in Japanese). Tokyo: Kadokawa.

Treiman, R., Mullenix, J., Bijeljac-Babic, R., & Richmond-Welty, E. D. (1995). The special role of rimes in the description, use and acquisition of English orthography. *Journal of Experimental Psychology: General, 124*, 107–136.

Tzivinikou, S. (2002). *Potential discriminative factors for dyslexia: a predictive statistical model based on the Palvidis Questionnaire distinguishing 9-9 year-old dyslexic and non-dyslexic control Greek children*. Unpublished Doctoral Dissertation, Brunel University, Middlesex, UK.

Uno, A., & Kambayashi, Y. (1998). Learning disabled child showing writing disorders with ADHD: Cognitive neuropsychological investigation about writing disorders. *Child Psychiatry and Neurology, 38*, 117–123 (in Japanese).

Uno, A., Haruhara, N., & Kaneko, M. (2002). *SCTAW–The standardised test of abstract words*. Tokyo: Interna Pub. (picture-word matching test in Japanese).

Uno, A., Haruhara, N., Kaneko, M., & Wydell, T. N. (2006). *STRAW—Shougakusei no Yomikaki Screening Kensa [in Japanese]—Screening test for reading and writing for Japanese primary school children*. Hiroshima, Japan: Saccess Bell Publishers.

Uno, A., Kaga, M., & Inagaki, M. (1995). A specific disorder of Kanji writing observed in a learning-disabled child: Cognitive-psychological and neuropsychological analysis. *No To Hattatsu (Brain and Child Development), 27*, 395–400 (in Japanese).

van der Wissel, A., & Zegers, F. E. (1985). Reading retardation revisited. *British Journal of Developmental Psychology, 3*, 3–9.

Van Orden, G. C. (1987). A ROWS is a ROSE: Spelling, sound and reading. *Memory & Cognition, 15*(3), 181–198.

Vogel, S. A. (1990). Gender differences in intelligence, language, visual-motor abilities, and academic achievement in students with learning disabilities: A review of the literature. *Journal of Learning Disabilities, 23*(1), 44–52.

Wimmer, H., Mayringer, H., & Landerl, K. (2000). The double-deficit hypothesis and difficulties in learning to read a regular orthography. *Journal of Educational Psychology, 92*(4), 668–680.

Wydell, T. N. (1998). What matters in Kanji word naming—consistency, regularity, or ON/KUN-reading difference? *Monograph in Reading and Writing: An Interdisciplinary Journal, 10*, 359–373.

Wydell, T. N. (2000). Advances in understanding cross cultural differences in dyslexia through a bilingual individual with monolingual dyslexia. In F. Columbus (Ed.), *Advances in psychology research* (Vol. 2, pp. 141–162). New York: Nova Science Publishers.

Wydell, T. N. (2003). Dyslexia in Japanese and the 'Hypothesis of Granularity and Transparency'. In A. Goulandris (Ed.), *Dyslexia in different languages: Cross-linguistic comparisons*. London: Whurr Publishers.

Wydell, T. N., & Butterworth, B. L. (1999). A case study of an English-Japanese bilingual with monolingual dyslexia. *Cognition, 70*, 273–305.

Wydell, T. N., Butterworth, B., & Patterson, K. (1995). The inconsistency of consistency effects in reading: The case of Japanese Kanji. *Journal of Experimental Psychology: Learning, Memory & Cognition, 21*(5), 1155–1168.

Wydell, T.N., Patterson, K., & Humphreys, G. W. (1993). Phonologically mediated access to meaning for KANJI: Is a ROWS still a ROSE in Japanese KANJI? *Journal of Experimental Psychology: Learning, Memory and Cognition, 19*, 491–514.