

Asia Pacific Journal of Developmental Differences  
Vol. 8, No.2, July 2021, pp. 270—284  
DOI: 10.3850/S2345734121000124



## Cognitive Information Processing and Environmental Factors in Hiragana Reading/Writing of Down syndrome Children- Compared to typically developing Children

Mariko Maeda<sup>1\*</sup>, Manami Koizumi<sup>1</sup>, Kaori Hosokawa<sup>2</sup> and Michio Kojima<sup>3</sup>

1. Graduate School of Comprehensive Human Sciences, University of Tsukuba
2. Faculty of Education, Chiba University
3. Faculty of Human Sciences, University of Tsukuba

---

### Abstract

*Introduction: Factors related to reading/writing skills of children with DS were investigated by focusing on their cognitive information processing abilities and environmental factors.*

*Methods: Participants were children with DS (N=30), typically developing (TD) children N=59. Hiragana reading/writing tasks and cognitive processing ability tasks were performed. Moreover, a questionnaire was administered to their parents to investigate the children's profiles and environmental factors.*

*Results: Reading/writing scores of children with DS with a mental age (MA) of 4, 5, and 6 years and TD children with a chronological age of 4, 5, and 6 years were compared to identify the types of characteristics in which children with DS score higher than TD children. We showed the difference in environmental factors related to cognitive information processing ability and reading/writing ability of DS and TD children.*

*Conclusion Factors related to reading/writing of children with DS were also shown.*

**Keywords:** Down syndrome, Hiragana, Reading and Writing skill

---

\* Correspondence to:

Mariko Maeda, Graduate School of Comprehensive Human Sciences, University of Tsukuba1, Email: maai.tks@gmail.com

## BACKGROUND

The Japanese writing system includes Hiragana, Katakana, and Kanji (Chinese characters), and sentences are composed of these characters. In elementary school, children usually first learn Hiragana, which is the basic Japanese writing system, and then learn Katakana. Children also start to learn Kanji in elementary school after learning Hiragana and Katakana. Hiragana includes various character types, such as voiceless sounds, voiced/semi-voiced sounds, and special syllables. Voiceless sounds consist of 46 characters, including combinations of five vowels (a, i, u, e, o) and nine consonants, and the syllabic nasal "n" (Fig.1). When pronouncing some of the voiceless sounds by adding a sonant mark or a p-sound mark, they become voiced or semi-voiced sounds. There are 20 voiced sound and 5 semi-voiced sound characters. When writing specific voiceless sounds short, and pronouncing them, or, pronouncing them long, they become special syllables.

There are four types of special syllables; geminate stop consonants, contracted sounds, long vowels, and contracted long vowels. Katakana characters were developed by simplifying specific Shakuji (Kanji used for sound equivalence). Kanji, which originated in China, is the most difficult of the Japanese writing systems. The Kanji teaching procedures are described in the *Gakunenbetsu Kanji Haitōhyō* (list of Kanji by school year) developed by the Japanese Ministry of Education as a part of educational guidelines. This list indicates which Kanji and the number of Kanji that students should learn in each grade. As the grade-level increases, the number and the difficulty of Kanji that students must learn increases. Specific researchers have reported that Hiragana reading and writing skills are acquired before school age.

Many studies related to reading and writing skills have been conducted in recent years in Japan. These studies have indicated that typically developing (TD) children can acquire Hiragana reading and writing skills around the age of 4, and cognitive processing abilities such as phonological awareness, visual cognition, and automatization, among others, are related to the acquisition of these skills (Shimamura, Mikami, 1994; Awaya, Uno, 2003; Uno, 2007; Inomata, Haruhara, 2013).

Hiragana has a regular grapheme-phoneme correspondence, such that one character corresponds to one mora. Therefore, phonological information processing ability, which is related to mora awareness, is involved in Hiragana acquisition (Amano, 1970). Moreover, one mora is represented by two characters in special Hiragana syllables, resulting in acquisition difficulties (Dairoku, 2000). Mitsuzuka (1994) demonstrated that young TD children's writing ability is correlated with figure-copying and spatial cognition task results, suggesting a relationship between writing ability and visual cognitive ability related to form and space perception. Moreover, previous studies on the correlation between reading and writing skills and the home environment have indicated that teaching to write at home affects children's writing skills. Furthermore, the frequency of

reading activities and the frequency of teaching letters affects the reading skills of 3-4-year-old children, but not the reading skills of 5-6-year-old children (Inomata, Uno, Sakai, Haruhara, 2016).

It has been reported in Japan, that cognitive processing abilities including phonological awareness, visual cognition, and manipulation of fingers are required for children with Down syndrome (DS) having intellectual disabilities to acquire Hiragana reading and writing skills, which are also necessary for TD children. Moreover, children with DS need to at least reach the developmental age of four in all these cognitive processing abilities (Kono,2014). Most of the past studies have been case studies that have attempted to verify the effects of teaching reading and writing skills on children with DS based on the child's conditions. These include, for example, a study that conducted teaching Hiragana reading using a top-down method of starting from word-learning, and gradually shifting to one-character learning; a study that used keywords as the intermediary for reading characters; and a study that taught writing by focusing on visual cognition (Kuboyama et al.,2008; Nagayama et al.,2010; Yamaguchi, 2006). However, no continuous studies have been conducted on factors related to reading and writing skills of children with Down syndrome in Japan.

The possibility that IQ and reading and writing skills are unrelated has been suggested (Kono, 2015). However, this possibility has been insufficiently investigated to date. Some of these studies have investigated children with intellectual disabilities and those with developmental disorders without distinguishing between the two. Other studies have reported findings on children other than those with DS. Furthermore, it is known that factors other than the level of intellectual development, such as the home environment might affect children's reading and writing skills. As described above, factors related to reading and writing skills of children with DS have not been sufficiently examined to date.

On the other hand, programs for teaching reading and writing skills for children and adolescents with DS have been developed overseas, administered, and their effects have been reported (Moni et al., 2000,Paola,2016). One such study examined correlations between reading and writing skills and phonological awareness by comparing TD children and children with DS between the ages of 5 and 18 years (Cossu et al.,1993,Laws et al.,2016, Loveall et al.,2016).

Overseas studies on reading and writing skills of children with DS have been conducted with a wide range of children, from early childhood to school age, and teaching programs have been developed for children in childhood to adolescence. The results of these studies suggest that reading and writing skills of individuals with DS might improve from early childhood to school age and adolescence.

As mentioned above, only a few studies have been conducted in Japan on the eading

and writing skills of children with DS and their characteristics have been insufficiently investigated to date. It is useful to understand the characteristics of children with DS when teaching them reading and writing skills. Therefore, in the present study, children's Hiragana reading and writing skills and their correlations with cognitive processing abilities as well as environmental abilities were examined in young children to high school students with DS by comparisons with TD children. Moreover, correlations with intellectual abilities were examined through comparisons between children with DS with a mental age of 4~6 and TD children.

## **METHODS**

### **Participants**

Participants were children with DS (N=30; 14 boys and 16 girls) and TD children (N=59; 27 boys and 32 girls) that were recruited from parents' associations, special education schools, and nursery schools, among others, in local communities. Requirements for children with DS included those that were interested in Hiragana, could read more than one character, and obtaining the parents' consent.

They comprised of 8 elementary school children, 14 junior high school students, and 8 senior high school students. They were affiliated to special needs classes (N=8) and special education schools (N=22). TD children comprised of 24 four-year-old children, 23 five-year-old children, and 12 six-year-old children. Table 1 shows the mean chronological age (CA) and the mean mental age(MA) of the participants.

### **Survey content**

By referring to previous studies, Hiragana reading and writing tasks and cognitive processing ability tasks were conducted with young children with DS and TD young children. Moreover, a questionnaire was administered to their parents to investigate the children's profiles and environmental factors.

### **Tasks of reading and writing Hiragana**

The tasks of reading and writing 46 voiceless sounds/ syllabic nasals, 20 voiced sounds, and 5 semi-voiced sounds, as well as tasks of reading 23 special syllables including a double consonant, contracted sounds, long vowels, and contracted long vowels were conducted, by referring to the Hiragana reading and writing test (The National Language Research Institute, 1972) used by Shimamura et al. (1994) and Ota et al. (2018). Recently, this test is administered to TD children for examining their Hiragana reading and writing skills development.

**Table 1** Participant characteristics by DS and TD children

		Age group						All	
		4 years		5 years		6 years		DS	TD
		DS	TD	DS	TD	DS	TD		
		N=8	N=24	N=12	N=23	N=10	N=12	N=30	N=59
CA	<b>Range</b> years: to months	8:04 to 16:02	4:00 to 4:11	8:06 to 15:08	5:00- to 5:11	11:02 to 16:11	6:00 to 6:07	8:04 to 16:11	4:00 to 6:07
	<b>Mean</b> years: months	11:07	4:04	12:08	5:04	14:09	6:01	13:01	5:01
	<b>SD</b> months	37.82	3.55	23.09	3.82	21.90	2.10	29.99	8.79
MA	<b>Range</b> years: to months	4:00 to 4:11	4:00 to 4:11	5:01 to 5:10	5:00 to 5:11	6:00 to 6:08	6:00 to 6:07	4:00 to 6:08	4:00 to 6:07
	<b>Mean</b> years: months	4:05	4:04	5:05	5:04	6:04	6:01	5:05	5:01
	<b>SD</b> months	3.90	3.55	3.20	3.82	2.68	2.10	9.36	8.79

**Tasks related to cognitive processing abilities**

Phonological awareness tasks consisted of mora segmentation of normal syllables, long vowels, and geminate stop consonants, as well as non-word repetition tasks of 4-5 mora words. Visual cognition tasks included line-drawing tasks, spatial cognition tasks, and figure copying tasks.

In the case of phonological tasks, practice exercises of 2-3-mora words were conducted twice before the main task in the following order based on Kakihana et al. (2009): normal syllables, long vowels, and geminate stop consonants. Moreover, for non-word repetition tasks, a practice exercise of three-mora words was conducted before the main

task in the following order: four-mora words and five-mora words also by referring to Kakihana et al. (2009). The above tasks were selected because they were used in a previous study to examine 3-4-year-old children's reading skills.

Line-drawing tasks of drawing straight lines with different thickness, C-curves, inverted C-curves, and wavy lines were conducted as visual cognition tasks by referring to Gunji et al. (2015). Correlations between these tasks in the Frostig Developmental Test of Visual Perception for assessing visual perception skills, and writing skills, have been reported.

Moreover, the participants were requested to conduct a spatial cognition task of reproducing two types of sample patterns by connecting nine dots consisting of 3 rows X 3 rows by drawing lines. Furthermore, the participants conducted a figure copying task of copying a triangle.

### **Questionnaire on basic attributes of children and life environment related to reading and writing skills:**

The question items in the questionnaire on the living environment were developed based on the children's basic attributes (age, affiliation, the presence of complications, among others) by referring to Hamano et al. (2012). The parents of the participants responded to the questions. The content of the question items included the following: past and present conditions of teaching reading/writing and the frequency of reading/writing activities in kindergartens, nursery schools, and schools, opportunities of contact with the characters and the frequency of reading and writing activities at home, children's interest in the characters, and the frequency of reading and writing activities in the current living environment.

### **Intellectual ability tests**

The Tanaka-Binet Intelligence Scale V (Tanaka Institute for Educational Research, 2005) was administered to children with DS. This is a standardized intelligence test with established reliability and validity for Japanese respondents, which is frequently used to assess the mental age and IQ of children with intellectual disabilities.

### **Procedures**

All the tasks were conducted individually by the first author.

### **Scoring**

Table 2 shows the number of tasks and scoring criteria of Hiragana reading and writing tasks and cognitive information processing ability tasks. Environmental factors were scored based on the responses to the questionnaire by calculating the number of years of being taught reading and writing and conducting reading and writing activities to

**Table 2** The number of tasks, the criteria, and the range of the scores

TASKS		THE NUMBER OF TASKS THE SCORING CRITERIA	SCORE RANGE
Reading & Writing in Hiragana	Reading Task	voiceless sounds 46 characters ◆ <b>1 point per character</b>	1~46
		voiced/ semi-voiced sounds voiced sounds 20 characters & semi-voiced sounds 25 characters ◆ <b>1 point per character</b>	0~25
		special syllables 3 characters and 20 words ◆ <b>1 point per character and word</b>	0~23
	Writing Task	voiceless sounds 46 characters ◆ <b>1 point per character</b>	0~46
		voiced/ semi-voiced sounds voiced sounds 20 characters & semi-voiced sounds 25 characters ◆ <b>1 point per character</b>	0~25
Tasks Related to Cognitive Processing Abilities	Phonological Awareness Tasks	mora segmentation 9 questions ◆ <b>1 point per question</b>	0~9
		non-word repetition tasks of 4 mora words 10 questions ◆ <b>1 point per question</b>	0~10
		non-word repetition tasks of 5 mora words 10 questions ◆ <b>1 point per question</b>	0~10
	Visual Cognition Tasks	line-drawing tasks 8 questions ◆ <b>2 points:</b> A continuous line is drawn between two parallel lines. ◆ <b>1 point:</b> The drawn line touches two parallel lines at one point or more, or the line sticks out from the start or endpoint of the two parallel lines by less than 1.3mm. ◆ <b>0 point:</b> The drawn line sticks out from the space between the parallel lines, or is cut off in the middle, or sticks out from the start or endpoint of the parallel lines by more than 1.3mm, or is shorter than the parallel lines by over 3 mm.	0~8
		spatial cognition tasks 2 questions ◆ <b>1 point:</b> The line is completely identical to the model. ◆ <b>0 point:</b> The line is different from the model.	0~2
		figure copying tasks 1 questions ◆ <b>Tanaka-Binet Intelligence Scale</b> scoring criteria was used.	0~1

date. Moreover, parents were requested to respond to questions using a four-point scale on opportunities that children had of contact with characters, the frequency of reading and writing activities, and the number of books or character learning materials at home. The total scores were calculated and regarded as the reading and writing activity at home score. Parents were also requested to respond to questions using a three-point scale on children's interest in the characters. The total scores were calculated and regarded as the children's interest in the characters scores.

### **Ethical considerations**

This study was conducted after obtaining approval from the ethics committee of the institution in which the author is enrolled. Prior to conducting the survey, consent was obtained from the representatives of parents' associations and school principals. Moreover, written or oral explanations were given to parents in advance about the outline of the study, the time that was required, and ethical considerations, among others. The survey was conducted after obtaining their consent.

### **Methods of Analysis**

Thirty responses were collected for the questionnaire on environmental factors from Children with DS's parents (the response rate=100%). Among them, 3 responses with missing values were excluded, and 27 data-sets were analysed. On the other hand, 50 responses were collected from TD children's parents (the response rate=85%). Among them, 4 responses with missing values were excluded, and 46 data-sets were analysed. Therefore, the number of participants in the analysis of the correlations with environmental factors was as follows. There are 7 children with DS with a MA four-years, 11 children with DS with a MA five-years, and 9 children with DS with a MA six-years. TD children: 17 four-year-old children, 19 five-year-old children, and 10 six-year-old children.

The assumption of a normal distribution was rejected for the character types in analysing the reading and writing task scores of children with DS. Therefore, a nonparametric test was used. First, differences in the scores of each task between children with DS and TD children were examined by classifying children with DS into MA of 4-, 5-, and 6-year-old groups and TD children into CA of 4-, 5-, and 6-year-old groups. The Mann-Whitney U test was conducted on the same age groups for the reading and writing task scores, cognitive processing ability task scores, and environmental factor scores as dependent variables and the presence of disabilities as an independent variable. Next, correlations between reading and writing task scores and cognitive processing ability task scores, as well as environmental factor scores were examined by calculating the Spearman's rank correlation coefficient with reading and writing activity scores, cognitive processing ability task scores, and environmental factor scores of children with DS and TD children as dependent variables.



## RESULT

Comparison of reading and writing task scores, cognitive processing ability task scores, and environmental factors scores between children with DS and TD children

Table 3 shows differences in reading and writing task scores based on the MA and the CA. Significant differences were shown in reading and writing task scores for writing voiceless sounds, reading and writing voiced/semi-voiced sounds, and reading special syllables in the four-year-old group. In the five- and six-year-old groups, significant differences were shown in writing voiceless sounds and voiced/semi-voiced sounds. The mean score of children with DS in each task was higher than TD children. On the other hand, no significant difference was shown in reading voiceless sounds.

Moreover, significant differences in cognitive processing ability task scores were shown in the 4-mora nonword repetition task and 5-mora nonword repetition task between four- and five-year-old groups. In the six-year-old group, a significant difference was shown in the 5-mora nonword repetition task. The mean score of TD children in each task was higher than that of children with DS. On the other hand, no significant differences were shown in the visual information processing ability tasks such as the line drawing task, spatial cognition task, and figure copying task, or in the mora segmentation tasks. Furthermore, there were significant differences in environmental factor scores in the number of years of being taught reading and writing as well as the number of years of reading and writing activities in all the age groups, such that the average number of years of both factors in children with DS was longer than TD children. On the other hand, no significant differences were shown in the reading and writing activity scores at home or the children's interest in the characters.

### Correlations with factors related to reading and writing task scores

Correlations between reading and writing task scores and cognitive processing task scores as well as environmental factor scores of children with DS and TD children, were examined (Table 4).

Regarding the correlation between the reading and writing task and cognitive information processing task, in children with DS, positive correlations were shown between reading and writing all the types of characters and the task of mora segmentation, the task of reading special syllables and line-drawing task, the task of writing voiceless sounds and figure copying task, as well as the task of writing semi-voiced sounds and 5-mora nonword repetition task. In contrast, no correlation was shown with the 4-mora nonword repetition task. In TD children, positive correlations were shown between the tasks of reading and writing all the types of characters and visual information processing ability tasks including the line-drawing task, spatial cognition task, and figure copying task, between the task of reading voiceless sounds and mora segmentation task as well as 4-mora nonword repetition task, and between the tasks of reading voiced/semi-voiced sounds as well as special syllables and 4-mora nonword

**Table 3** The mean scores of the reading and writing tasks, cognitive processing ability tasks, and environmental factor scores in each MA or CA group and the results of the examination.

	DS 4 year (N=8)			TD 4 year (N=24)			DS 5 year (N=12)			TD 5 year (N=23)			DS 6 year (N=10)			TD 6 year (N=12)		
	M	SD	U	M	SD	U	M	SD	U	M	SD	U	M	SD	U	M	SD	U
	voiceless sounds reading task	42.38	7.50		27.88	17.49	5.09	44.00	1.85	41.09	11.31	1.98		45.30	1.05	45.50	1.00	0.40
voiced/semi-voiced sounds reading task	19.63	9.05		8.33	9.77	<b>8.09<sup>*</sup></b>	21.75	3.72	19.13	9.17	0.08		24.60	0.69	23.75	2.59	0.007	
special syllables reading task	12.13	9.17		1.13	3.84	<b>16.21<sup>**</sup></b>	17.50	6.92	11.48	8.71	3.50		21.10	1.66	17.67	7.45	0.750	
voiceless sounds writing task	34.00	14.83		2.17	4.74	<b>16.56<sup>**</sup></b>	43.42	3.17	18.22	17.19	<b>14.23<sup>**</sup></b>		44.40	1.50	30.75	14.88	<b>9.33<sup>**</sup></b>	
voiced/semi-voiced sounds writing task	11.13	9.09		0.25	1.22	<b>21.75<sup>**</sup></b>	16.33	7.15	6.74	8.91	<b>7.26<sup>**</sup></b>		22.40	2.17	12.67	7.49	<b>11.83<sup>**</sup></b>	
mora segmentation	5.50	1.92		6.08	2.08	0.90	6.50	2.11	7.13	1.25	0.47		7.90	1.28	6.62	2.29	2.75	
non-word repetition tasks of 4 mora words	5.50	2.72		8.42	2.06	<b>11.56<sup>*</sup></b>	6.08	2.67	9.26	1.09	<b>13.50<sup>**</sup></b>		7.60	2.50	8.83	1.40	1.41	
non-word repetition tasks of 5 mora words	3.13	3.04		8.83	2.07	<b>14.82<sup>**</sup></b>	4.17	3.09	9.00	1.12	16.88		6.40	2.63	9.17	1.03	<b>9.39<sup>**</sup></b>	
line-drawing tasks	7.13	3.60		4.88	2.86	2.83	8.50	4.01	6.96	2.94	1.75		9.60	2.91	9.08	2.57	0.58	
spatial cognition tasks	1.38	0.91		0.54	0.83	4.85	1.33	0.88	1.35	0.83	0.00		1.80	0.63	1.58	0.79	0.69	
figure copying tasks	0.63	0.51		0.33	0.48	2.05	0.83	0.38	0.78	0.42	0.12		1.00	0.00	0.92	0.28	0.83	
years of being taught reading <sup>‡1</sup>	5.71	3.86		0.41	0.79	<b>16.21<sup>**</sup></b>	7.27	2.68	0.89	1.10	<b>20.34<sup>**</sup></b>		9.22	2.10	0.90	1.19	<b>13.14<sup>**</sup></b>	
years of being taught writing <sup>‡1</sup>	5.14	3.28		0.35	0.70	<b>15.93<sup>**</sup></b>	6.91	2.30	0.53	0.69	<b>21.50<sup>**</sup></b>		8.33	2.64	1.00	0.81	<b>13.01<sup>**</sup></b>	
years of reading activities <sup>‡1</sup>	4.71	4.07		0.47	0.80	<b>11.63<sup>*</sup></b>	7.36	2.69	1.00	1.24	<b>19.65<sup>**</sup></b>		8.22	1.98	1.20	1.31	<b>13.01<sup>**</sup></b>	
years of writing activities <sup>‡1</sup>	4.14	3.43		0.18	0.52	<b>17.37<sup>**</sup></b>	6.91	2.42	0.47	1.07	<b>22.28<sup>**</sup></b>		8.44	2.06	0.80	1.13	<b>13.32<sup>**</sup></b>	
the reading and writing activity at home score <sup>‡1</sup>	19.00	2.82		18.29	2.59	0.54	19.82	3.97	19.63	2.67	0.13		19.33	2.06	17.50	3.59	1.26	
the children's interest in the characters score <sup>‡1</sup>	16.43	2.44		16.53	3.16	0.05	15.91	2.42	17.42	3.45	2.86		14.22	3.15	17.60	2.71	3.87	

\*p<.05, \*\*p<.01, \*\*\*p<.001

‡1: DS: 7 four-year-old children, 11 five-year-old children, and 9 six-year-old children. TD: 17 four-year-old children, 19 five-year-old children, and 10 six-year-old children.

**Table 4** Correlation between the scores of reading and writing tasks and cognitive processing ability tasks as well as environmental factors.

	voiceless sounds reading task		voiced/semi-voiced sounds reading task		special syllables reading task		voiceless sounds writing task		voiced/semi-voiced sounds writing task	
	DS N=30	TD N=59	DS N=30	TD N=59	DS N=30	TD N=59	DS N=30	TD N=59	DS N=30	TD N=59
voiceless sounds reading task										
voiced/semi-voiced sounds reading task	<b>0.57<sup>•</sup></b>	<b>0.88<sup>•••</sup></b>								
special syllables reading task	0.41 <sup>•</sup>	<b>0.74<sup>••</sup></b>	<b>0.47<sup>••</sup></b>	<b>0.87<sup>•••</sup></b>						
voiceless sounds writing task	0.28	<b>0.75<sup>••</sup></b>	0.26	<b>0.77<sup>••</sup></b>	0.39	<b>0.78<sup>••</sup></b>				
voiced/semi-voiced sounds writing task	0.41 <sup>•</sup>	<b>0.67<sup>••</sup></b>	<b>0.52<sup>••</sup></b>	<b>0.77<sup>••</sup></b>	<b>0.51<sup>••</sup></b>	<b>0.81<sup>••</sup></b>	<b>0.59<sup>••</sup></b>	<b>0.89<sup>•••</sup></b>		
mora segmentation	<b>0.50<sup>••</sup></b>	<b>0.33<sup>•</sup></b>	<b>0.58<sup>••</sup></b>	0.31 <sup>•</sup>	<b>0.72<sup>••</sup></b>	0.33 <sup>•</sup>	<b>0.50<sup>••</sup></b>	0.24	<b>0.66<sup>••</sup></b>	0.24
non-word repetition tasks of 4 mora words	0.24	<b>0.39<sup>•</sup></b>	0.14	<b>0.34<sup>•</sup></b>	0.11	<b>0.37<sup>•</sup></b>	-0.03	0.31 <sup>•</sup>	0.31	0.30
non-word repetition tasks of 5 mora words	0.17	0.23	0.19	0.16	0.28	0.17	0.01	0.22	<b>0.47<sup>••</sup></b>	0.16
line-drawing tasks	0.32	<b>0.34<sup>•</sup></b>	0.14	<b>0.43<sup>••</sup></b>	<b>0.61<sup>••</sup></b>	<b>0.52<sup>••</sup></b>	0.44 <sup>•</sup>	<b>0.58<sup>••</sup></b>	0.34	<b>0.54<sup>••</sup></b>
spatial cognition tasks	0.28	<b>0.50<sup>••</sup></b>	0.14	<b>0.55<sup>••</sup></b>	0.34	<b>0.61<sup>••</sup></b>	0.41 <sup>•</sup>	<b>0.58<sup>••</sup></b>	0.29	<b>0.55<sup>••</sup></b>
figure copying tasks	0.25	<b>0.47<sup>••</sup></b>	0.27	<b>0.45<sup>••</sup></b>	0.22	<b>0.57<sup>••</sup></b>	<b>0.48<sup>••</sup></b>	<b>0.58<sup>••</sup></b>	0.39	<b>0.47<sup>••</sup></b>
years of being taught reading <sup>※1</sup>	0.16	0.13	0.36	-0.02	<b>0.73<sup>••</sup></b>	-0.03	0.27	0.06	0.44	0.03
years of being taught writing <sup>※1</sup>	0.21	0.03	0.47	0.01	<b>0.73<sup>••</sup></b>	-0.04	0.25	0.11	0.40	0.06
years of reading activities <sup>※1</sup>	0.08	0.21	0.35	0.07	<b>0.73<sup>••</sup></b>	0.01	0.24	0.25	0.38	0.17
years of writing activities <sup>※1</sup>	0.07	0.07	0.31	0.09	<b>0.68<sup>••</sup></b>	0.05	0.17	0.24	0.35	0.21
the reading and writing activity at home score <sup>※1</sup>	-0.18	0.33 <sup>•</sup>	-0.11	0.19	-0.22	0.17	0.06	0.14	-0.09	0.02
the children's interest in the characters score <sup>※1</sup>	0.11	0.03	0.03	0.08	0.005	0.15	0.10	0.11	-0.07	0.03
MA	0.34	-	0.45 <sup>•</sup>	-	0.41 <sup>•</sup>	-	0.43 <sup>•</sup>	-	<b>0.67<sup>••</sup></b>	-
CA	0.25	<b>0.57<sup>••</sup></b>	0.41 <sup>•</sup>	<b>0.59<sup>••</sup></b>	<b>0.68<sup>••</sup></b>	<b>0.66<sup>••</sup></b>	0.27	<b>0.68<sup>••</sup></b>	<b>0.47<sup>••</sup></b>	<b>0.65<sup>••</sup></b>

<sup>•</sup>p<.05, <sup>••</sup>p<.01, <sup>•••</sup>p<.001

※1:DS:27 children, TD:46 children

repetition task, whereas no correlation was shown with the 5-mora nonword repetition task.

Regarding correlations between reading and writing tasks and environmental factor scores, in children with DS, positive correlations were shown between the task of reading special syllables and the number of years of teaching reading and writing as well as the number of years of experiencing reading and writing activities, whereas no correlations were shown with other reading and writing tasks. In TD children, there were no correlations between reading and writing tasks and environmental factor scores.

As for correlations between reading and writing tasks and MA as well as CA, in children with DS, positive correlations were shown between the task of reading special syllables and CA and between the task of writing voiced/semi-voiced sounds and MA as well as CA. In TD children, a positive correlation was shown between the tasks of reading and writing all the types of characters and CA.

## DISCUSSION

Comparison of reading and writing task scores, cognitive processing ability task scores, and environmental factors scores between children with DS and TD children Utashiro et al. (2015) indicated that the reading ability of children with intellectual and developmental disabilities with a MA of four years was higher than TD children with a CA of four years. The same result was indicated in the present study on children with DS with a MA of four years. Moreover, the result of no difference in the single character reading task score between five- or six-year-old children with DS and TD children was consistent with Utashiro et al. (2015). It has been indicated that four-year-old TD children become able to read about half the voiceless sounds and syllabic nasals (Shimamura et al., 1994). The present study indicated the reading ability of Children with DS with a MA of 4 years was higher than TD children. Moreover, the writing ability of children with DS was higher than TD children of all age groups (4-, 5-, and 6-year-old groups), suggesting that writing ability might be affected by life experience. It was suggested that children with DS might be able to acquire reading and writing abilities that are higher than their MA level, assumed based on TD children, as a result of receiving continuous teaching and conducting continuous learning activities

Regarding cognitive processing ability task scores, no differences were shown in visual information processing ability tasks and mora segmentation tasks between children with DS and TD children, suggesting that these abilities might be acquired based on MA. On the other hand, differences were shown in the scores of 4-mora and 5-mora nonword repetition tasks between children with DS and TD children. Previous studies have indicated that children with DS have a poor memory of auditory verbal stimulation. In nonword repetition tasks, participants are required to reproduce words only by listening (Kanno, 1992). Therefore, the weakness of verbal short-term memory in children with DS might have affected these results.

## Correlations with factors related to reading and writing task scores

Different tasks were correlated with reading and writing tasks between children with DS and TD children. In children with DS, positive correlations were shown between all the reading and writing tasks and mora segmentation tasks. Cossu et al. (1993) suggested that the phoneme segmentation ability in children with DS was lower, compared to TD children with an equal level of reading ability. In Japanese, character notation is performed based on the mora. Therefore, the awareness of mora would have a significant effect on reading and writing abilities. In other words, it is considered that mora segmentation ability of general syllables and long vowel sounds, as well as a double consonant, would be necessary for children with DS to acquire reading and writing abilities.

It has been indicated that the ability to read contracted syllables develops in TD children in the senior class of kindergarten without teaching (Endo, 1990). The present study indicated there was a low correlation between the ability to read special syllables and the number of years of teaching or reading and writing activities in 4~6-year-old TD children. On the other hand, in children with DS, a moderate to strong correlation was shown between the ability to read special syllables and the number of years of teaching or reading and writing activities, suggesting a strong effect of the learning experience. In TD children, line-drawing, spatial cognition, and triangle copying abilities had a significant effect on Hiragana writing ability, which is consistent with previous studies (Gunji et al., 2015). On the other hand, in children with DS, only the figure copying task had a moderate correlation with the ability to write voiceless sounds. It is considered that the ability to copy a triangle especially affects the writing ability of children with DS.

A moderate correlation was indicated between the ability to write voiced/semi-voiced sounds and the 5-mora nonword repetition task in children with DS, whereas no such correlation was shown in TD children. Charles et al. (2012) indicated that the word listening ability did not have a significant effect on children with DS's reading ability, whereas Cossu et al. (1993) indicated that listening and writing words task score in children with DS was lower, compared to TD children with an identical level of the reading ability. The writing task used in the present study was as follows; looking at the illustration drawn on the sheet and writing the name of the illustration. This task requires visual information, and participants do not need listening and discriminating characters. However, the discrimination between voiced and semi-voiced sounds might be affected by the auditory speech discrimination ability. Moreover, the score of the 5-mora nonword repetition task of 6-year-old children with DS was lower than 6-year-old TD children. It was suggested that poor verbal short-term memory in children with DS might affect the ability to write voiced/semi-voiced sounds.

## LIMITATIONS

This study examined correlations between reading and writing abilities and cognitive processing abilities as well as environmental factors in children with DS. It was indicated children with DS with a MA of four could read most of the voiceless sounds and voices/ semi-voiced sounds. Since it was suggested that cognitive processing ability affects the reading and writing ability of children with Down syndrome, it is necessary to consider effective teaching of reading and writing ability. In the future, children with DS with a MA of under four should be examined. Moreover, it was indicated that the 5-mora nonword repetition task was correlated to the task of writing voiced/semi-voiced sounds, and a correlation with the auditory listening ability was suggested. Therefore, the level of the auditory speech discrimination ability that is necessary for phonological information processing should be investigated.

## REFERENCES

- Amano, K. (1970). Formation of the Act of Analyzing Phonemic Structure of words and its Relation to Learning Japanese Syllabic Characters (Kanamoji). *Japanese Journal of Educational Psychology*, 18, 12-24.
- Awaya, N., Uno, A., Syoji, A., & Kanbayashi, Y. (2003). A developmental dysgraphic child with disorders in both phonological and visual information processing, *Child's spirit and nerve* 43, 131-138.
- Cossu G., Rocchini, F., & Marshall, J. C. (1993). When reading is acquired but phonemic awareness is not: A study of literacy in Down's syndrome. *Cognition* 46, 129-138.
- Endo, M. (1990). How young children learn to read and spell Yoo-on (A small-sized Kana character? *Japanese Journal of Educational Psychology* 38, 213-222.
- Gunji, R., & Shoji, H. (2015). Cognitive Factors in the Development of Writing Hiragana Characters in Young Children. *Japan Academy of Learning Disabilities* 24, 238-253.
- Hulme C., Goetz K., Brigstocke S., Nash, H. M., Lervåg A., & Snowling, M. J. (2012). The growth of reading skills in children with Down Syndrome. *Developmental Science* 15, 320-329.
- Hamano, T., & Uchida, N. (2012). International comparative study on the process of acquiring literacy in childhood and the influence of environmental factors. *Ochanomizu University Annual Report*, 13-41.
- Inomata T., Uno, A., & Haruhara, N. (2013). Investigation of Cognitive Factors Affecting Reading and Spelling Abilities of Hiragana Characters in Kindergarten Children. *The Japan Society of Logopedics and Phoniatrics* 54, 122-128.
- Inomata T., Uno A., Sakai A., & Haruhara, N. (2016). Contribution of Cognitive Abilities and Home Literacy Activities to Hiragana Reading and Spelling Skills in Kindergarten Children. *The Japan Society of Logopedics and Phoniatrics* 57, 208-216.
- Kono, T. (2014). A review of research on reading and writing training for children with intellectual disability. *Kanazawa Seiryō University Human science research* 8, 51-56.
- Kono, T., & Shima, M. (2015). Cognitive characteristics about reading and writing in children with intellectual disability -A preliminary case study- Kanazawa Seiryō University *Human science research* 8, 41-44.
- Kanno, A., Ikeda, Y., eds. (1992). Chapter 4 Cognitive Development and Guidance, *Development and Education of Children with Down Syndrome*. Meiji Tosho, Co., Ltd. 58-80.

- Kakahana S., Ando J., Koyama, M., Itaka, S., & Sugahara, I. (2009). Cognitive Factors Relating to the Development of Early Literacy in the Kana Syllabary. *Japanese Journal of Education Psychology* 57, 295-308.
- The National Language Research Institute. (1972). *Reading and Writing Ability in Pre-school Children*. Tokyo-Shoseki (publishers) Ltd.
- Kuboyama, Y., & Ishizaka, I. (2008). A Practical Research on Teaching to Read for a Child with Intellectual Disabilities-Small step studies of hiragana, katakana and kanji. *The Japanese Society for Studies on Educational Practices* 16, 153-160.
- Laws, G., Brown, H., & Main E. (2016). Reading comprehension in children with Down syndrome. *Read Writ* 29, 21-45.
- Loveall, J. S., Connors, A. F. (2016). Reading Skills in Down Syndrome: An Examination of Orthographic Knowledge. *American Journal on Intellectual and Developmental Disabilities* 121, 95-110.
- Moni, K. B. & Jobking, A. (2000). LATCH-ON: A program to develop literacy in young adults with Down syndrome. *Journal of Adolescent and Adult Literacy* 44, 40-49.
- Nonaka, T. (2017). Cultural entrainment of motor skill development: Learning to write hiragana in Japanese primary school. *Developmental Psychobiology*, 1-18.
- Nagayama, Y., Kojima, M. (2010). Instruction for Reading Hiragana to children with Down syndrome. *Japanese Journal on Support System for Developmental Disabilities*, 9, 17-23.
- Ota S., Uno, A. & Inomata, T. (2018). Attainment Level of Hiragana Reading/Spelling in Kindergarten Children. *The Japan Society of Logopedics and Phoniatrics* 59, 9-15.
- Paola, C., Leah, M., Jill, M. P., & Amanda, S. (2016). An early literacy program for young children with down syndrome - changes observed over one year. *Journal of policy and practice in intellectual disabilities*, 13, 102-110.
- Shimamura, N., & Mikami, H. (1994). Acquisition of Hiragana Letters by Pre-school Children-In Comparison with the 1967 Investigation of the National Language Research Institute-. *Japanese Journal of Educational Psychology*, 42, 70-75.
- Tanaka Institute for Educational Research (2003). *The Tanaka-Binet Intelligence Scale (V)*. Taken Publishing Inc.
- Uno, A. (2007). *III Disability edition. II. Reading and writing development and its disability. Language and mental development and disability*. Nagai Shoten Co., Ltd.130-141.
- Utashiro, M., & Hashimoto, S. (2015). Research on Hiragana Acquisition in Children with Intellectual and Developmental Disabilities. *Bulletin of Tokyo Gakuji University Educational Practice Research Support Center*, 11, 21-26.
- Yamaguchi, N. (2006). Study on Learning Effect of Visual Perception Task in Hiragana Writing Learning of Down syndrome child A Bulletin of the Center for Educational Practice, *Hirosaki University* 4, 95-100.