The present study aimed to investigate the relationship between properties of early development of the understanding of words and equivalence cognition of matching pictures and of expectancies in children with severe motor and intellectual disabilities. For that aim, the present study analyzed expectancy heart rate responses in a modified sample matching task, using the S1-S2 paradigm.

Method

Participants

The participants were 12 children with severe motor and intellectual disabilities (5 females, 7 males), who had been diagnosed by physicians, and who were students at a special education school for children with physical disabilities (see Table 1).

Developmental age of communication was calculated by averaging the ages on three aspects of the Enjoji Developmental Test of Infants (Enjoji, 1977), namely, interaction with persons, utterances, and understanding of words. The range of the developmental age of communication of the participants was from 3 months to 1 years 4 months.

The parents of all participants were informed about the aim and design of the present study, and written permissions were obtained from them.

Using recording of evoked potentials, all of the participants were evaluated as not having any severe malfunction of the auditory or visual senses.

Assessment of Verbal Development

The participants' understanding and expression of spoken words were assessed by having the mothers and teachers of the participants complete the Japanese version of the MacArthur Communicative Developmental Inventory. This test includes words used in the daily life of young children. The mothers and teachers of the children were asked to evaluate whether the children could understand and/or express each word. Words used only with small children in nursery schools were excluded from the evaluation. In order to study the characteristics of the words understood by the children in the present study, the words tested in the MacArthur Communicative Developmental Inventory were classified into nine categories. The classifications and the number of words in each category are as follows; names of animals and vehicles (45 words), names of foods (30 words), names of body parts and clothes (39 words), names of tools and other objects in daily life (59 words), words related to school (35 words), words related to familiar persons and greetings (39 words), words related to motor actions in daily life (55 words), adjectives and adverbs related to daily care (45 words) and words related to teaching in daily care (59 words).

Two participants were evaluated as having the number of words of expression at a level of 16–18 months, but it was difficult for them to express their demands by one-word utterances. The other 10 participants did not speak words.

TABLE 1 Participants From Each Group: CA, Developmental Age of Communication, Number of Words Understood, Number of Correct Choices, Heart Rate Responses and Causes

Participants	CA (years: months)	Developmental age of communication (years: months)	Number of words understood		Number of correct choices (Number of choices, Number of Yes/No responses)			Heart Rate responses			Cause
			Mother	Teacher	Shape +color	Shape	Color	Shape +color	Shape	Color	
Group A											
1	8 : 1	1 : 2	272	79	4 (3, 1)	6 (2, 4)	2 (0, 2)	—	↓○	↓○	Infection
2	14 : 6	0 : 9	159	60	7 (2, 5)	6 (3, 3)	0 (0, 0)	↑☆	—	—	Asphyxia
3	13 : 7	1 : 4	89	0	5 (4, 1)	4 (2, 2)	1 (1, 0)	↓○	—	—	Asphyxia
4	8 : 2	0 : 5	66	0	6 (3, 3)	1 (1, 0)	2 (0, 2)	↓○	↓○	↑○	Unknown
5	17: 5	0 : 7	61	4	5 (4, 1)	3 (2, 1)	6 (6, 0)	↓○	↓○	↑☆	Infection
Group B											
6	7 : 4	0 : 9	19	1	0 (0, 0)	0 (0, 0)	0 (0, 0)	—	—	—	Asphyxia
7	11 : 6	1 : 0	17	10	2 (0, 2)	3 (0, 3)	2 (0, 2)	—	—	↓○	Unknown
8	16 : 11	0 : 8	2	6	2 (0, 2)	5 (0, 5)	2 (0, 2)	↑○	—	—	Unknown
9	15 : 1	0 : 4	1	1	4 (0, 4)	2 (0, 2)	1 (0, 1)	—	—	↓○	Rett syndrome.
10*(3)	15 : 11	0 : 4	0	3	0 (0, 0)	0 (0, 0)	0 (0, 0)	—	—	—	Encephalopathy
11*(3)	9 : 0	0 : 3	0	0	6 (4, 2)	2 (2, 0)	4 (3, 1)	—	—	—	Encephalopathy
12	14 : 5	0 : 7	0	1	3 (1, 2)	5 (1, 4)	7 (2, 5)	—	↓○	—	Unknown

Notes. Arrows pointing down indicate occurrences of expectancy heart rate (HR) responses with decrease. Arrows pointing up indicate occurrences of expectancy heart rate responses with increase. Circles indicate expectancy heart rate responses that occurred only on match trials. Stars indicate expectancy heart rate responses that occurred only on mismatch trials. Dashes indicate that expectancy heart rate responses did not occur on either match or mismatch trials. Developmental age of communication is the average age on 3 aspects of the Enjoji Developmental Test of Infants (Enjoji, 1977), namely, interaction with persons, utterances, and understanding of words. In order to examine heart rate change before S1 stimuli, heart rates before a 2-s S1 stimulus in each session were compared to 30 s of resting heart rate. An asterisk and a number within parentheses after a participant's number indicate that a significant change was observed in the session with that number.

Task of Sample Matching With the S1-S2 Paradigm

Before the task of sample matching of pictures, the mothers were asked to indicate which behavior was used to judge participants' expression of "Yes" or "No".

Since both the color and shape of teaching materials have been known to prompt responses effectively in the task of sample matching, the present study examined three conditions of matching, namely, shape with color, shape, and color.

In each of these three conditions, eight different types of sample stimuli were used. A total of 24 sessions of sample matching was presented randomly. Rest periods were inserted according to the participant's condition. For the stimuli that were shape with color, the sample stimuli and choice stimuli consisted of illustrations of animals and vehicles painted in multiple colors. For the shape stimuli, the sample stimuli and choice stimuli consisted of different geometric figures painted with the same primary colors. For the color stimuli, the stimuli were the same geometric figures painted with different primary colors. Because a transparent sheet was found to be good to use for choice stimuli when teaching matching of identical stimuli (Ejiri, Matsui, & Koike, 2006), a transparent sheet was used for the choice stimuli in the present study.

Initially, resting heart rates were recorded during 30s before the start of the sample matching task.

During the sample matching task, heart rate responses were measured. A sample stimulus and two choice stimuli were presented in front of the participants. The experimenter asked, "Which is the same stimulus as the upper one?" (Fig. 1 (1)). If choosing behavior (looking at and/or reaching for a choice stimulus) was observed, it was recorded as a correct choice. When the latency of a correct response was longer than about 4 s, the positions of the choice stimuli were exchanged, and the experimenter asked again. When choosing behavior was not observed, the experimenter pointed to one of the choice stimuli and asked, "Is this one the same as the upper one?" Based on the mother's report of the behavior that that participant used to indicate "Yes" or "No," the participant's behavior was evaluated. The behavior of looking at the choice stimulus or at the experimenter's face, change in body movements, change in breathing, and laughing are examples of the behavior evaluated as "Yes". Absence of the behavior of looking at the choice stimulus or the experimenter's face, or a displeased expression were evaluated as "No". Instructions were presented for each stimulus. Correct behaviors of Yes/No were counted as occurrences of correct choice. When correct behaviors of Yes/No were not observed to either stimulus, that trial was counted as an occurrence of an incorrect choice.

At the S1 time, when the experimenter, instead of the child, grasped the chosen stimulus, a brief sound was presented (Fig. 1 (2)). During the S1-S2 interval, the chosen stimulus was moved toward the position of the sample stimulus (Fig. 1 (3)). At the S2 time, the chosen stimulus was superimposed on the sample stimulus and a reinforcing stimulus was presented (Fig. 1 (4)). When the chosen stimulus was identical with the sample stimulus, cheery music was presented for 4 s as a reinforcing stimulus. After that, a mismatch-trial was administered, in which the experimenter substituted the child's choice of mismatch response. When the chosen stimulus was not identical with the sample stimulus, a buzzer sound was presented. After that, a match-trial was administered, in which the experimenter substituted the child's choice of match response. When a participant's choice was ambiguous, the experimenter substituted the child's choices of match and mismatch, respectively.

The behavior of the participants was recorded by two digital-video recorders, which were placed in front of the participants.

The same experiments were done twice on different days with an interval of about 1 month for two of the participants, in order to examine the stability of the expectancy heart rate responses.

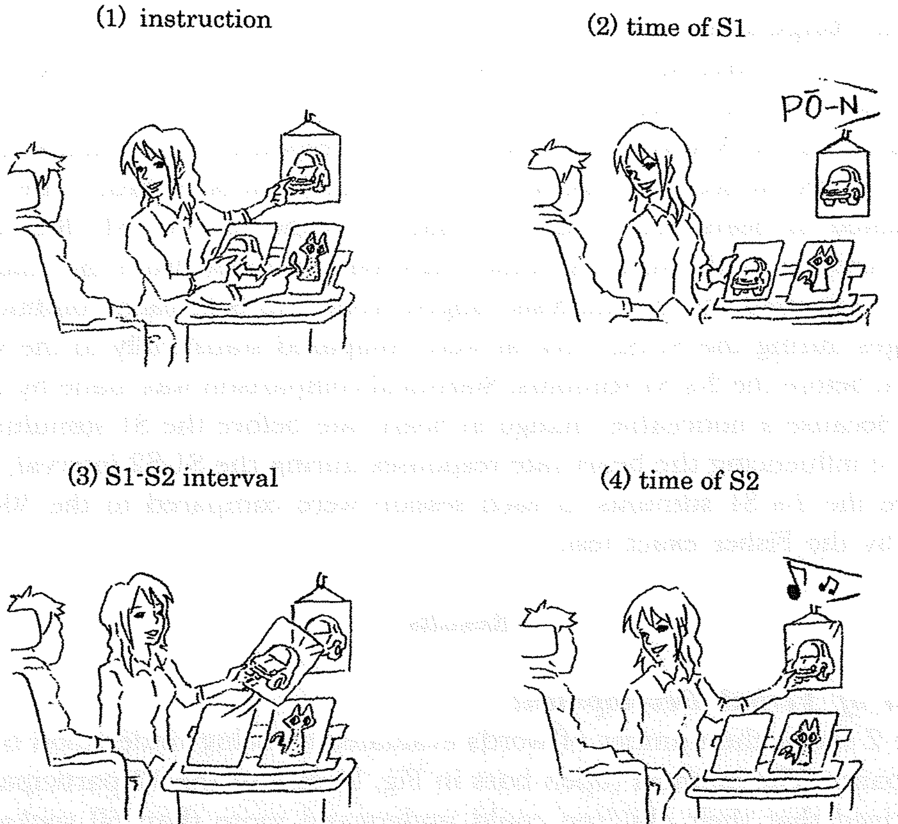

FIG. 1 Illustration of the Sample Matching Task With S1-S2

Notes. (1) The experimenter asks the participant, "Which is the same stimulus as the upper one?" (2) At time S1, the experimenter holds the chosen stimulus, and a brief sound is presented. (3) During the S1-S2 interval, the experimenter moves the chosen stimulus toward the position of the sample stimulus. (4) At time S2, the chosen stimulus is superimposed on the sample stimulus and a reinforcing stimulus is presented when the chosen stimulus is identical with the sample stimulus

Analysis

Choice Responses

Because the participants' choices were judged by the experimenter, reliability of the experimenter's judgments was examined by calculating the ratio of agreements between the experimenter and an assistant. An assistant observed the participants' behavior on the digital-video record, and judged the participant's choices. For choosing behaviors, the ratios of agreements ranged from 0.60 to 0.81; for Yes/No behaviors, the ratios of agreements ranged from 0.4 to 0.62.

Based on the participant's choosing and Yes/No behavior, the frequency of correct choices was calculated in each matching condition.

Heart Rate Responses

Through A-D conversion of data, R-waves were detected in the EKGs, and the intervals between R-waves were calculated. The sampling rate of A-D conversion was 100 Hz. Based on the R-wave data, the heart rate responses were calculated through the method of sec-by-sec analysis, and the averaged traces of heart rate responses were calculated in beats per second in relation to the time of S1 (Kumoi, 2001). Because of artifacts in the records, some trials were excluded from the analysis. The number of trials used for the analysis ranged from 5 to 8 in each condition. Heart rates changes during the S1-S2 interval were compared statistically to the variations in heart rate before the 2-s S1 stimulus. Statistical comparison was made by the Fisher exact test. Because a noticeable change in heart rate before the S1 stimulus had the possibility of influencing the heart rate responses during the S1-S2 interval, the heart rates before the 2-s S1 stimulus in each session were compared to the 30-s resting heart rate by the Fisher exact test.

Results

Assessment of Verbal Development

Figure 2 shows the number of words evaluated as being understood by each of the participants. The mothers (open bars in Fig. 2) of 5 of the 12 participants (1, 2, 3, 4, 5) judged that their children could understand more than 60 spoken words. Because no category had more than 59 words, this suggests that those who could understand more than 60 words were being reported to be able to understand words in more than one category. Thus, these participants were considered in the evaluations by their mothers to have a good understanding of words. These participants were classified into Group A in the present study. Each of the remaining 7 participants (6, 7, 8, 9, 10, 11, 12) was reported to be able to understand fewer than 20 words. They were judged by their mothers as not having a good understanding of words, and were classified into Group B in the present study.

The teachers (filled bars in Fig. 2) evaluated 2 of the participants in Group A

(1, 2) as being able to understand more than 60 words. The other 3 participants in Group A (3, 4, 5) were judged by their teachers as being able to understand fewer than 5 words. These participants were evaluated quite differently by their mothers and their teachers. The participants in Group B were evaluated by their teachers as being able to understand only a small number of words.

The present study examined the characteristics of the words understood by the participants. Figure 3 shows the percentage of words in each category that were said to be understood by the participants. In the evaluations by the mothers and teachers, the participants in Group A were rated as having a higher percentage of understanding of the words in the food category (b) and in the category related to familiar persons and greetings (f) in comparison with the other categories. This tendency was also reported in Group B.

Correct Choices of Matching Stimuli

Table 1 has a summary description of the participants, including the number of words understood, the total number of correct choices, and the heart rate responses. The number of correct choices is the sum of the number of choices (lefthand number in the parentheses) and the number of Yes/No responses (righthand number in the parentheses).

Eight sessions were presented in each condition. In the condition of shape with color, the number of correct choosing behaviors as well as the number of correct

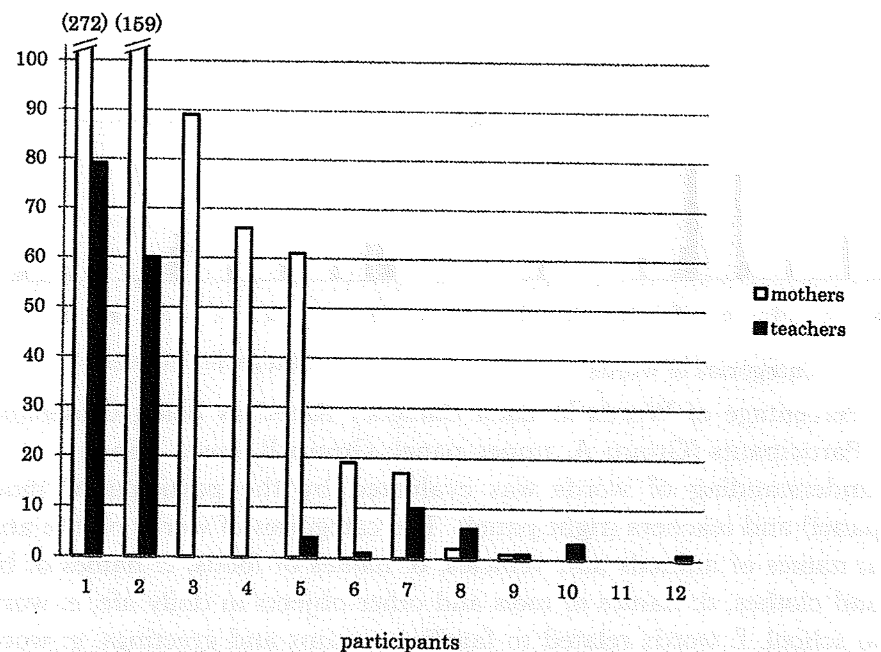

FIG. 2 Number of Words Evaluated as Understood by Mothers and Teachers
Notes. Number of words that the mothers (open bars) and teachers (filled bars) evaluated as understood, plotted for each participant. The ordinate displays the number of words evaluated.

choices in Group A was significantly larger than in Group B ($p<.05$, Fisher exact test). In the condition of shape, the number of correct choosing behaviors in Group A was significantly larger than in Group B ($p<.05$, Fisher Exact test).

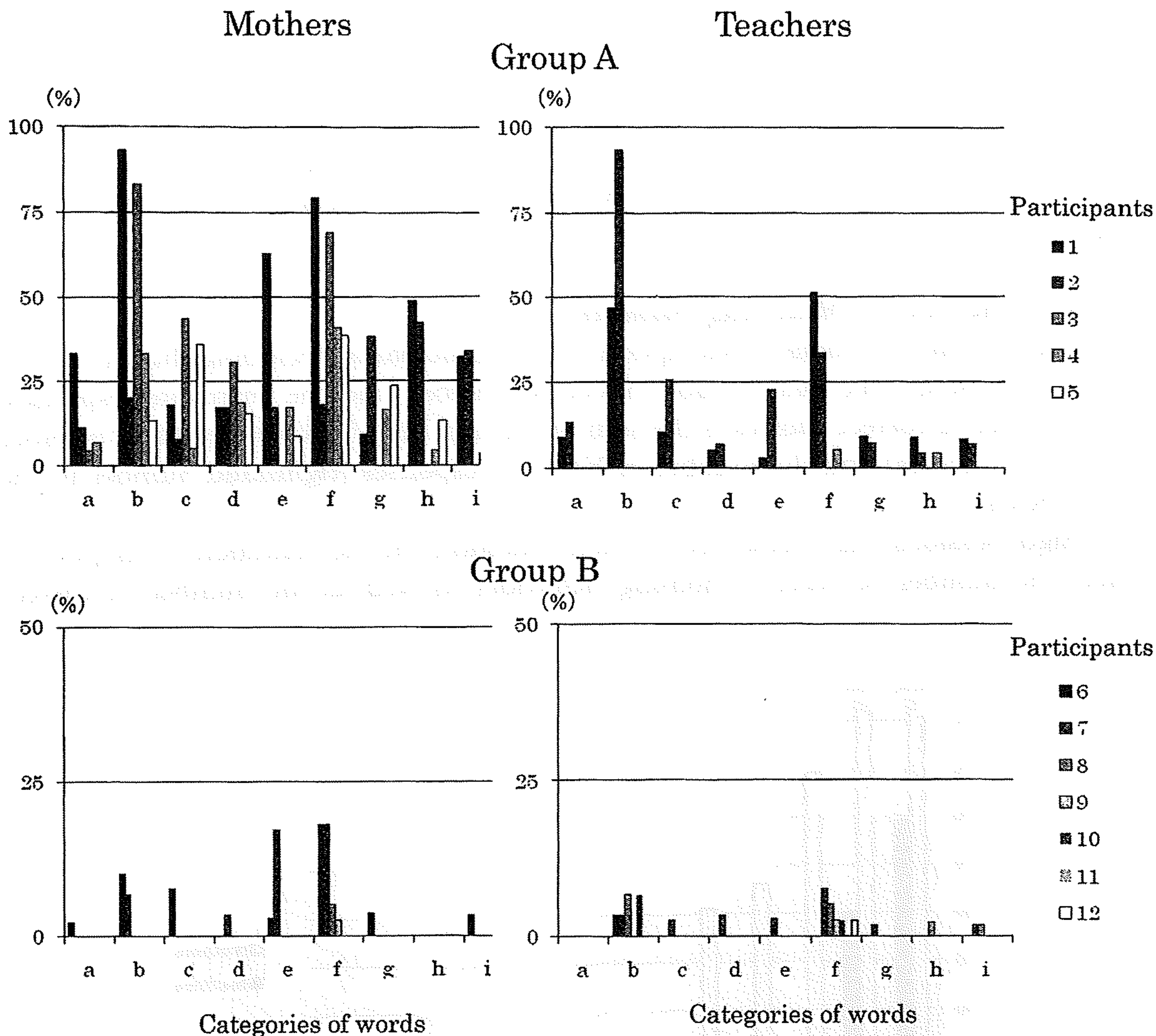

FIG. 3 Percentage of Words in Each Category Rated as Being Understood by the Participants (Group A, upper panel; Group B, lower panel)

Notes. Understanding of words was evaluated by the participants' mothers (left panel) and teachers (right panel). The categories of words on the abscissa are: a: names of animals and vehicles, b: names of foods, c: names of body parts and clothes, d: names of tools and other objects in daily life, e: words related to school, f: words related to familiar persons and greetings, g: words related to motor actions in daily life, h: adjectives and adverbs in daily care, and i: words related to teaching in daily care. The ordinate displays the percentage of words in each category understood by the participants.

Heart Rate Responses

In the present study, a significant increase or decrease in heart rate during the S1-S2 interval compared to variations in heart rate 2s before the S1 stimulus was defined as an expectancy heart rate response.

Figure 4 shows typical traces of expectancy heart rate responses. Four of the 10 traces of expectancy heart rate responses with decreased change and 2 of the 4 traces with increased change are shown on matching trials with identical pictures (match-trials; darker lines) and matching trials with different pictures (mismatch-trials; lighter lines). The asterisks denote values of heart rates that differed significantly from the variation of heart rates 2-s before the S1 stimulus. Asterisks are shown only in traces of match-trials in participants 1, 5, 7, 8, and 9.

As shown in Table 1, the ratio of occurrences of expectancy heart rate responses in Group A was significantly larger than that in Group B ($p<.05$, Fisher exact test). Those participants in Group A whose understanding of words was confirmed only by

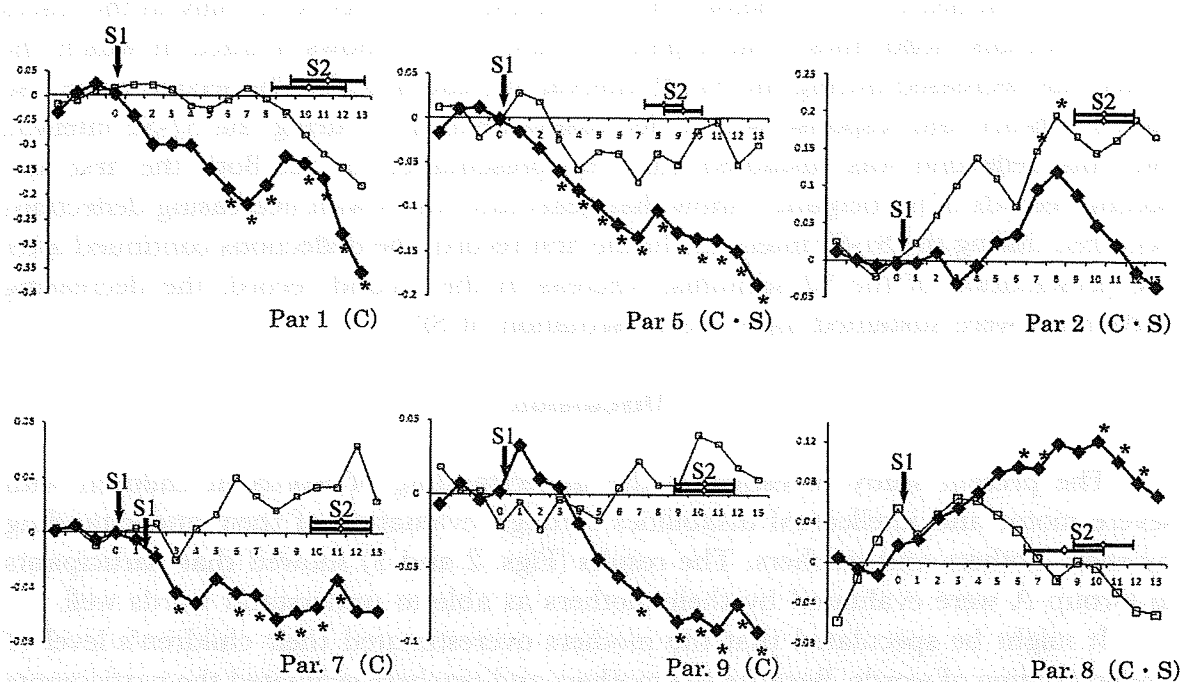

FIG. 4 Typical Expectancy Heart Rate Responses Records

Notes. Heart rate responses that showed significant decreases or increases during the S1-S2 intervals compared to variations in heart rate 2 s before the S1 stimulus are plotted as expectancy heart rate responses. Asterisks denote heart rates that differed significantly from the variation of heart rate 2 s before the S1 stimulus. The darker lines signify the results of trials of matching identical pictures (match-trials), and the lighter lines, results of trials of matching different pictures (mismatch-trials). Bars indicate means (open circles) ± 1 SD of the S2 start times. The upper bars indicate match-trials; the lower bars, mismatch-trials. The unit of time is 0.5 s. "Par" = participant.

their mothers, that is, not by their teachers (Participants (3, 4, 5), were all shown to exhibit expectancy heart rate responses.

The participants in Group B tended to show expectancy heart rate responses in one condition (shape or color) preferentially. Expectancy heart rate responses were observed in the condition with a relatively low frequency of correct choices.

In order to examine heart rate changes before the S1 stimulus, heart rates 2 s before the S1 stimulus in each session were compared to a 30-s measure of heart rate when resting. An asterisk and a number within parentheses after a participant's number in Table 1 indicate that a significant change was observed in the session with that number. Heart rate changes before S1 were significantly different from resting heart rates in only 2 of the participants.

Stability of Heart Rate Responses

Figure 5 shows traces of expectancy heart rate responses which were measured on two different days. Asterisks denote heart rates that differed significantly from the variation of in heart rate 2 s before the S1 stimulus. Asterisks occur only in the traces of match-trials (solid lines). Participant 3's first record shows a trace in which the heart rate decreased during the S1-S2 interval for match-trials. The second trace also shows a heart rate response with a decreasing deflection during the S1-S2 interval. But this deflection was sustained after the presentation of S2. Both the first and second records of participant 5 show that heart rate traces with decreasing deflections occurred during the S1-S2 intervals. In the first record, the deflections continued after the presentation of the S2 stimulus, whereas in the second record, the decreasing deflections were sustained after the presentation of S2.

Discussion

The present study investigated the understanding of words in children with severe motor and intellectual disabilities through evaluation of their understanding by their mothers and teachers. The results (Figs. 2 and 3) showed that participants in Group A were evaluated by their mothers as able to understand words well.

It might be speculated that the mothers overestimated their children's level of understanding of words. Because the mothers and teachers evaluated the participants in Group B similarly, it is possible to suppose that mothers do not typically overestimate their children's communication ability by much. It seems more likely that the mothers evaluated their children's understanding of words in a different context of interaction than the teachers did.

The present study examined the performance of the participants on a sample matching task (see Table 1). In the condition of shape with color, the number of correct choices by the participants in Group A was larger than that of those in Group B. It is inferred that the participants in Group A might attain the level of cognitive development that would enable them to choose correct stimuli in a condition of shape with color.

The present study examined equivalence cognition which accompanies expectancy through analyzing expectancy heart rate responses. All the participants in Group A whose understanding of words was evaluated as good by their mothers showed heart rate responses that decreased or increased significantly during the S1-S2 interval (expectancy heart rate responses). Heart rate changes with decreasing deflection have been considered to reflect change of attention toward an occurrence of S2 (Kitajima et al., 1993). Heart rate changes with increasing deflection during the S1-S2 interval have been considered to relate to emotional responses such as laughing induced by the S2 stimuli (Katagiri et al., 1999). Because information on match or

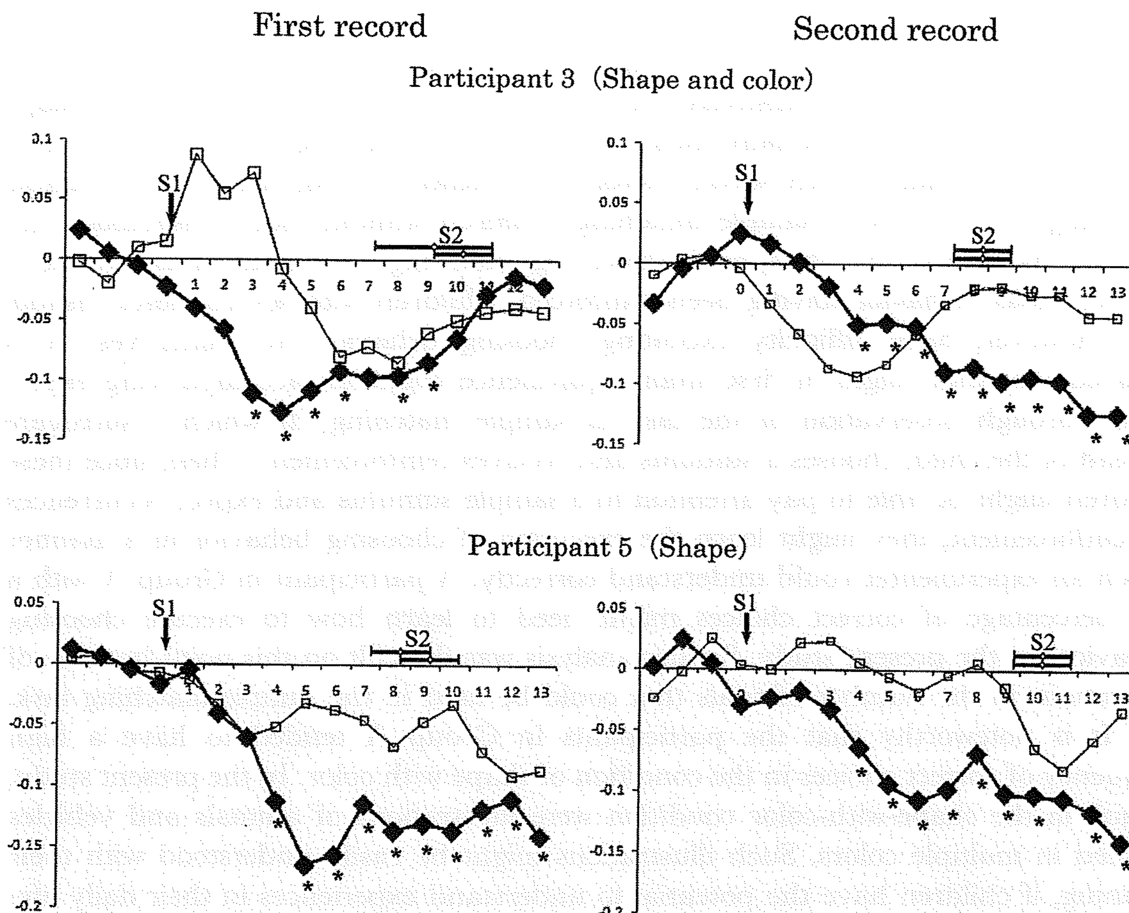

FIG. 5 Expectancy Heart Rate Response Records of Two Participants

Notes. In order to examine the stability of the expectancy heart rate response, heart rate responses were measured twice, with about 1 month between measurements. The darker lines signify the results of trials of matching identical pictures (match-trials), and the lighter lines, the results of trials of matching different pictures (mismatch-trials). Asterisks denote heart rates that differed significantly from the variation in heart rate 2 s before the S1 stimulus. Bars indicate means (open circle) ± 1 SD of start times of S2. The upper bars indicate match-trials; the lower bars, mismatch-trials. The unit of time is 0.5 s.

mismatch was presented by the S2 stimuli, if a participant's attention or emotional processes begin to change at the time of the presentation of the S1 stimulus, it is speculated that the children might have equivalence cognition of matching stimuli which accompanies expectancy, and judge the stimulus pictures as identical at the time of the S1 stimulus. Two of the participants (2, 5) might have understood the mismatch situation and showed emotional responses of laughing on mismatch trials.

Thus, the participants in Group A, whose understanding of words was evaluated as good by their mothers, might have equivalence cognition accompanying expectancy on the task of sample matching of visual information of both shape and color. When children have equivalence cognition accompanying expectancy, active learning through observation might be possible, especially learning the relation between spoken words and objects in their daily life.

Two of the participants in Group A (4, 5) exhibited expectancy heart rate responses, but showed a relatively low frequency of correct choices in the shape condition. In order to explain their poor correct choice performance, we must consider how children with severe motor and intellectual disabilities learn sample matching. In the task of sample matching, children without motor disabilities can respond spontaneously. Thus, equivalence cognition might be attained as a result of correct choice behavior having been reinforced. Children with severe motor disabilities, however, have difficulty executing choosing behavior by themselves. It is inferred that they might at first attain equivalence cognition accompanying expectancy through observation of the task of sample matching, in which a surrogate instead of the child, chooses a stimulus and receives reinforcement. Then, since these children might be able to pay attention to a sample stimulus and expect occurrences of reinforcement, they might learn the execution of choosing behavior in a manner which an experimenter could understand correctly. A participant in Group A with a low percentage of correct choices might need to learn how to execute choosing behavior. In the present study, further analysis was difficult on this point because of restrictions in the number of trials that could be used in the sample matching task.

It is noteworthy that the participants in Group A tended to have a high frequency of correct choices in the condition of shape with color. In the present study, stimuli in the shape-with-color condition were illustrations of animals and vehicles painted in multiple colors. Such illustrations might be easily understood with their meaning, if children have the potential to understand experiences in their daily life. The participants in Group A might have a relatively high potential for receiving experiences in their daily life and might be able to understand stimuli that have shape with color as meaningful stimuli, which would result in a high frequencies of correct choices in that condition.

Some participants in Group A (2, 4, 5) showed expectancy heart rate responses with increased change in one of conditions of shape/color. This suggests emotional responses reflecting the individual preferences of the children shape/color. Because the children's emotional responses of laughing were considered important in terms of interactions between the children and adults, it might be useful to utilize individual preferences for shape/color in training situations, aiming to facilitate communication between adults and the children with severe motor and intellectual disabilities.

The mothers of the participants in Group A reported that their children could understand well names of foods, and words related to familiar persons and greetings (see Fig. 3). This was also reported by the teachers. Because names of foods and words related to familiar persons and greetings are related to participants' preference, understanding those words might be evaluated through observing expectancy behaviors to preferred objects. In the participants in Group A whose understanding of words was incorrectly evaluated by their teachers (3, 4, 5), it is possible that expressions of expectancy behaviors are restricted to specific objects. If so, then their teachers might find it difficult to evaluate expectancy behaviors in the classroom.

In some of the participants in Group B (6, 7, 8, 10, 12), the frequency of correct choices was lower than in the participants in Group A in the condition involviong matching on shape with color (see Table 1). The ratio of occurrence of expectancy heart rate responses in Group B was also lower than in Group A. Thus, participants in Group B, whose understanding of words was not evaluated as good by both their mothers and teachers, had not attained enough equivalence cognition to enable them to choose the stimuli successfully through utilizing visual information regarding both shape and color.

Three participants in Group B (7, 9, 12) showed correct choices and expectancy heart rate responses in one of the conditions of shape or color, and seemed to have a preference. This may indicate that some of the participants in Group B had a preference for shape or color individually and showed correct choices based on the equivalence cognition which accompanies expectancy.

Expectancy heart rate responses were not observed in the condition with a high frequencu of correct choices in 3 of the participants in Group B (8, 11, 12). Two of the participants (8, 12) tended to show correct choices not by choosing behavior but by Yes/No behavior.

In previous studies of children with severe intellectual disabilities, a facilitating task called *huruiwake* in Japanese has proved useful (Ejiri et al., 2006; Odera et al., 1998). In that task, a teacher directly guides the children's attention to the choice stimuli. It has been reported that children who had been unable to choose by themselves a choice stimulus that was identical with the sample stimulus, succeeded with *huruiwake*. Because, in the present experiment, in situations with Yes/No behaviors, the experimenter also directly guided the children's attention to the choice stimuli, the two of the participants in Group B (8, 12) with high frequencies of correct choices by Yes/No behaviors might be able to attain equivalence cognition with an experimenter's support. Participant 11 who made correct choices by choosing behaviors might be able to attain equivalence cognition without an experimenter's support. It also might be possible that the stimulus conditions of the present study were not fully adequate for the participants to be able to have equivalence cognition accompanying expectancy.

Two of the participants in Group B (6, 10) did not show correct choices and expectancy heart rate responses in any of the conditions. In the present study, the absence of severe malfunctions of the auditory and visual senses was confirmed by recording evoked potentials. In the sample matching task, visual discrimination of objects as well as control of attention to the stimuli being presented were necessary fundamental processes for making correct choices. In these two participants, malfunction of these fundamental processes were inferred. Further study is needed on this point.

In teaching children with severe motor and intellectual disabilities, it has been regarded to be especially important to present the teacher's instruction based on the children's responsiveness (Yoshikawa, 2005). The results of the present study suggest that children with severe motor and intellectual disabilities, whose understanding of words has been evaluated as good by their mothers and/or teachers, appear to have equivalence cognition accompanying expectancy. Considering the property of expectancy of each child, it might be possible to construct effective stimulus conditions for active learning in each child with severe motor and intellectual disabilities. Further study would also be useful on this point.

References

Ejiri, M., Matsui, H., & Koike, T. (2006) Training of small numeral manipulation in children with severe intellectual disabilities. *Japanese Journal of Special Education*, 44, 25-33. (in Japanese)

Enjoji, M. (1977) *Manual: Enjoji Developmental Test of Infants*. Keio Tsushin, Tokyo. (in Japanese)

Iino, J. (2005) *Construction of class for children with profound retardation*. Jiaasu Kyoiku Shin Sha, Tokyo. (in Japanese)

Katagiri, K., Koike, T., & Kitajima, Y. (1999) *Cognitive development of children with profound retardation and its facilitation*. Kita Ooji Shobo, Kyoto, Japan. (in Japanese)

Kitajima, Y., Koike, T., Katada, A., & Matsuno, Y. (1993) The expectancy response in persons with profound retardation. *Japanese Journal of Special Education*, 30, 43-54. (in Japanese)

Komuku, T. & Watamaki, T (2004) *The Japanese MacArthur Communicative Developmental Inventory; Words and gestures*. Kyoto International Social Welfare Exchange Center, Kyoto. (in Japanese)

Kumoi, M. (2001) Supporting expectancy responses through helping the initiation of S1-S2 sequences: Expectancy heart rate responses in persons with severe mental and physical disabilities. *Japanese Journal of Special Education*, 39, 31-40. (in Japanese)

Nagasaki, T. & Onosato, M. (1996) *Development of communication and its teaching program*. Nihon Bunka Kagaku Sha, Tokyo.

Odera, T., Kurai, N., & Satake, T. (1998) *National Rehabilitation Center for the Disabled's 〈S-S Test〉 for language-retarded children with the sign-significate relations.*, Escor Publishers, Chiba, Japan. (in Japanese)

Oishi, T. (2006) From medical care to support of communication. In J. Iino (Ed), *Toward the teaching of facilitating communication*. Jiaasu Kyoiku Shin Sha, Tokyo, 108-115. (in

Japanese)

Otomo, K (2005) The vocabulary of students with physical and intellectual impairment. *Bulletin of the Center for the Research and Support of Educational Practice*, 1, 149-156. (in Japanese)

Takaizumi, Y. & Ishida, H. (1999) The significance of AAC in persons with severe motor and intellectual disabilities and how to support. *Japanese Journal of Comunication Disorders*, 16, 40-46. (in Japanese)

Yoshikawa T. (2005) Classroom teaching which facilitates communication development. In J. Iino (Ed.), *Construction of classroom teaching for children with severe disabilities.* Jiaasu Kyoiku Shin Sha, Tokyo, 44-53. (in Japanese)

—Received June 19, 2008; Accepted February 21, 2009—

特殊教育学研究, 47 (2), 81-90, 2009.

LD児における漢字の読みの学習過程とその促進に関する研究

後藤隆章*・赤塚めぐみ**・池尻加奈子***
小池敏英****

本研究は漢字書字に困難を示すLD児に関して、漢字と読みの対連合学習における、読みと視覚刺激の先行対呈示に伴う学習の促進効果について検討することを目的とした。学習の促進効果量は、対連合学習の総学習量が健常児群の平均 $-1SD$ の値よりも低いLD児（A群7名）のほうが、平均 $-1SD$ より高いLD児（B群13名）よりも有意に大きかった。A群がひらがな文の読み困難を示す割合は、B群よりも高い傾向があり、LD児の漢字の読み学習の特徴がひらがな文の読み困難と関連することが示唆される。情報処理特性との関連については、判別分析より数唱の評価点を説明変数として用いたときに85.0%の正判別率が得られ、A群とB群を区別する指標として有効であることが指摘できた。以上より、聴覚記憶に困難を示すLD児においては、読みと視覚刺激の先行対呈示による支援手続きが、漢字の読みの学習に有効であることが指摘できた。

キー・ワード：LD　対連合課題　読みの学習過程　視覚的イメージ

Ⅰ．問題と目的

読字書字の困難はlearning disabilities（以下LD）児における中核的な障害であり、特に漢字の読字書字困難は、教科学習に大きな影響を与える。これまでLD児における漢字の読字書字に関する検討は、読字困難と書字困難の両側面に関して検討されてきたが、その相互の関係についての検討は少ない。

河村・新妻・益田・中山・前川（2007）は、漢字の書字困難を示す事例について、読み書き困難の様相を複数の漢字について検討した結果、読めない漢字は、書けない傾向が強いことを指摘した。また、Goto, Kumoi, Koike, and Ohta (2008) は、ひらがな文の読み困難を示す事例では、漢字の読字困難を示すことを指摘した。漢字の読字と書字に困難を示す者においては、漢字の読み学習は大切な指導課題となる。

このことから、漢字の書字困難を示すLD児を対象として、漢字の読みの学習特性を明らかにし、その学習特性との関連で、効果的な支援方法を明らかにする必要があろう。

* 東京学芸大学大学院連合学校教育学研究科
** 磐田市発達支援センター「はあと」
*** 東京学芸大学附属特別支援学校
**** 東京学芸大学

漢字の読み書き困難を示すLD児に関しては、漢字の書きのみ困難を示すLD児と比べて、聴覚記憶における音韻ループの困難を示すことが指摘されている（Song, Goto, Koike, & Ohta, 2007）。LD児の読み書きに対する支援手続きについて検討するためには、聴覚記憶を含め、情報処理特性との関連より明らかにする必要がある。

LD児の漢字の読み学習の特徴に関しては、複数の意味や読み方をもつ漢字について、読字困難が生じやすいことが指摘されている（大石, 2007）が、単一の読みをもつ漢字に関する学習であっても、読字困難を示す可能性も考えられる。この点については、読みの指導を受けた経験がなく、単一の読みをもつ漢字について、漢字の読みを学習する過程を検討し、その学習特性を明らかにする研究が必要であろう。

読みの支援方法に関しては、見本合わせ課題による支援手続きとともに、対連合学習課題に基づく支援手続きが、従来、報告されてきた。対連合学習課題に基づく支援手続きに関しては、Duyck, Szmalec, Kemps, and Vandierendonck (2003) の研究を挙げることができる。

Duyck et al. (2003) は、構音抑制によって音韻ループを妨害する学習条件を設定し、この条件において学習促進が生じる手続きについて検討した。学習課題と

して、有意味単語と無意味単語の対連合学習を検討した。構音抑制とは、学習中に、学習者が課題とは無関連なことばを反復発声することで、音韻ループを妨害する手続きである。Duyck et al. (2003) は、学習試行に先立って、無意味単語と視覚図形刺激の対呈示を反復して経験した場合、学習試行で学習が促進されたことを指摘した。この点について、無意味単語について視覚的イメージが形成され、その結果、学習における音韻ループの関与が減少したために構音抑制の影響が減少し、学習促進が生じたことを考察した。Duyck et al. (2003) は、また、音韻ループが機能不全を示す成人や小児の事例において、視覚的イメージを媒介とした学習は効果的であることを指摘した。

漢字の読み書き困難を示すLD児には、音韻ループの弱さを示す事例が多いことが報告されている (Song et al., 2007)。これより、漢字の読み書き困難を示すLD児でも、漢字と読みの対連合学習において、読みの視覚的イメージの形成を図ることで、学習促進が生じることが予想される。

以上より、本研究では、漢字書字に著しい困難を示すLD児を対象とし、未経験で新規な漢字の読みを学習する課題を設定して漢字の読みの学習特性を検討する。さらに、読みの視覚的イメージの形成が及ぼす学習促進に関して、学習特性との関連で検討することを目的とした。

漢字の読み課題としては、魚偏の漢字（以下　魚漢字）とその読み（魚名）の学習課題を設定した。魚のカラー写真刺激とひらがな単語（魚名）の対呈示を反復して学習前に経験することで、読みの視覚的イメージが形成され、学習が促進されることが予想される。学習の促進効果は、健常児の標準値との関連で評価することとした。漢字の読みの学習困難が標準値との関連で明らかになったLD児では、音韻ループの機能不全を示し、さらにひらがな文やひらがな・漢字単語の読字困難をあわせもっていることが推測できる。そこで本研究では、LD児における漢字の読み学習の特徴と読字困難、および情報処理の特徴との関連についてあわせて検討することとした。

II. 方　法

1. 対　象

1）健常児：小学校1年生から6年生までの健常児95名を対象とした。担任からの聞き取り調査を行い、国語の学習に著しい遅れを示す対象者はいないことを確認した。

2）LD児：小学2年生から中学2年生の読み書きに困難を示すLD児20名を対象とした。本研究において対象としたLDの基準は次の3点である。対象者は、① WISC-IIIのFIQが70以上であるもの、② VIQ、PIQ、FIQのいずれかが85以上であるもの、③ 2年生と3年生に関しては1学年下、4年生以上に関しては当該学年2学年下の国語課題（教研式国語標準学力検査CRT-II; 辰野・北尾, 2005）において著しい学習の困難が認められるもの、④ これまで脳損傷に関する病歴を有していないものとした。対象者20名全員、通常学級に在籍し、そのうち7名は、ことばの通級による指導を受けていた。残りの13名は大学研究室での漢字の読み書き指導を受けていた。

本研究の対象LD児に対して漢字読み書きテスト（石井・雲井・小池, 2004）を実施したところ、すべての事例は当該学年2学年下（2・3年生に関しては1学年下）の代表的漢字20字の書きテストで60%以下の成績を示した。読みテストにおいては、60%以上であったものが9名、60%以下であったものが11名であった（Table 1）。すべての対象者について、ひらがな文字を読めることを確認できた。

本研究では、K-ABCの下位検査項目である、「ことばの読み」課題を実施し標準得点を求めた。対象児S7とS20に関しては中学1年生であったため、ことばの読みの標準得点は補正の手続きを用いて算出した。

本研究では、葛西・関・小枝（2006）に基づき、ひらがな文の読みを評価した。その結果、LD児の在籍学年の健常児の基準値と比べて、ひらがな文について音読に要した時間が著しく長く、誤読数が著しく多いものを読み障害を示すものとし、10名認めた。Goto et al. (2008) に従い、ひらがな文について著しい読み困難を示したLD児10名をSRD児、示さなかったLD児10名をNSRD児として分類した。

2. 刺激材料

国語辞典（広辞苑第5版, 岩波書店）より、2音節から3音節である魚偏の漢字14個を選定した。写真刺激は、魚偏の漢字に対応する当該の魚のカラー写真とした。5つの魚漢字からなるリストを2種作成し、1年生から4年生の課題（リストA、Table 2）とした。5年生と6年生に関しては、学習過程で天井効果が予想されたため、6つの魚漢字からなる課題（リストB）を作成した。リスト間で魚の名前の文字数は同じとした。実験に先立ち、すべての対象者に対して、学習材料とする魚漢字を読むことができないことを確認し

Table 1　LD 事例における群指数と読み書き課題の結果

事例	学年	漢字テストの正答率		文読み課題	K-ABC	WISC-III			
		読み	書き		ことばの読み	言語理解	知覚統合	注意記憶	処理速度
S1*	小 3	56.4	33.3	SRD	74	115	98	94	83
S2*	小 3	30	13.3	SRD	68	95	116	88	94
S3*	小 5	60	6.8	SRD	95	94	67	91	78
S4*	小 5	35	11.6	SRD	62	99	97	85	72
S5*	小 5	88.4	50.9	NSRD	71	89	79	71	103
S6*	小 6	43.1	6.8	SRD	76	99	69	82	106
S7*	中 1	13.7	1.7	SRD	60	80	85	82	78
S8	小 3	19.4	0	SRD	65	100	98	68	92
S9	小 3	71.6	21.6	NSRD	101	133	121	121	97
S10	小 3	100	58.3	NSRD	150	105	115	112	89
S11	小 4	46.5	13.7	SRD	71	86	76	109	83
S12	小 5	76.6	21.6	NSRD	83	92	110	100	86
S13	小 5	90.9	3.6	NSRD	100	92	58	100	86
S14	小 5	40	3.6	SRD	64	100	110	100	92
S15	小 5	92.3	38.1	NSRD	89	120	98	88	100
S16	小 6	25	3.3	SRD	86	82	93	100	92
S17	小 6	98.2	60	NSRD	114	89	80	88	92
S18	小 6	94.8	24.1	NSRD	82	111	97	103	58
S19	小 6	48.2	25.8	NSRD	73	92	95	94	103
S20	中 1	98.2	32.7	NSRD	112	111	84	82	78

対象児の配列は, Fig. 1 の順とした. 読み書き課題については, 在籍 2 学年下（2・3 年生に関しては 1 学年下）の漢字テスト（石井ら, 2004）の正答率と文読み課題（葛西ら, 2006）による評価を表記した. 文読み課題により, 読み障害のある LD 児（SRD）とない LD 児（NSRD）に分類した. アスタリスク（*）は, 第 2 回学習での総学習量が健常児群の平均値 $-1SD$ の総学習量より小さかった LD 児を示す.

Table 2　刺激材料（リスト A）

コントロール条件		写真刺激呈示条件	
刺激語	反応語	刺激語	反応語
鰖	たかべ	鱰	しいら
鯷	ひしこ	鱮	たなご
鯎	うぐい	魳	かます
鯒	こち	鱛	えそ
鮸	にべ	鮠	はや

小学校 1 年生から 4 年生と LD 児に対しては, リスト A を用いた. 小学校 5・6 年生には, リスト B を用いた. リスト B は, リスト A のコントロール条件に鰍（かじか）と, 写真刺激呈示条件に鮬（せいご）を付加して作成した.

た。LD 事例に対しては、リスト A を用いて課題を行った。

3. 手続き

課題は、練習課題、前学習課題、学習課題から構成された。それぞれの課題は PC 画面上に呈示した。学習条件は、前学習課題の内容により、写真刺激を漢字の読み学習に先立って呈示する「写真刺激呈示条件」と「コントロール条件」を設定した。

練習課題では、練習用の魚漢字、魚名のひらがな単語、魚の写真刺激を用いた。コントロール条件においては、はじめに、練習用魚漢字と魚名のひらがな単語を呈示し、「今からこのように、画面上に出てくる魚の漢字の読み方を覚えてもらいます」と教示した。次に、練習用の魚漢字のみを画面上に呈示し、魚の漢字の読み方がわかった場合には、読み上げるよう求めた。

写真刺激呈示条件においては、練習用の魚の写真刺激と魚名のひらがな単語を画面上に呈示し、「今から画面に出てくる魚の写真と魚の名前を見ていてください。魚の名前を覚えようとしなくてもかまいません」と教示した。そのあと、コントロール条件の練習課題と同様の説明がなされた。

前学習課題では、当該の魚のカラー写真刺激とひらがな単語を用いた。写真刺激は、背景が黒のスクリー

Table 3　健常児群の各学年における総学習量平均と標準偏差

グループ	CA 歳：月齢	実施課題	総学習量平均		学習効果量
			コントロール	写真刺激呈示	
1年生（$n=15$）	7：5 (0.3)	リストA	9.7 (5.1)	9.9 (5.9)	0.1　(2.9)
2年生（$n=16$）	8：4 (0.3)	リストA	12.3 (5.2)	17.1 (5.9)	4.9* (4.5)
3年生（$n=16$）	9：4 (0.4)	リストA	15.1 (5.1)	18.8 (4.1)	3.8* (6.2)
4年生（$n=16$）	10：5 (0.3)	リストA	18.3 (5.4)	20.3 (3.5)	2.1　(5.1)
5年生（$n=16$）	11：4 (0.3)	リストB	19.4 (5.9)	24.6 (3.5)	5.2* (6.3)
6年生（$n=16$）	12：5 (0.3)	リストB	23.4 (5.7)	24.0 (6.7)	0.6　(4.9)

表中のアスタリスク (*) は，コントロール条件と写真刺激呈示条件の間で有意差が認められたことを示す ($p<.05$)．括弧内の数字は標準偏差を示す．1年生から4年生は，5対の漢字読みを5試行学習した総学習量を示す．5・6年生は6対の漢字読みを5試行学習した総学習量を示す．

ン上の白四角形（7 cm×18 cm）の中に呈示した。ひらがな単語は、学習課題で用いられる魚名とし、白四角の上に3 cm×10 cmの大きさで呈示した。写真刺激呈示条件では、学習課題で用いられる写真刺激と、対応する魚名のひらがな単語を呈示した。コントロール条件では、写真刺激を呈示せず、白四角刺激のみと魚名のひらがな単語を呈示した。

はじめに、写真刺激とひらがな単語を同時に呈示した。写真・ひらがな単語刺激の呈示時間は4秒とし、コンピュータ制御した。1年生から4年生は5個、5年生と6年生は6個の写真・ひらがな単語刺激を1セットとし、10セット呈示した。各セットにおいて、写真・ひらがな単語刺激の呈示順序はランダムとした。

学習課題は、学習期とテスト期から構成した。学習期では、刺激語（漢字で示された魚名）と反応語（魚名のひらがな単語）を対にして呈示した。対象者には、漢字に対する読みを記憶するよう教示した。刺激語と反応語の対刺激の呈示時間は4秒で、対刺激と対刺激の間には、ブランク刺激を2秒呈示した。1年生から4年生は5対、5年生と6年生は6対を1セットとして呈示した。学習期の後に、テスト期を行った。テスト期では、刺激語のみ7秒ずつ順次呈示し、対象者に対して反応語を口頭で言うよう求めた。学習期とテスト期を1試行として、各学年において5試行実施した。各試行の学習期において、対刺激の呈示順序はランダムとした。

LD児に対しては、第1回目の対連合学習課題の実施2週間後に、同じ課題による第2回目の対連合学習課題を実施した。すべてのLD児に対しては、リストAを用いた。

4. 分　析

分析は、総学習量と写真刺激呈示の効果量について行った。総学習量は、テスト期における学習課題5試行の正答数の総数とした。写真刺激呈示の効果量は、写真刺激呈示条件とコントロール条件の総学習量の差とした。健常児の各学年について、各条件の総学習量の平均と標準偏差値を算出し、写真刺激呈示の効果量の平均と標準偏差値を算出した。これに基づき、LD児の各事例について、総学習量と写真刺激呈示の効果量を、それぞれ標準得点に換算した。

III. 結　果

1. 健常児

Table 3は健常児の総学習量について示したものである。

1年生から4年生では、学習する魚漢字の数は5個であった。総学習量に関して、4（学年）×2（条件）を要因とする2要因分散分析を行った。学年と条件のそれぞれに関して主効果が認められ（学年：$F(3,59)=12.55$, $p<.01$, 条件：$F(1,59)=19.51$, $p<.01$）、学年と条件で交互作用が認められた（$F(3,59)=2.80$, $p<.05$）。単純主効果の検定により、2年生群と3年生群において条件要因で単純主効果が認められ（$p<.05$）、コントロール条件と写真刺激呈示条件における学年要因で単純主効果が認められた（$p<.05$）。これより2年生群と3年生群では、写真刺激呈示条件の学習量は、コントロール条件と比べて有意に大きいことが指摘できる。

5年生と6年生では、学習する魚漢字の数は6個であった。総学習量に関して、2（学年）×2（条件）を要因とする分散分析を行った。条件に関して主効果が認められ（$F(1,30)=8.53$, $p<.01$）、学年と条件で交互作用が認められた（$F(1,30)=5.26$, $p<.05$）。単純主効果の検定より、5年生群において条件要因で単純主

効果が認められ ($p<.05$)、コントロール条件における学年要因で単純主効果が認められた ($p<.05$)。これより5年生群では、写真刺激呈示条件の学習量は、コントロール条件と比べて有意に大きいことが指摘できる。

2. LD 児

1）第1回学習と第2回学習の成績について：Fig. 1は、LD 児の第1回学習と第2回学習における総学習量を、標準得点として示したものである。標準得点は、LD 児の在籍学年（5年生以上の LD 児に関しては健常児4年生群）における健常児群の総学習量の平均と標準偏差に基づき算出した。Fig. 1は、対象者を、第2回学習における総学習量の順に配列して表示したものである。これより、20名中7名では、第1回学習と第2回学習の総学習量が、健常児の平均 $-1SD$ の総学習量より小さいことが指摘できる。他の13名では、第2回学習の総学習量は、健常児の平均 $-1SD$ の総学習量より大きいことが指摘できる。第1回学習と第2回学習の総学習量が健常児の平均 $-1SD$ の総学習量より小さい事例では、魚漢字の読みの学習がきわめて困難であることが指摘できる。そこで、本研究では、第1回学習と第2回学習の総学習量が健常児群の平均値 $-1SD$ の総学習量より小さい LD 児7名をA群、第2回学習の総学習量が、健常児の平均値 $-1SD$ の総学習量より大きい LD 児13名をB群に分類し、写真刺激呈示条件における学習促進の効果について検討する。

Fig. 2は、A群の事例2名とB群の事例2名における学習曲線を示す。

A群に関して、対象児 S7 は第1回と第2回学習において写真刺激呈示条件における正答数は、コントロール条件と比べて、5試行中5試行で大きいことが指摘できる。第1回と第2回学習において、写真刺激呈示条件がコントロール条件より5試行中3試行以上で正答数が大きい特徴は、A群の7名中3名でみられた。対象児 S2 は、第2回学習において写真刺激呈示条件における正答数は、コントロール条件と比べて5試行中5試行で大きかった。第2回学習においてのみ、写真刺激呈示条件がコントロール条件より5試行中3試行以上で正答数が大きい特徴は、A群の7名中4名でみられた。

B群に関して、対象児 S16 は第1回と第2回学習において写真刺激呈示条件における正答数は、コントロール条件と比べて5試行中3試行以上で小さいことが指摘できる。第1回と第2回学習において、写真刺激呈示条件がコントロール条件より5試行中3試行以上で正答数が小さい特徴は、B群の13名中7名でみられた。対象児 S10 は、第1回と第2回学習とも、写真刺激呈示条件とコントロール条件で正答数に差はみられなかった。このような特徴は、B群の13名中4名でみられた。

Fig. 3は、A群とB群における、コントロール条件と写真刺激呈示条件の総学習量と学習効果量の標準得点を示す。学習効果量について、A群では、第2回学習で全例とも、健常児の効果量の平均から平均 $+2SD$ の範囲内の値を示した。

学習効果量に関して、2（第1回学習・第2回学習）×2（A群・B群）を要因とする2要因分散分析を行った。A群・B群において主効果が認められ ($F(1,18)=8.04$, $p<.05$)、A群・B群と第1回学習・第2回学習

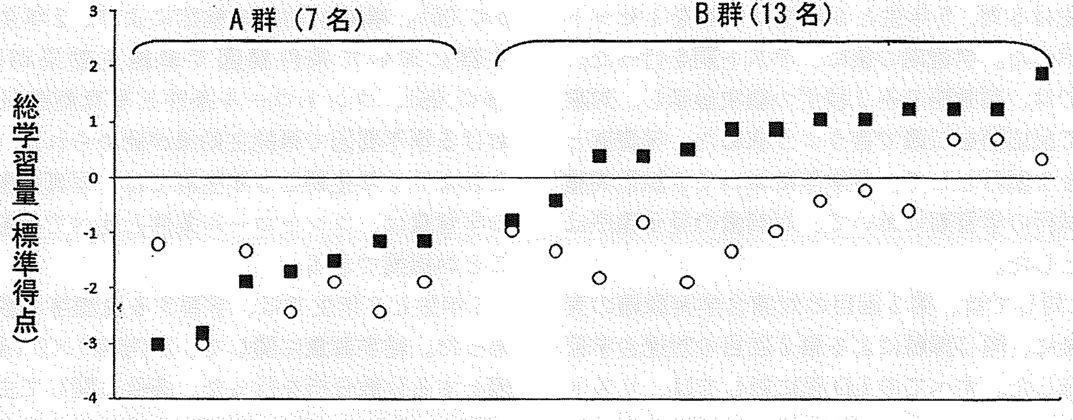

Fig. 1　第1回・第2回学習のコントロール条件における総学習量（LD 児）
各 LD 事例の総学習量について，健常児群を基準として標準得点を表示した．対象児は，第2回の総学習量が小さいものから順に配列した．○：第1回，■：第2回．

に交互作用が認められた（$F(1, 18) = 4.59$, $p < .01$）。単純主効果の検定より、A 群で単純主効果が認められ（$p < .05$）、第 2 回学習で単純主効果が認められた（$p < .05$）。これより、A 群における視覚刺激の先行呈示に伴う学習量の増加は、B 群よりも大きく、第 1 回学習よりも第 2 回学習で大きいことが指摘できる。

A 群と B 群では、視覚刺激の先行呈示に伴う学習効果量は異なることが指摘できた。そこで、各群における文読み課題の成績ならびに情報処理の特性について検討する。

2）読み課題の成績との関連：読み課題は、文読み課題とひらがなと漢字単語の読み課題について検討した。

本研究における読み障害は、文読み課題（葛西ら, 2006）に基づき、ひらがな文の音読に要した時間と誤読数が、健常児の平均値 +2*SD* の範囲を超える LD 児とし、読み障害を示した者（SRD）と示さなかった者（NSRD）に分類して（Goto et al., 2008）、検討を行う。

ひらがな文の読みに要した時間が長く、誤読数が健常児の平均値 +2*SD* の範囲を超える SRD 児は、A 群において 7 名中 6 名、B 群では 13 名中 4 名であり、B 群と比べて A 群の割合が有意に大きい傾向を指摘できた（Fisher 直接検定, $p = 0.057$, Table 1）。

ひらがなと漢字単語の読みに関しては、K-ABC 検査の「ことばの読み」により評価した（Table 1）。

「ことばの読み」の標準得点は、A 群よりも B 群のほうが有意に高いことが指摘できた（Mann-Whitney 検定, $U = 20.5$, $p < .05$）。

3）情報処理の特性との関連：情報処理の特性は、WISC-IIIの群指数によって検討を行う。A 群と B 群を判別する情報処理特性について、WISC-IIIの群指数を説明変数としたステップワイズ法による判別分析を用いて分析を行った。その結果、説明変数に注意記憶を用いたとき、判別関数は $y = 0.083 \times$（注意記憶）$- 7.741$ であり（Wilks' $\lambda = 0.78$, $p < .05$）、正判別率は 70.0% であった。さらに A 群と B 群を判別する情報処理特性について、WISC-IIIの下位検査評価点を説明変数としたステップワイズ法による判別分析を用いて分析を行った結果、説明変数に WISC-III の「数唱」課題を用いたとき、判別関数は $y = 0.474 \times$（数唱）$- 4.221$ であり（Wilks' $\lambda = 0.55$, $p < .01$）、正判別率は 85.0% であった。

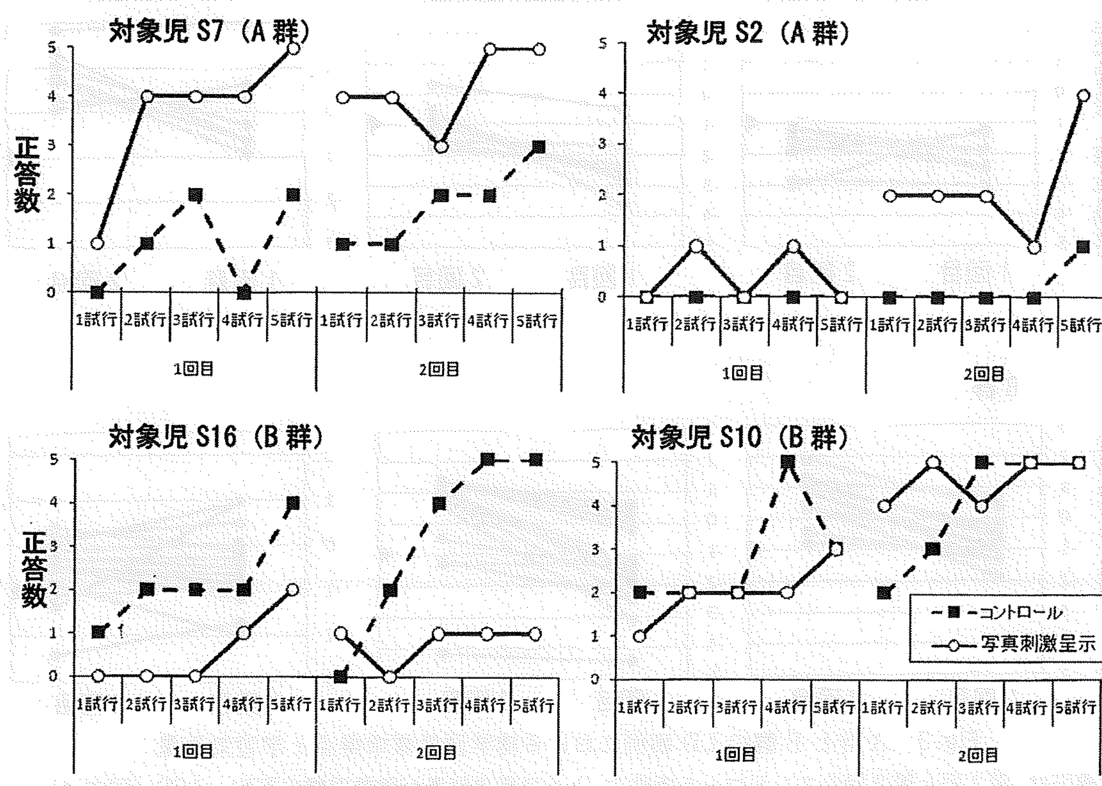

Fig. 2　A 群（上段）と B 群（下段）の代表 LD 事例における学習曲線
対象児は, Table 1 に対応する.