Original Article

Early Development of Understanding Words and Equivalence Cognition of Matching Pictures: Children With Severe Motor and Intellectual Disabilities

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The present study aimed to investigate the relation between early development of the understanding of words and equivalence cognition of matching pictures in children with severe motor and intellectual disabilities (SMID). Equivalence cognition accompanying expectancy was evaluated by measuring expectancy heart rate (HR) responses on a task of sample matching with an S1-S2 paradigm. Using the Japanese MacArthur Communicative Developmental Inventory, mothers of 5 of the 12 participants evaluated their children as being able to understand more than 60 words (Group A). The teachers of 3 of the participants in Group A did not evaluate those participants as being able to understand as many words. The mothers and teachers evaluated 7 participants as understanding fewer than 20 words (Group B). In the task of matching sample shapes with colors, the number of correct choices by the children in Group A was larger than that by the children in Group B. The ratio of occurrence of expectancy heart rate responses in the Group A children was larger than that in the Group B children. Participants in Group A whose understanding of words was evaluated as good by their mothers might have equivalence cognition of matching pictures, which accompanies expectancy.

Key Words: sample matching task, expectancy heart rate responses, Japanese MacArthur Communicative Developmental Inventory, cognition of equivalence, children with severe motor and intellectual disabilities

Introduction

With progress in the technology of augmentative and alternative communication (AAC), methods of teaching children with severe motor and intellectual disabilities (SMID) have been studied (Iino, 2005; Takaizumi & Ishida, 1999). Evaluation of the

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T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

early development of the understanding of words in such children is needed for useful application of the technology of augmentative and alternative communication (Oishi, 2006).

In a study of early development of understanding words, Nagasaki and Onosato (1996) examined behavior patterns of young infants at about 8 months and above. They found that young infants can pay attention to objects pointed to by their mothers. Nagasaki and Onosato (1996) also noted that visual discrimination of object shapes develops during early infancy, in that infants can identify objects that their mothers indicate with spoken words.

Development of the understanding of words is delayed in children with severe motor and intellectual disabilities. Such children also have weak responsiveness to visual stimuli. This is considered to be related to the underdevelopment of their visual cognition (Katagiri, Koike, & Kitajima, 1999). Thus, in order to clarify early development of the understanding of words in children with severe motor and intellectual disabilities, it is important to investigate how visual cognition relates to development of the understanding of words.

In a study of development of understanding words in children with motor and intellectual disabilities, Otomo (2005) asked mothers to complete the Japanese version of the MacArthur Communicative Developmental Inventory (Komuku & Watamaki, 2004). The results indicated that children with motor and intellectual disabilities were reported to have good understanding of words related to routine events of daily life. Because all the children's understanding of words was also evaluated by their teachers, it is possible that the evaluations by teachers based on their classroom contacts with the children were different from the evaluations by mothers, based on their experience with their children at home. If so, then for investigation of the understanding of words by children with severe motor and intellectual disabilities, evaluations by their teachers might be needed in addition to evaluations by their mothers. Some children with severe motor and intellectual disabilities might be evaluated by both their teachers and their mothers as having good understanding of words, whereas others might be evaluated by both teachers and mothers as not having a good understanding of words. These children might show an obvious tendency to respond or not respond to spoken words. But other children with severe motor and intellectual disabilities might be evaluated only by their mothers as understanding some words. Their responses might not be as obvious, but they may exhibit behavior that enables their mothers to understand their children's responses to words in their daily care of them. Thus, these children are considered to be early in the process of development of their understanding of words, and they might be able to attain an early stage of cognitive development.

In a study of the development of visual cognition before the attainment of the understanding of words, Odera, Kurai, and Satake (1998) examined the process of training children with severe intellectual disabilities. Odera et al. (1998) suggested that the ability to match pictures on common visual features through recognizing the equivalence of stimuli in the task of sample matching was a prerequisite conditions

Equivalence Cognition in Children With SMID

for the development of the understanding of spoken words. On the basis of the findings of Odera et al. (1998), children with severe motor and intellectual disabilities who are evaluated by their mothers as having an understanding of words and who are considered to be early in the process of development of the understanding of words, might attain equivalence cognition of matching pictures.

In classroom teaching, when children with severe intellectual disabilities have not showed stable matching behavior, adjustments for each child of the shape and color of the stimuli have been known to be effective for prompting matching behavior. This suggests that children with severe intellectual disabilities might have shape or color preferences. From this, it can be inferred that children with severe motor disabilities as well as intellectual disabilities might also have shape or color preferences and might also show preferences when matching on shape or color.

Because children with severe motor and intellectual disabilities have severe motor disabilities, accurate observation of their matching behavior is difficult, and correct evaluation of equivalence cognition is also uncertain. Thus, in order to study the behavior of children with severe motor and intellectual disabilities, it is necessary to develop a method for evaluating equivalence cognition of matching in such children. Kitajima, Koike, Katada, and Matsuno (1993) found that expectancy heart rate (HR) responses could be observed in an S1-S2 paradigm in children with severe motor and intellectual disabilities whose communication ages were approximately 8 months and above. In a sample matching task, the behavior of choosing a stimulus identical to the sample was reinforced immediately. When children with severe motor and intellectual disabilities were slow to choose a stimulus, a supporter made the choice for them. Thus, using the S1-S2 paradigm, expectancy heart rate responses could be recorded during the sample matching task. In this situation, S1 was the time of the supporter's choice, and S2, the time of the delivery of the reinforcing stimulus. When the chosen stimulus was identical with the sample, the reinforcing stimulus (S2) was presented. When expectancy heart rate responses occurred in the S1-S2 interval on trials in which the stimuli were identical, it was speculated that the children might have judged the pictures to be identical and hence have expected the reinforcing stimulus (S2).

Through the observation of children's correct choices in a sample matching task, equivalence cognitions can be inferred. From the findings with respect to expectancy heart rate responses, equivalence cognitions that accompany expectancy can be inferred. Because equivalence cognition accompanying expectancy is considered to allow children with severe motor and intellectual disabilities to learn relations between objects actively, despite their severe motor dysfunctions, equivalence cognition with expectancy might widen the possibilities for them to be able to understand relations between objects and spoken words.

On the basis of the above, children with severe motor and intellectual disabilities, whose understanding of words is developing and which has been evaluated mainly by their mothers, might show expectancy heart rate responses on trials with identical stimuli and attain the equivalence cognition that accompanies expectancy.

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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.

Equivalence Cognition in Children With SMID

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	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.

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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

Equivalence Cognition in Children With SMID

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

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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

Equivalence Cognition in Children With SMID

(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.

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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.

Equivalence Cognition in Children With SMID

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) $\pm$ 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.

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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.

Equivalence Cognition in Children With SMID

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.

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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

Equivalence Cognition in Children With SMID

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 involving 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 frequency 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

T. Koike, Y. Yoshida, M. Kumoi & K. Katagiri

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)

Equivalence Cognition in Children With SMID

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 Communication 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)

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