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9 The Effect of the Respondent-Type Procedure on Acquisition and Transfer of Literacy in Students with Developmental Disabilities

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I. Introduction

Equivalent relation and respondent-type procedure

Equivalent relation or stimulus equivalence (Sidman & Tailby, 1982; Sidman, 1994 and 2000) is derived relation without direct training through a series of interrelated conditional discriminations. This was demonstrated, for example, when the participants learned to choose the stimulus B in the presence of stimulus A and to choose stimulus C in the presence of stimulus B. After the training, most of them could correct an untrained relation such as: choosing A in the presence of B (symmetry), choosing B in the presence of C (symmetry), choosing A in the presence of C (transitivity or equivalence), and choosing C in the presence of A (transitivity). The phenomenon of equivalent relation or stimulus equivalence was reported in various subjects such as children (Saunders, Drake, & Spradlin, 1999), children with developmental disabilities (Yamamoto & Shimizu, 2001), infrahuman (Yamamoto & Asano, 1995), and other species (Schusterman & Kastak, 1993; Manabe, Kawashima, & Staddon, 1995).

In learning reading and writing, one important target is acquisition of the equivalent relation among the characters, the objects, and vocal responses (Hayes & Hayes, 1992; Mackay, 1985). For example, comprehension of reading could define the relation between words or sentences and meanings, or the relation among the words, mediating vocal responses, and meanings. When students learn such equivalent relations, they acquire ones by the single discrimination task (Shenk, 1995; Smeets & Barnes, 1997), the arbitrary matching-to-sample task (Yamamoto & Shimizu, 2001), or the constructional matching-to-sample task (Stromer & Mackay, 1992; Calcagno, Dube, Galvao, & Sidman, 1994; Yamamoto & Miya, 1999; Sugasawara & Yamamoto, 2007).

More recently, the respondent-type procedure (Ret-procedure) was used for acquiring equivalent relations (Leader, Barnes, & Smeets, 1996; Smeets, Leader, & Barnes, 1997). With the Ret-procedure, participants were only required to observe the stimuli presented sequentially on a computer display, and were not required to provide overt responses (such as choosing or constructing the comparisons). Although they did not show the overt operant responses explicitly, they demonstrated the equivalent relations such as symmetry, transitivity, and equivalence after Ret-procedure training (Leader et al., 1996). In addition, Smeets et al. (1997) reported that participants including children and adults showed higher accuracy in the transfer test after Ret-procedure training than after the arbitrary matching-to-sample task training. Smeets et al. (1997) argued that the Ret-procedure was more effective than arbitrary matching-to-sample tasks for acquiring equivalent relations.

Clayton and Hayes (2004), however, demonstrated another perspective. They trained participants by the Ret-procedure training and arbitrary matching-to-sample task using Kanji stimuli. Most of the participants could not read Kanji stimuli (such as the non-sense figure). They showed higher accuracy in the transfer test after the arbitrary matching-to-sample task training than after Ret-procedure training. The Japanese participant, who could read the Kanji stimuli, conversely showed high accuracy in the transfer test after Ret-procedure training (Clayton & Hayes, 2004). In the research of equivalence relation, some researchers emphasized the function of naming, called "naming hypothesis" (Horne & Lowe, 1996). When children, who did not identify the equivalent relations after arbitrary matching-to-sample tasks training, were trained to common name each class member, they could show the equivalent relations (Eikeseth & Smith, 1992). Horne and Lowe (1996), in particular

argued that naming was based on equivalent relations though the acquisition of listener behavior. Clayton and Hayes (2004) argued that namable stimuli accelerated so as to acquire the stimulus class or to enhance the stimulus class as "extra-experimental histories." Naming was one of the important factors necessary to acquire the equivalent relation.

Transfer of Reading and Writing

In most transfer test situations, participants were assessed for derived relation to choose the comparison, irrespective of the arbitrary matching-to-sample task or the Ret-procedure task. In contrast, in the academic setting, studnets were required to do differential responding by reading or writing their responses. Students with developmental disabilities often showed difficulties in acquiring the equivalent relations among the printed words, the spoken words, and their meanings (Yamamoto & Shimizu, 2001). Consequently, it has remained important from the perspective of basic and applied research to find a method for producing equivalent relation and transfer of reading and writing responses.

In the present study, participants showed some differential responding in reading or writing, when they were trained in equivalent relations through the arbitrary matching-to-sample (Yamamoto & Shimizu, 2001) or the constructional matching-to-sample (Stromer, Mackay, Howell, McVay, & Flusser, 1996; Sugasawara & Yamamoto, 2007). In this research, participants had some relevant skills in copying alphabetic characters and providing echoic responses to the pronunciation of each Japanese Kana character before training. The differential outcome procedure was used in the training to provide a specific reinforcing stimulus after a particular response (Dube & McIlvane, 1995; Sidman, 2000). For example, when the student selected the correct comparison stimulus, the spoken word was presented as the differential outcome stimulus. Several pre-skills, in addition to the differential outcome procedure, facilitated acquisition of the equivalent relations and/or to transfer the differential responding by students. From those results, we assumed that the participants could show differential responding through Ret-procedure training, which facilitated acquisition of the equivalent relation.

In this study, we examined whether the Ret-procedure training would facilitate emergence of a Kanji writing response in students with developmental

disabilities. For example, a Kana word corresponding with the reading of a Kanji character and the Kanji character were used as a stimulus-pair. Students were required to observe some stimulus-pairs presented sequentially on a computer display. We expected students would not only acquire the equivalent relation but would also be able to dictate the Kanji character from the spoken kanji stimulus.

1. Method

1.1. Participants

In this study, six students with developmental disabilities (four boys and two girls; age = 10:11 to 13:01) participated. Students ranged from 5th to 7th grade in elementary school or junior high school. They were each diagnosed with developmental disabilities (four autistic disorders, one AD/HD, and one LD). Either their teacher or parents had asked us to provide some academic skills instruction for the participants. The mean of their full IQ score was 76 (range = 48 to 143), the mean verbal IQ score was 76 (range = 43 to 148), and the mean performance IQ was 81 (range = 57 to 128) by WISC-III (Japanese Wechsler Intelligence Scale for Children-Third Edition, 1998).

Before the assessment, we provided written instruction to their parents about the contents of this program, treatment of personal data, and their rights to drop out from the program. Then, we obtained written confirmation from all parents for participation in this study

1.2. Materials & Setting

The computer programs were created using Adobe Macromedia Director MX® and IBM NOTE PC (Sony PCG-TR5B) was used to present the stimuli. For the assessment of writing responses, a sheet (A4 size) with a printed ruled line (2 cm spacing) was used. The assessment and training were conducted mainly in the education support center and the private educational support room.

Table 1 Stimulus sets for each of the students.

	Set-A												Set-B						Set-C					
	known items					unknown items							unknown items						unknown items					
Key	灰	竜	源	鉱	疑	遺	観	忠	供	至	装	挙	湯	翼	銃	則	著	存	–	–	–	–	–	
Kou	決	商	客	漢	落	面	熱	所	箱	発	館	送	飛	望	印	祝	差	伝	–	–	–	–	–	–
Akira	骨	源	呼	紅	己	砂	座	降	誤	駅	団	晩	裁	至	到	千	敬	映	–	–	–	–	–	–
Mari	命	求	機	潮	暇	鉄	点	駅	住	等	度	重	党	調	象	荷	速	老	–	–	–	–	–	–
Ai	疑	吸	民	快	映	割	刊	異	華	反	連	沿	域	液	個	管	慣	抵	–	–	–	–	–	–
Hiro	吸	述	筆	素	灰	敬	刻	装	希	映	郷	潮	権	異	誤	革	撃	供	疑	蒸	拡	机	経	域

1.3. Stimulus set

We conducted a pre-assessment to assess unknown Kanji characters. In the pre-assessment, forty Kanji characters that each participant had the opportunity to learn from ex-two grade to their actual grade were assessed. Participants were required to write forty Kanji characters from readings printed in Kana (pronunciation). We randomly chose the six known Kanji characters and twenty or eighteen unknown Kanji characters from the pre-assessment result. We randomly assigned six unknown kanji stimuli to one stimulus set. All of the Kanji stimuli and stimulus sets are presented on Table.1.

1.4. Experimental design

In this study, a multi-probe design (Barlow & Hersen, 1984/1997) among stimulus sets was conducted. Two or three stimulus sets were assigned to each participant. For the baseline of the first stimulus set, we conducted only one block with all participants. For the second or third stimulus sets, we conducted two or more blocks. When participants reached up to either the learning criterion or unlearning criterion of the first or second stimulus set, they were required to try the next stimulus set. In this study, the students participated in one to five sessions for three weeks. One session could continue up to one hour.

1.5. Procedure

1.5.1. Baseline

In the baseline, we assessed the writing responses from spoken Kanji stimuli. For this task, the student was required to write Kanji characters correctly in

response to the spoken word of Kanji stimuli on the assessment sheet. For example, the student listened to the spoken Kanji stimulus "i-nu (which means dog)" by the experimenter, and then the student was required to dictate Kanji character "犬" (which means dog) in the assessment sheet.

At first, we instructed the student to draw a circle when he/she could not write or recall the Kanji character. Each trial began with the presentation of the spoken Kanji stimulus. The student was required to write the kanji character corresponding to the spoken Kanji stimulus correctly. When the student showed no response after 10 sec, we instructed that a circle be drawn again. The student was not given feedback for "correct" or "incorrect" writing responses during the baseline. This baseline consisted of eighteen or twenty-four trials including six known Kanji stimuli and twelve or eighteen unknown kanji stimuli. We recorded the number of correct responses to evaluate their Kanji writing skills.

1.5.2. Ret-procedure training

In this task, we introduced the Ret-procedure training by initially only requiring the student to observe the stimuli presented sequentially on the computer display. The training consisted of six paired stimuli that included Kanji characters and Kana words and the corresponding pronunciation of Kanji characters. At first, a Kana word stimulus was presented in the middle of the display for 1 sec. After 1 sec, a blank screen was presented for a 0.5 sec inter-stimulus interval. Then, the Kanji character was presented in the middle of the display for 1 sec. After 1 sec, the blank screen was presented again for a 3 sec inter-trial interval. For example, the kana word "いぬ (dog)" was presented for 1sec. The blank screen was presented for 0.5 sec; then, the Kanji character "犬 (dog) " was presented. The stimulus pair was always indicated by a Kana word then followed by the appropriate Kanji character. We implemented the presentation time of each stimulus, inter-stimulus interval, and inter trial interval in accordance with Leader et al. (1996). One block consisted of eighteen trials, with six stimulus pairs presented three times quasi-randomly. After the training, we introduced the transfer test quickly.

1.5.3. The transfer test

For the transfer test, the student was required to write the spoken Kanji stimulus again. Eighteen or twenty-four Kanji stimuli were presented randomly. Each trial began with the presentation of the spoken Kanji stimulus, then the student

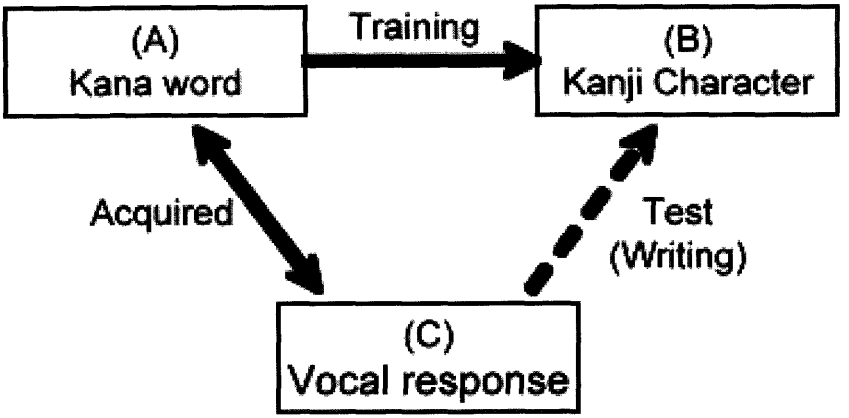

Fig. 1 Training and test relations

was required to write the Kanji character correctly. When the student wrote the Kanji characters or drew a circle meaning unknown or no recollection of the Kanji character, the next trial was conducted. We did not provide the student with contingent feedback. Basically, the transfer test was the same procedure as was used for the pre-assessment.

In the transfer test, when students could write the trained kanji stimuli correctly over 80% of the time, we conducted the next stimulus set in Ret-procedure training. If students showed low accuracy in the transfer test, we trained using the same stimulus set by Ret-procedure training again. Then we re-tested the transfer test.

If the student showed less than 65% accuracy in the second transfer test, we ramped down to half of the stimuli in all stimulus sets, on the assumption that an overfull stimuli level had been reached by the participant. We chose nine stimuli consisting of three known kanji stimuli in the known stimulus set, three stimuli written correctly in unknown stimulus set A, and three stimuli that were determined randomly. Training and test relations showed figure 1.

1.6. Dependent Measures

In this study, we evaluated two dependent measures: the percent of correctly dictated-responses in the baseline and the transfer test, and the mediating

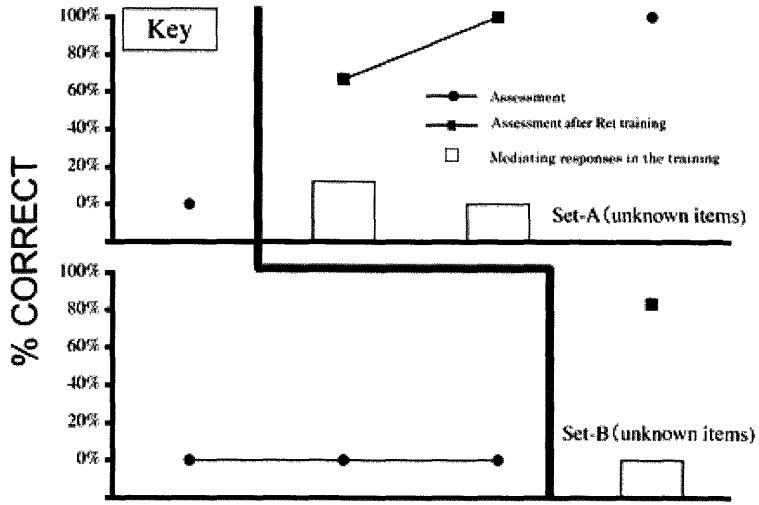

Fig. 2 Percent of correct Kanji dictation writing responses by Key

responses, such as vocalizations or responses made with a finger for the presented stimuli in Ret-procedure training. Mediating responses, were defined as overt operant responses that included reading responses to the presented Kana and Kanji stimulus and writing responses made with a finger. When the student used such overt responses, we counted one response in per trial. We calculated the rate of mediating responses used in the trials.

2. Result

Figure 2 shows the percentage of correct dictation responses, and the rate of mediating responses for each stimulus set at the baseline and the transfer test in Key. In two unknown stimulus sets, Key could not dictate all twelve Kanji characters correctly during the first blocks of the baseline. Then we introduced the Ret-procedure training to the unknown stimulus set A. During the Ret-procedure training, Key showed mediating responses including vocalization of Kanji stimuli and kana word stimuli in two trials, which was 11% of all trials. In the transfer test, Key showed 67% accuracy in her responses, which showed she could write four of six Kanji characters. Key was required to try the Ret-procedure training to the unknown stimulus set A

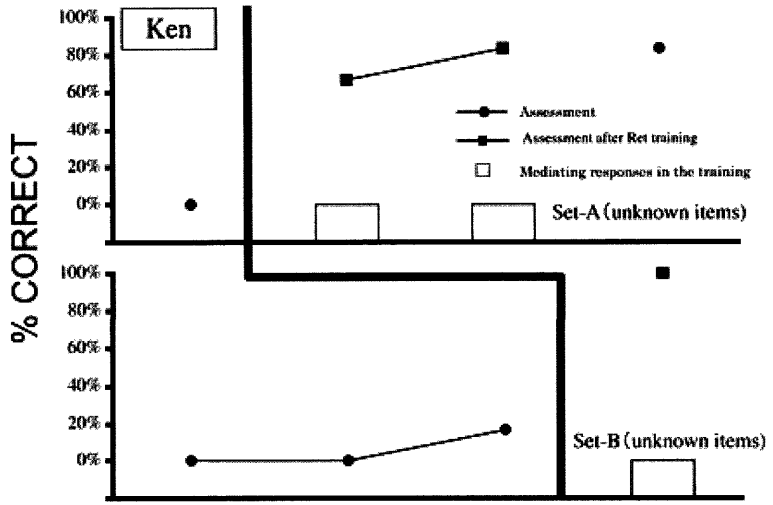

Fig.3 Percent of correct Kanji dictation writing responses by Ken

again, because Key had not achieved the 80% learning criterion. In the second transfer test, Key could respond correctly to all trained kanji stimuli. In the second Ret-procedure training, Key showed no mediating responses.

Key could not write the kanji characters in the unknown stimulus set B for three blocks of the baseline. Then, we introduced the Ret-procedure training to the unknown stimulus set B. In the first transfer test, Key showed correct responses at 83%, which showed that she could write five of six Kanji characters. Key passed the learning criterion only once in training. Key showed 100% accuracy in her responses for stimulus set A. In the training for unknown stimulus set B, Key showed no mediating responses. Key could consistently write the correct Kanji characters in known stimuli during all phases.

Figure 3 shows the percentage of correct dictation responses and the rate of mediating responses in Ken. Ken showed results that were similar to Key's. For the two unknown stimulus sets, Ken could not dictate all twelve Kanji characters correctly. During Ret-procedure training with unknown set A, Ken showed no mediating responses. In the first transfer test, Ken showed 67% accuracy. Ken was then required to try the Ret-procedure training to the unknown stimulus set A again. In the second transfer test, Key could identify all trained kanji stimuli correctly. In the second training, Key showed no

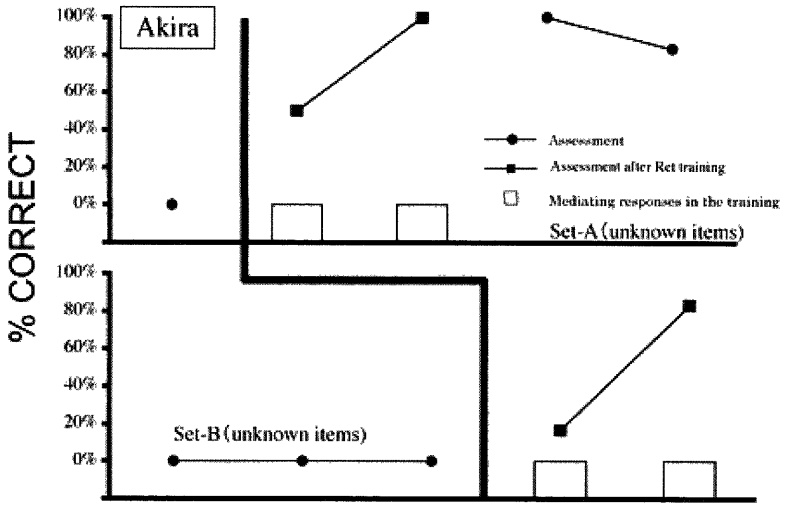

Fig. 4 Percent of correct Kanji dictation writing responses by Akira

mediating responses.

Ken could not write the kanji characters in the unknown stimulus set B for three blocks of the baseline. Then, we introduced Ret-procedure training to the unknown stimulus set B. In the first transfer test, Ken achieved 100% accuracy for responses to set B and 87% for responses to set A. In the training for unknown stimulus set B, Key showed no mediating responses. Key could consistently write the correct Kanji characters in known stimuli in this study.

Figure 4 shows the percentage of correctly written responses and the rate of mediating responses for Akira. Akira showed similar results as Key and Ken did. For the two unknown stimulus sets, Akira also could not dictate all twelve Kanji characters correctly. In the first transfer test, Akira showed 50% accuracy. In the second transfer test, Akira could write all Kanji stimuli in set A correctly. Then, we introduced Ret-procedure training to the unknown stimulus set B. In the first transfer test, Akira showed 16% accuracy in responses to set B and 100% accuracy in responding to set A. We provided Ret-procedure training for stimulus set B again. In the second transfer test, she showed 100% accuracy in responding to set A and 87% accuracy in responding to set B. In all of the training phases, Akira showed no overt mediating responses.

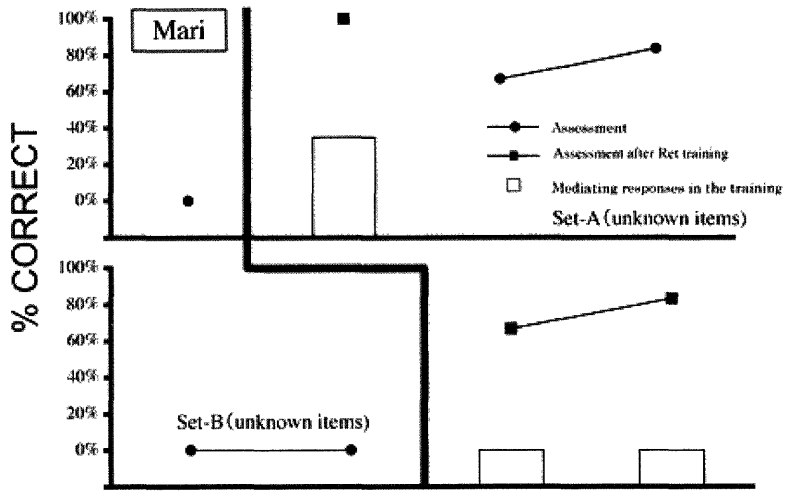

Fig. 5 Percent of correct Kanji dictation writing responses by Mari

Figure 5 shows the percentage of correct writing responses and the rate of mediating responses in Mari. For the two unknown stimulus sets, Mari could not dictate all twelve Kanji characters correctly. In the first transfer test, Mari could dictate all the Kanji stimuli. During Ret-procedure training, Mari showed mediating responses in six trials, which equaled 33% of all trials, including the vocalization of Kanji stimuli and Kana word stimuli. We introduced the next set with Ret-procedure training. In the first transfer test, she showed 67 % accuracy for responses to set B and 67% accuracy for responses to set A. We provided Ret-procedure training for stimulus set B again. In the second transfer test, she showed 86 % accuracy in responding to both set A and set B. In the training phase of set B, Mari showed no overt mediating responses.

Figure 6 shows the percentage of accurate writing responses and the rate of mediating responses in Ai. For the two unknown stimulus sets, Ai could not dictate all twelve Kanji characters correctly. In the first transfer test after the training of set A, Ai could dictate only one of six Kanji stimuli. In addition, she could not write half of Kanji characters, which were assigned to known stimuli. During Ret-procedure training, Mari showed mediating responses in four trials, which equaled to 22% of all trials, including the vocalization and the writing responses made using a finger. We introduced the Ret-

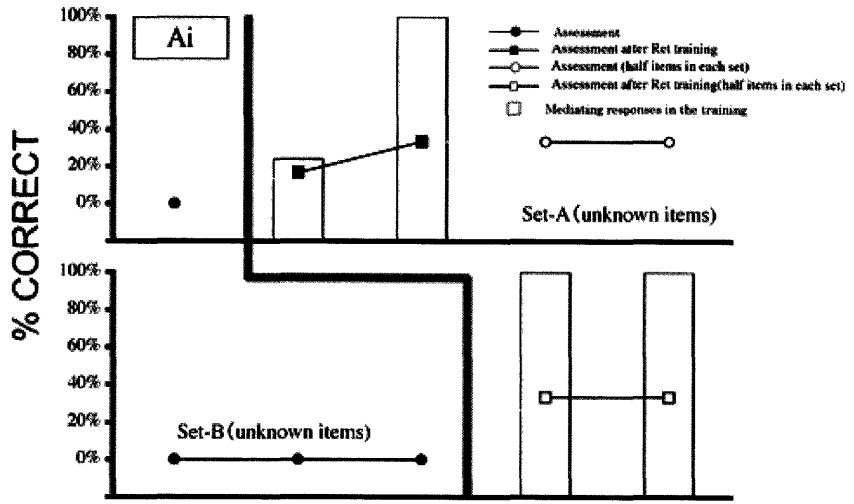

Fig. 6 Percent of correct Kanji dictation writing responses by Ai

procedure training again. In the second transfer test, she showed 33 % of correct responses to set A and 50% of correct responses to known stimuli.

Ai showed mediating responses in all trials, including vocalization and the writing responses made using a finger. She was required to train in the reduced stimulus set, which consisted of three of six Kanji stimuli in the stimulus set B, because she could not pass the learning criterion. We retained the stimuli for writing correct Kanji characters in known stimuli and unknown stimulus of set A. In the first transfer test after the training for set B, she showed 33 % accuracy in her responses. She showed 100% accuracy for Kanji writing for three known Kanji stimuli; however, she could write one of three Kanji characters in set A. After re-training for set B, she also showed 33 % of accuracy in her responses. During the training phase for set B, Ai showed overt mediating responses in all trials. We then stopped training and testing with Ai.

Figure 7 shows the percentage of correct writing responses and the rate of mediating responses for Hiro. We introduce three stimulus sets. For the three unknown stimulus sets, Hiro could not dictate most Kanji characters correctly. Hiro showed 50% accuracy and 83% accuracy in the first and second transfer tests, respectively. After training for Sets B and C, he could dictate all Kanji

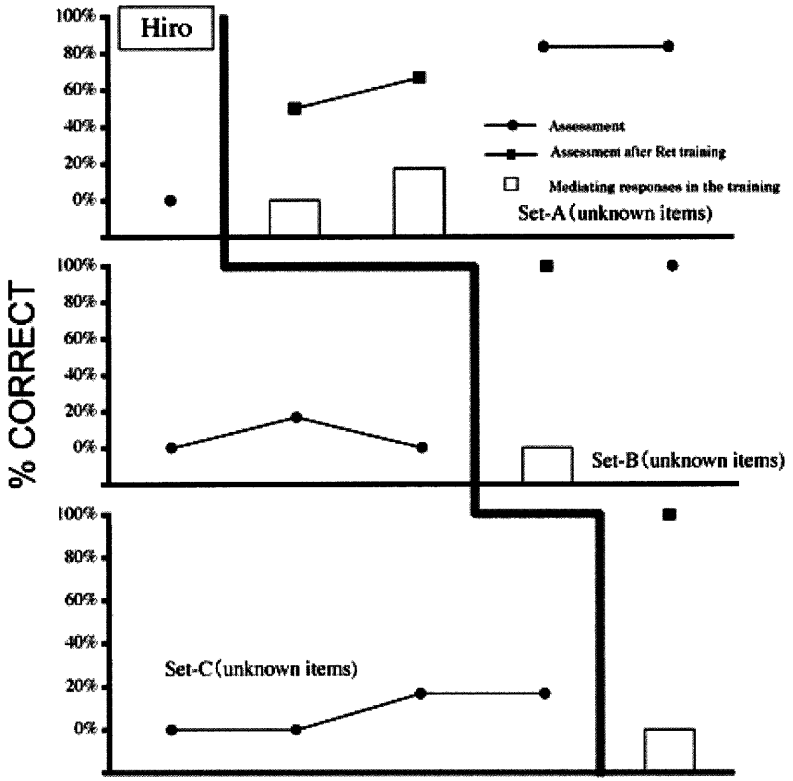

Fig. 7 Percent of correct Kanji dictation writing responses by Hiro

characters in first transfer test. He showed no overt mediating responses in any of the training phases.

We calculated the correlation between the occurrence rates of mediating responses and the number of learned Kanji characters immediately after the transfer test. The correlation r was -0.61 and moderately significant ($F = 11.58$, $p < .01$).

3. Discussion

In this study, six students with developmental disabilities were trained to learn the relation between Kanji characters and the Kana words in correspondence to the pronunciation of Kanji stimulus by Ret-procedure training. As a result,

five of six students showed the transfer to dictation of the kanji characters without direct training.

3.1. Acquisition of equivalent relation via Ret-procedure

In the Ret-procedure, stimulus-pairs were presented consequentially with a shorter inter-stimulus interval than the inter-trial interval. Why did students acquire the equivalent relation among the trained stimuli? In the developmental process, children as listeners learned the relation between the object and corresponding name through simultaneous presentation (Horne & Lowe, 1996). For example, when the child saw the dog, the parent said, "That is a dog!" The child acquired the relationship between the name "dog" and the dog. In many cases, seeing the dog and hearing the word "dog" could simultaneously occur. Woodward and Hoyne (1999) reported that infants of 13 months could learn the relation between material pointed to with an index finger and the non-sense name that it was called by the experimenter.

Stimulus-pairs were presented in small intervals to facilitate equivalence in individuals, because they were often exposed to a contingency of reinforcement when the individual related adjacent stimuli. Through the history of reinforcement, the individual had acquired generalized contextual cues such as "sameness" or "coordination" (Barnes, 1994).

Students would acquire the relation between a Kana word and the corresponding Kanji character due to visual stimuli by successive presentation. The acquisition of that relation had a potential that was accelerated by the corresponding vocal responses. We assumed that the equivalent relation was formed among the Kana words, Kanji characters, and vocal responses.

In this study, we defined the vocal responses as the naming of common Kana words and Kanji characters. For example, as when the uppercase of "A" and lowercase of "a" are similarly pronounced "ei" in English. In Japanese, the Kana word "いぬ (meaning dog)" and the Kanji character "犬" were both pronounced "i-nu." In fact, three participants showed overt responses in reading Kana words and Kanji characters. Naming of common Kana words accelerated the equivalent relation among stimuli (Eikeseth & Smith, 1992).

In most Ret-procedure research, the experimenter used three-types of visual stimuli, but did not include an auditory stimulus. Participants could acquire the equivalent relation among the visual stimuli (Smeets, Leader, Barnes,

1996). However, Clayton and Hayes (2000) indicated that participants showed low accuracy in the transfer test after Ret-procedure training, when participants had difficulty naming each stimulus. The results argued that when participants overtly named the stimuli, they were affected by the naming. In this study, three of six students showed no overt naming behavior. However, we assumed that they would read the Kana word and Kanji character implicitly, because they showed high accuracy in transfer test.

3.2. Transfer to writing

Some research has reported that participants who acquired the equivalent relation among the printed word, the spoken word, and the meaning by the matching-to-sample, often showed some behavioral untrained transfers such as reading, typing, and writing (Stromer et al., 1996; Yamamoto & Shimizu, 2001; Sugasawara & Yamamoto, 2007). In this study, five of six participants showed the transfer of writing Kanji characters after Ret-procedure training without direct training.

Students could not dictate the Kanji characters for the baseline. However, students had basic writing skills such as tracing, copying, and dictating, and could write many Kanji characters in the pre-assessment. Therefore, students were required to copy each Kanji character in a delayed situation. In this study, five of six students showed the Kanji writing response such as differential responding. These results argued that: (1) students acquired the equivalent relation among the spoken Kanji stimulus, the printed Kanji character, and the Kana word corresponding reading of Kanji stimulus via Ret-procedure and (2) students showed transfer to the differential responding not only via the matching-to-sample task, but also via Ret-procedure.

One of the students could not dictate most of the Kanji stimuli of the known and unknown stimuli. If writing responses were defined as "delayed copying" or "recall" in this study, one of the factors determining the accuracy of writing, was the complexity of the Kanji stimulus. For example, writing between the landscape and line art, have different difficulties, because each sample has a different type of complexity. When participants memorized the complex stimuli, they often used mediating responses such as external speech behavior and writing by using a finger, or some type of rehearsal. In fact, one student showed many mediating responses in the training. This is significant to the

negative correlation between the rate of occurrence of mediating responses and the percent of correct dictate-responses in the transfer test. We assumed that naming or vocalization had a mediating function for acquiring the equivalent relation or facilitating the differential responding for two reasons. First of all, whether stimuli could be named or not by the participant affected the accuracy of the equivalent relation (Eikeseth & Smith, 1992; Clayton & Hayes, 2000). Second, the rate of overt mediating responses including vocalization and/ or writing by using a finger was correlated with the percent of correctly dictated-responses in this study. We assumed that writing responses made by using a finger functioned to facilitate the hand writing as a differential response, because both responses had similarity in topography and function.

These results suggested that the Ret-procedure training was not effective for participants who showed many overt mediating responses. Clayton and Hayes (2000) reported that an arbitrary matching-to-sample task which needs the overt operant responses, was more effective than Ret-procedure for difficult to name stimuli. In future research, the Ret-procedure, the arbitrary matching-to sample, and the constructional matching-to-sample using namable and unnamable stimuli to acquire the equivalent relations and to test the transfer of differential responding should be compared.

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