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38 The Effect of Stimulus Pairing on Relational Learning in a Child with Autism Spectrum Disorder

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Introduction

Learning of arbitrary relations between stimuli (i.e., relational learning) is said to be a kind of basis from which a behavioral analysis of language and cognition may grow (Hayes, Fox, Gifford, Wilson, Barnes-Holmes, & Healy, 2001; Yamamoto, 1992). One of the most basic relational learning is equivalence relation (or stimulus equivalence). Equivalence relation is defined as an establishment of several untrained stimulus relations after some stimulus relations are trained (Sidman & Tailby, 1982). For example, a child is trained to choose B in the presence of A and to choose C in the presence of B. As a result, the child is able to understand the trained conditional relationship between these stimuli (i.e., if A, then B and if B, then C). Equivalence relations are established when a child could demonstrate the following untrained relational learning: symmetrical relations (i.e., if B, then A and if C, then B), transitive relations (i.e., if A, then C), and equivalence relations (i.e., if C, then A). Equivalence relations has emerged in learning of language and cognition for children with developmental disabilities (e.g., Noro, 2005; Omori, Sugasawara, & Yamamoto, 2011; see Rehfeldt, 2011).

In general, matching-to-sample (MTS) method is used for the training and testing of equivalence relations. In MTS method, a child is reinforced when s/he chooses one stimulus out of two or more choice stimuli (i.e.,

comparison stimuli) corresponding to a sample stimulus. For example, if the auditory stimulus "ball" is presented as a sample stimulus, a child's choice of a picture of a ball from among multiple comparison stimuli of pictures is reinforced. As a result, the child can always choose the picture of a ball in the presence of the auditory stimulus "ball" That is, the child learns an auditory stimulus => picture stimulus relation. The left side of the arrow represents the sample stimulus, and the right side represents the comparison stimulus.

On the other hand, some relational learning methods other than MTS method are used in several studies (Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989; Leader, Barnes, & Smeets, 1996; Minster, Elliffe, & Muthukumaraswamy, 2011; Rehfeldt, Latimore, & Stromer, 2003). Stimulus pairing is another method for establishing relational learning. Stimulus contiguity in stimulus pairing is one of the relational learning processes other than conditional discrimination. Stimulus contiguity is playing an important role for developing early language in naturalistic settings (Baldwin, 1991; Whitehurst, Kedesdy, & Wite, 1982). The method is also effectively applicable to children with ASD for relational learning (Takahashi, Yamamoto, & Noro, 2011).

Many literatures have demonstrated that children with ASD show delay in language development from their early ages. When the stimulus contiguity functions as learning process of early language development in naturalistic settings, it would be meaningful to study the conditions in which the relational learning is established or promoted. In this study, we examined whether the difference in modality of stimulus relations would affect the relational learning by stimulus contiguity method. In conditional discrimination process (i.e., MTS method), it was demonstrated that auditory-visual equivalence relations were established more quickly than visual-visual equivalence relations (Green, 1990). As a reason of such difference, she suggested the possibility that the participants had learning history more often in auditory-visual relations than in visual-visual relations in their naturalistic settings. When similar results were demonstrated by stimulus contiguity, learning history would also affect the relational learning.

In the present study, we clarified the effect of stimulus pairing method (Takahashi et al., 2011) for the establishment of relational learning by stimulus contiguity in a child with ASD. In addition, we conducted pre-

liminary comparison of the learning effects of visual-auditory stimulus pairing method with those of visual-visual stimulus pairing method.

Method

1. Participant

The participant was a 9-year-old boy who had been diagnosed with ASD. On Tanaka - Binet intelligence test, his mental age (MA) was 3 years 10 months old. His vocabulary age (VA) measured by Picture Vocabulary Test was 4 years 6 months old. He was enrolled in special needs education school. He had generalized echoic repertory. He could read almost all Japanese syllabary characters (i.e., Hiragana) and also words constructed of the characters slowly. However, he could not read any kanji characters. Before the present study, he was trained to learn several kanji-picture relations by stimulus pairing method, but he could not learn any equivalence relation including these kanji characters. Thereafter, he was trained by kanji-auditory stimulus pairing method using other stimulus sets, and he could learn some kanji-auditory stimulus relations. The difference in learning effect was observed between stimulus sets, but it was not examined within stimulus set.

2. Stimuli

Nine kanji characters, which were selected from Kyoiku Kanji (Ministry of Education, Culture, Sports, Science, and Technology; 1998) or Jōyō Kanji, 9 dictated readings of each kanji character or dictated names of pictures (auditory stimulus), and 9 picture stimuli corresponding to the meaning of each kanji character or dictated name were used. Table 1 shows 9 stimulus classes, which were learned in this study. The participant could name all the pictures. These stimulus classes were divided into 3 stimulus sets each comprising 3 stimulus classes (see Table 1). In stimulus pairing, two training conditions were implemented: visual-visual (i.e., kanji-picture) stimulus pairing training and visual-auditory (i.e., kanji-auditory) stimulus pairing training. Symmetrical relation and equivalence relation were assessed as measure of equivalence relation. In addition, reading of kanji was also assessed (see Fig. 1).

Table 1 Stimulus class and stimulus sets

SET	Picture stimulus	Kanji character	Auditory stimulus
SET 1		絵	/e/ (picture)
		顔	/kao/ (face)
		刀	/katana/ (sword)
SET 2		聞	/kiku/ (listen)
		投	/nageru/ (throw)
		飲	/nomu/ (drink)
SET 5		猿	/saru/ (monkey)
		猫	/neko/ (cat)
		豚	/buta/ (pig)

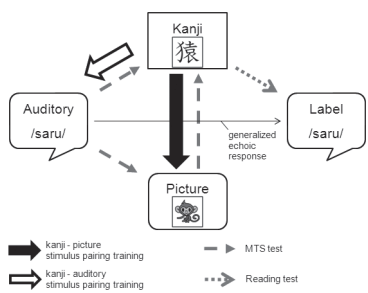

Figure 1 An example of stimulus relation trained and tested

3. Procedure

All tasks were conducted using a personal computer. A 17 inch touch-sensitive screen which was connected to the personal computer was used to show the stimuli and to detect his responses. All tasks were controlled by a pro-

gram, created using visual basic .NET. To assess the effect of stimulus pairing method, we compared the numbers of correct responses in MTS tests during baseline phase, stimulus pairing training phase, and probe phase. And to assess the difference in learning effects between visual-visual stimulus pairing and visual-auditory stimulus pairing, we conducted kanji-picture stimulus pairing training first. When he could not learn the stimulus relation, then kanji-auditory relations were trained using the same stimulus set. This study used a non-concurrent multiple baseline design across the stimulus sets.

3.1 Pretest

Before the baseline phase started, 3-choice identity MTS tests were conducted to assess whether the participant could discriminate the kanji characters in a targeted stimulus class set. The participant clicked-hold on a comparison stimulus and drag and drop it anywhere on sample stimulus. All nine trials were conducted in one test block. Each Kanji character in a stimulus set was presented as a sample stimulus three times in a random sequence during one block. The positions of correct comparison stimuli were changed so that they were not the same for more than three successive trials. Intertrial intervals (ITI) were of 1 second each, during which a blank screen was displayed. Reinforcing stimuli after correct choices and retrials after wrong choices were not presented. To maintain his compliance, the participant's favorite video clips or a small amount of edibles were presented after termination of the final trial of every block, regardless of his performance in the MTS task. When he showed correct choices in all the test trials of one block, the baseline phase was initiated.

3.2 Baseline phase

Three-choice arbitrary MTS tests were conducted. The participant performed three types of MTS tests in one test block: three trials of auditory stimuli => picture stimuli, three trials of picture stimuli => kanji characters, and three trials of auditory stimuli => Kanji characters. The procedure of arbitrary MTS test was almost identical to identity MTS test in pretest. Fig.2 illustrates one trial of picture => kanji and auditory => kanji MTS tests.

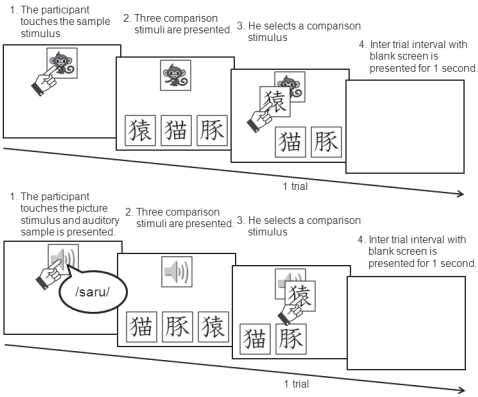

Figure 2 picture=>kanji MTS test trial (upper portion) and auditory=>kanji MTS test trial (lower portion).

3.3 Kanji-picture stimulus pairing training phase

During kanji-picture stimulus pairing training phase, kanji characters in a trained stimulus set was paired with corresponding picture stimuli. In a stimulus pairing training trial, one of kanji character in the stimulus set was presented on the monitor at the random position. Immediately after the participant touched the kanji character, the kanji character was cleared, and corresponding picture stimulus was presented on the same position for 1 second (see the upper portion of Fig.3). ITI were 1 second with a blank screen. These stimulus pairings were conducted in a total of 12 trials in one block, that is, each kanji in the stimulus class set was paired with its corresponding picture stimulus four times in one block in a random order.

Immediately after one block of stimulus pairing was completed, 6 trials of the MTS tests were conducted. These MTS tests consisted of 3 picture-kanji MTS test trials and 3 dictated name-picture MTS test trials. The former test was the test of symmetrical relation with stimulus pairing training. The cycle of this stimulus pairing training block and MTS test block was continued until the following criteria for attainment and termination were met. Attainment criterion was achieved if the participant completed all of the MTS tests for 3 successive blocks. Criteria for termination were achieved if the participant was not able to complete all the MTS tests for 3 successive blocks or he was not able to achieve the attainment criterion within five training-test block cycles. When these criteria were achieved, he finished the

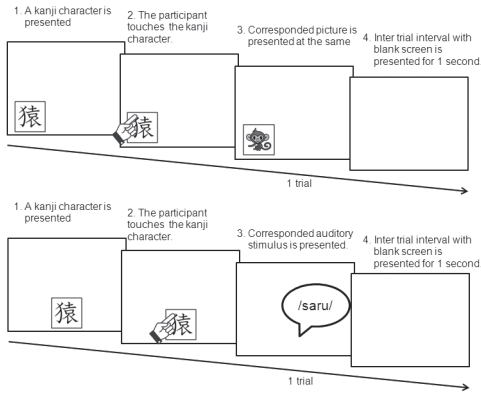

Figure 3 kanji-picture stimulus pairing training trial (upper portion) and kanji-auditory stimulus pairing training trial (lower portion).

training and test cycle and progressed to probe phase.

3.4 probe phase (1st)

Arbitrary MTS tests which were identical in baseline phase were conducted. In this first probe phase, the symmetrical relation (i.e., picture => kanji) and equivalence relation (i.e., auditory => kanji) of trained stimulus relation in the last kanji-picture stimulus pairing were assessed. In addition, reading tests of kanji character were also conducted. In the reading test trial, the participant was instructed to read aloud one Kanji character presented in the upper center of the screen. Neither corrective feedbacks nor verbal models of correct responses were presented for his reading responses. Each Kanji character in a stimulus set was presented as a sample stimulus once in a random sequence during one block.

3.5 Kanji-auditory stimulus pairing training phase

During kanji-auditory stimulus pairing training phase, kanji characters in a trained stimulus class set was paired with corresponding auditory stimuli (see the lower portion of Fig.3). This training phase was implemented when the participant could not learn equivalence relation with the kanji-picture stimulus pairing training phase. In MTS tests, auditory => kanji MTS tests were assessed as symmetrical relation in this phase. The criteria for attainment and termination were identical to the one during kanji-picture stimulus pairing phase.

3.6 probe phase (2nd)

MTS tests and reading tests which were identical to the first probe phase were conducted. During this phase, auditory => kanji and picture => kanji MTS tests were assessed as symmetry and equivalence relation respectively.

Results

Fig. 4 shows the percentage of correct choices in picture => kanji MTS test,

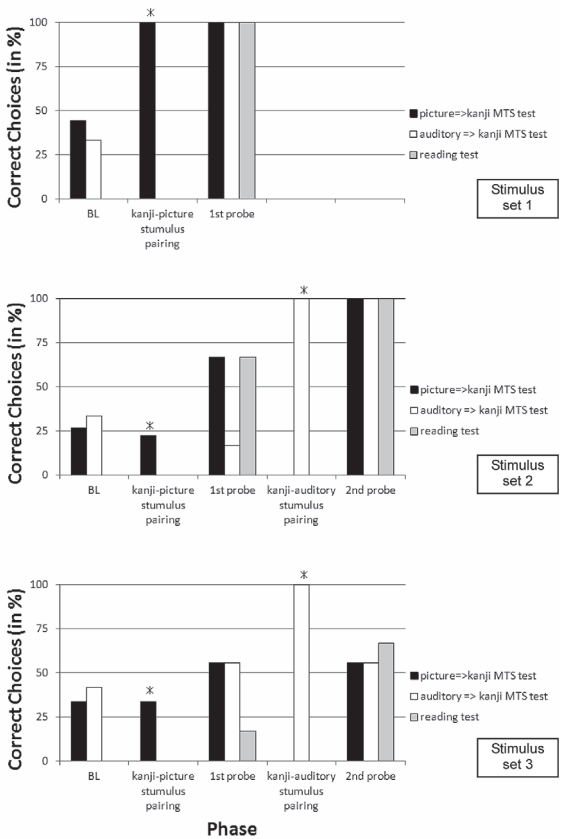

Figure 4 Percentage of correct choices in MTS test and reading test.
Note: Asterisks indicate the percentage of correct choices in the last three consecutive test blocks during the phase.

auditory => kanji MTS test, and reading test during the baseline phase, kanji-picture stimulus pairing training phase, first probe phase, kanji-auditory stimulus pairing training phase, and second probe phase.

In pretest, the participant could select identical kanji comparison stimulus to kanji sample stimulus. These results showed that he could discriminate kanji stimuli and perform MTS test correctly without any feedbacks or reinforcers for his choice responses in each trial.

In baseline phase, the participant exhibited correct choices in almost all auditory => picture MTS test trials. However, he exhibited chance-level performances of auditory => kanji and picture => kanji MTS test trials.

During kanji-picture stimulus pairing training phase, he exhibited high-level performances of picture => kanji MTS test trials (i.e., symmetry test trials) and achieved criteria for attainment in one of three stimulus class sets (stimulus class set 1). In the remaining two stimulus sets (stimulus class set 2 and 3), he exhibited low-level performance of symmetry MTS test, and the training phase was terminated.

During the first probe phase, he exhibited high-level performances of both symmetry and equivalence MTS test trials and reading test trials in the stimulus set 1. However, he exhibited low-level and astable performances of both symmetry and equivalence MTS test trials in the stimulus set 2 and 3.

During the next training phase, kanji-auditory stimulus pairing training was implemented with the stimulus set 2 and 3. During this training phase, he exhibited high-level performances of symmetry MTS test trials (i.e., auditory => kanji MTS test trials) in the all stimulus sets in which kanji-picture stimulus pairing training was ineffective.

During the second probe phase, he exhibited high-level and stable performances of both symmetry and equivalence MTS test trials and reading test trials in the stimulus set 2. However, he exhibited low-level and astable performances of both symmetry and equivalence MTS test trials and reading test trials in the stimulus set 3. As a response tendency which was seen in these test trials of stimulus set 3, he looked confused with the two kanji characters (“猿” and “猫”) because they had a resemble part of “犭”.

Discussion

In this study, we examined the effect of kanji-picture and kanji-auditory stimulus pairing training for a child with ASD. As the result, he could learn the equivalence relation in one of three stimulus sets with kanji-picture stimulus pairing training and the performances were transferred to reading. In the remaining two stimulus set in which kanji-picture stimulus pairing training was ineffective, he could learn the symmetrical relation with kanji-auditory stimulus pairing training in the two stimulus sets.

Establishment of equivalence relation and transfer to the reading performance were observed in the one of two stimulus class sets. These results suggest that stimulus pairing training (i.e., learning by stimulus contiguity) was effective learning process for the children with ASD as the study of Takahashi et al. (2011).

In this study, we conducted two types of stimulus pairing training (i.e., kanji-picture and kanji-auditory pairing training), and both were effective in establishing equivalence relation. However, the result of this study suggests the possibility that kanji-auditory (i.e., visual-auditory) pairing training was more effective than kanji-picture (i.e., visual-visual) stimulus pairing training because the former training was effective even when the latter training was not effective in the same stimulus set. That is, this study suggests that the similar outcomes of previous study with MTS method (Green, 1990) were seen in the stimulus pairing method (learning by stimulus contiguity), and some learning history may function to promote or inhibit (i.e., control) the learning by stimulus contiguity.

Since the data of this study is obtained by only one child with ASD, more participants would be needed to examine the effect of stimulus pairing method on equivalence relations. This study did not control the order of two training. Thus, we could not eliminate the possibility that the result was affected by the order or frequency of training. The further research needs to control these factors. Finally, the detail of learning history that establish or promote the relational learning by stimulus contiguity is not specified thus far. To promote generative relational learning for individuals who has limited learning history and relational learning repertory, the analysis of necessary conditions of learning by stimulus contiguity to establish relational

learning would be needed.

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