Memory Strategies for Serial Recall in Adults with Intellectual Disabilities

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Abstract: This study was conducted to investigate the memory strategy for serial recall in adults with general intellectual disability (ID) using the picture memory span task. Relations between memory strategies and two aspects of intellectual abilities, *i.e.*, verbal and nonverbal abilities, were investigated. Study participants were 19 adults with general ID (*i.e.,* ID of unknown etiologies). The picture memory span task, which can assess features of memory coding, was administered under four conditions: control, visually similar, phonologically similar, and long-name condition. The picture vocabulary test – revised (PVTR) and Raven color progressive matrices (RCPM) were conducted. Performance on the picture memory span task revealed that participants with ID used visual and verbal strategies for memory coding. Individual differences in verbal ability were interrelated with the degree of verbal strategy use. Results of this study suggest that features of memory coding of adults with ID do not contradict their level of intellectual development.

Keywords: Intellectual disability (ID), memory coding, picture memory span task, verbal abilities, nonverbal abilities.

Intellectual disability (ID) refers to an intellectual or adaptive difficulty with onset occurring before 18 years of age [1]. Intellectual abilities are a series of cognitive processes such as memory, attention, and language comprehension. Persons with ID are well known to have poor memory capacities [2]. In recent years, investigations of the memory capacities of persons with ID have been based on Baddeley's multi-component model of working memory, which consists of a control system (*i.e*., central executive) and three dependent memory storage modes, *i.e*., phonological loop, visuospatial sketchpad, and episodic buffer [3]. Henry [2], after reviewing working memory research conducted of children with ID, reported that children with ID have small phonological short-term memory capacity. The same review suggests that capacities of visuospatial short-term memory were limited in this population. However, factors restricting the memory capacities of persons with ID were not well investigated.

Strategic recall is a key factor for memory capacity enhancement. Memory strategies of several kinds were used in strategic recall, e.g., verbal labeling, rehearsal, and chunking. Palmar [4] reported four-stage development of verbal and visual strategies in memory recall, as described also by Henry [2]. Palmar [4] used picture memory span tasks, which were originally developed by Hitch *et al.* [5] to assess the visual similarity effects (VSE) of children's serial recall. In the picture memory span task, participants were required to memorize a series of visual pictures with manipulated visual or phonological similarity. The VSE means that participants showed more difficulties in remembering visually similar items such as *knife*, *pen*, and *tie*. Hitch *et al.* [5] reported that five-year-old children showed the VSE, and interpreted that children at this age used a visual memory strategy. In other words, children tried to remember the presented pictures as visual images. According to Palmar's cross-sectional and sequential study [4], children aged 3–4 years used no particular strategy. After the children began to use the visual memory strategy, children aged 6–8 years used visual and verbal strategies (*i.e*., dual strategy stage). The verbal strategy shows that children tried to remember the presented pictures using the verbal code and rehearsal. This strategy was confirmed by the presence of the phonological similar effect (PSE) and word length effect (WLE). When the PSE was observed in the picture memory span task, participants showed greater difficulty in remembering phonologically similar items such as *hat*, *pan*, and *ant*.

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The WLE means that participants showed more difficulties in remembering long-named items that need more time for inner articulation such as *banana*, *elephant*, and *strawberry*. Finally, children aged 10 years used this verbal strategy predominantly, and frequently observed PSE and WLE.

Henry [6] reported that mental age (MA) influenced the memory strategies used in the picture memory span task of children with ID of unknown etiologies (*i.e.*, general ID). In their study, children with ID for whom MA was younger than six years showed no evidence of a particular memory strategy. Children with ID for whom MA was older than six years, however, showed VSE and WLE, which implied the existence of a dual strategy stage. Although the finding of Henry presented above [6] is interesting for elucidating memory strategy on serial recall in persons with general ID, no further research has been conducted from this viewpoint. In Henry's study [6], the participants were 36 children in the developmental period of 8–13 years of age. Is there a similar finding related to memory strategies on serial recall in adults with general ID? The present study is an attempt to clarify this point. Moreover, we investigate the relation between memory strategies and two aspects of intellectual abilities: verbal and nonverbal abilities. The MAs analyzed by Henry [6] were based on nonverbal ability. Consequently, the relation between memory strategies and verbal ability in persons with ID has not been investigated well.

To summarize, this study was designed to investigate memory strategies for serial recall in adults with general ID using the picture memory span task. According to results of an earlier study, we specifically examined several recall effects: VSE, PSE, and WLE.

METHOD

Participants

Table **1** presents characteristics of the study participants: 19 adults (11 men, 8 women) with ID free from sensory and motor impairments such as blindness, low vision, deafness, and cerebral palsy. No participants had specific etiology of ID such as Down syndrome or autism. Chronological age (CA) was 18–62 years (mean (*M*) = 35.4, standard deviation (*SD*) = 13.4). Participants with ID had been diagnosed by psychiatrists as having intellectual developmental disabilities; 11 participants were assessed for their intelligence quotient (IQ) using a standardized intelligence test such as the Binet intelligence scale. The IQ was 19–68 (*M* = 43.9, *SD* = 15.6). All participants were users at two residential care facilities. Consent for adults with intellectual disabilities to participate in the study was obtained from the institutions at which they lived. Participants were under no obligation to take part in the tests. The purposes of the tests were explained. Only persons who consented to participate freely and voluntarily were included. We tried to measure the performance of all users without sensory and motor impairments at each institution, but did not measure the performance of users who clearly showed difficulty in understanding instructions. The participants' CA, IQ, and etiology of ID were surveyed from the personal histories kept at the institutions.

To confirm the validity of the task conducted in this study, a control group comprising typical adults was examined. The control group comprised 18 university students (9 men, 9 women), none of whom reported any neuro-logical or physical difficulty. Chronological ages were 18–24 years (*M* = 21.7, *SD* = 1.4). The test purpose was explained to each. Only participants who consen-ted to participate freely and voluntarily were included. Ethical approval for the study was obtained from the Research Ethics Board at Tokyo Gakugei University.

Measures

Three tasks were conducted for adults with ID: picture memory span task, picture vocabulary test – revised, and Raven color progressive matrices. For typical adults, only the picture memory span task was conducted. Measurements were conducted in a private room at each institution.

Table 1: Participant Characteristics in each Group

	Adults with ID (*n*=19)				Typical adults (*n*=18)			
	M	***SD***	**Min**	**Max**	***M***	***SD***	**Min**	**Max**
Chronological age (years)	35.4	13.4	18	62	21.7	1.4	18	24
PVTR Score	53.8	22.7	9	85				
RCPM Score	22.0	6.9	14	34				

Picture Memory Span Task

1) Stimulus

According to an earlier study [6], nine picture stimuli of four types were used for this study: control, visual similarity, phonological similarity, and long-named stimuli. The control stimuli were presented in a control condition. They consisted phonologically dissimilar two-mora Japanese words. These words were represented by visually dissimilar drawings. The control stimuli consisted of *ant* (in Japanese, "a-ri"), *pot* ("na-be"), *whistle* ("fu-e"), *star* ("ho-shi"), *barrel* ("ta-ru"), *squirrel* ("ri-su"), *deer* ("shi-ka"), *shoes* ("kutsu"), and *book* ("ho-n").

The visually similar stimuli were presented in a visually similar condition, and consisted of eight phonologically dissimilar two-mora Japanese words and a three-mora Japanese word. These words were represented by visually similar, thin-sticks drawings with varying detail. The visually similar stimuli were *stick* (in Japanese, "tsu-e"), *sword* ("ke-n"), *screw* ("ne-zi"), *umbrella* ("ka-sa"), *chopsticks* ("ha-shi"), *comb* ("ku-shi"), *writing brush* ("fu-de"), *pencil* ("pe-n"), and *bat* ("ba-tto").

The phonologically similar stimuli were presented in a phonologically similar condition. They consisted of phonologically similar two-mora Japanese words. These words were represented by visually dissimilar drawings. The phonologically similar stimuli consisted of *alligator* (in Japanese, "wa-ni"), *foot* ("a-shi"), *shell* ("ka-i"), *key* ("ka-gi"), *chopsticks* ("ha-shi"), *bee* ("ha-chi"), *crab* ("ka-ni"), *rhinoceros* ("sa-i"), and *ant* ("a-ri"). These Japanese words were phonologically similar: The vowel sound of the first syllable was Japanese "a"; the vowel sound of the second syllable was Japanese "i".

The long-name stimuli were presented in a long-name condition. They consisted of phonologically dissimilar four-mora Japanese words. These words were represented by visually dissimilar drawings. The long-name stimuli were *pencil* (in Japanese, "e-n-pi-tsu"), *penguin* ("pe-n-gi-n"), *candle* ("ro-u-so-ku"), *bicycle* ("ji-te-n-sya"), *truck* ("to-ra-kku"), *airplane* ("hi-ko-u-ki"), *carrot* ("ni-n-zi-n"), *glove* ("te-bu-ku-ro"), and *sun* ("ta-i-yo-u").

The degree of visual or phonological similarity of each stimulus was confirmed by two raters. The average acquisition ages of respective words used in the conditions were almost equal. Response boards using each condition were 16.5 cm × 28.5 cm. They included all nine picture stimuli from each condition set in a 3 × 3 array. For this study, 36 types of response boards of different stimuli placement were prepared in each condition.

2) Procedure

For this study, the picture memory task was administered under four conditions: control, visually similar, phonologically similar, and long-name condition. All trials of four conditions consisted of three phases: naming, memory, and recall phase. The participants sat in front of a computer screen with their hands resting on a table. In the naming phase, participants were presented some response board on the computer screen and were required to name each stimulus. If a participant could not name all stimuli, then measurement of this task was finished and not analyzed. In the memory phase, participants were asked to remember the serial order of the presented stimulus. A stimulus generated using a personal computer was presented in the middle of a computer screen for 1 .5 s. The presented stimulus sequences were increased from 1 to 9. For this study, the number of sequences was defined as the stimulus span. Each stimulus span comprised two trials, each consisting of a different order of stimulus. Eight sets of each stimulus span were prepared within each condition. Then each set was conducted randomly for each participant. Participants were given trials of increasing the stimulus span within each condition, starting with one-item trials, and increasing up to nine-sequential trials. After this memory phase, the recall phase was conducted. In this phase, participants were presented another response board, which differs from that used in the naming phase, on the computer screen and were required to reproduce the serial order of the presented stimulus by pointing to each stimulus of the response board. When participants reproduced it correctly, the next stimulus span was presented. Second trials of the same stimulus span were presented if participants were unable to reproduce them correctly. The response boards used in the recall phase differed from first trials. Each response board was selected randomly for each participant. When participants were unable to reproduce them correctly in the second trial, measurement of this condition was finished and other conditions were conducted. Measurement was begun at one of the four conditions. Each condition was conducted in random order for each participant. For the one-item trials of each condition, a participant who pointed at more than one item was excluded from analyses because such a participant was not able to understand the rule of this study.

3) Scoring

The score of each condition was calculated following the procedures described hereinafter. If the first trial of each stimulus span was reproduced in the correct order, then a participant was awarded 1 point. A participant was awarded 0.5 points if the second trial was reproduced correctly. Zero points were given if neither trial was reproduced correctly. These points were summed in each condition and were used as the participant's representative value of each condition. These scores (*i.e.,* the picture memory span task score) were 0–9.

To evaluate individual differences in the effect of three experimental conditions, *i.e.*, visually similar, phonologically similar, and long-name condition, each effect score (ratio) was calculated according to the following formula using each picture memory span task score: (Control – each experimental condition) / (Control + each experimental condition) × 100. Higher effect scores indicate a greater effect of the experimental condition.

Picture Vocabulary Test-Revised (PVTR)

According to the test manual, the picture vocabulary test-revised (PVTR; [7]) was conducted to assess the verbal ability of participants with ID. The norm attached to the test manual was used when raw scores were converted to a PVTR score. The PVTR score was 0–89.

Raven Color Progressive Matrices (RCPM)

According to the test manual, Raven color progressive matrices (RCPM; [8]) were conducted to assess the nonverbal ability of participants with ID. The raw scores were analyzed as a RCPM score. The RCPM score was 10–35.

Statistical Analysis

Software (SPSS ver. 22.0; SPSS Inc.) was used for statistical analyses. In all analyses, significance was inferred for $p < .05$. All the measured values in both groups (*i.e.*, picture memory span task scores of four conditions and effect scores of three experimental conditions; see Table **2**) were tested for deviation from normality. In typical adults, all measures were normally distributed. The tests, however, revealed that not all measures were normally distributed in adults with ID. Based on these results, nonparametric analyses were used for this study. The Friedman test was used to analyze the picture memory span task score (*i.e.*, average rank) of each condition of the two groups. Spearman correlation and partial Spearman correlation were used to analyze the relation between each effect score and fundamental participant attributes such as chronological age, PVTR, and RCPM score.

RESULTS

Table **2** presents the descriptive statistics (i.e., median (*Me*) and quartile deviation (*Q*)) for all measured variables in both groups. Table **3** presents the average ranks of each picture memory span task score in two groups. For typical adults, the Friedman test revealed a significant difference among the average ranks of four conditions of the picture memory span task score (χ^2 (3) =28.4, $p < .001$). The subsequent pair-comparison revealed that the average rank on the score of the phonologically similar and long-name condition were significantly lower than that of the control condition. No significant difference was found between the phonologically similar and long-name condition. The average rank on the score of the visually similar condition was not significantly different from the control and long-name condition. Significant difference was found between the phonologically similar and visually similar condition.

For adults with ID, the Friedman test revealed a significant difference among the average rank of four conditions of the picture memory span task score (χ^2 (3) =21.1, $p < .001$). The subsequent pair-comparison revealed that the average rank of scores of the phonologically similar and visually similar condition was significantly lower than that of the control condition. No significant difference was found in other pair comparisons.

Table **4** presents correlation matrices between the respective effect scores and fundamental participant attributes in adults with ID. The PVTR score was correlated significantly and positively with an effect score of the phonologically similar and long-name condition (phonologically similar, r_s = 0.603, $p < .001$; long name, r_s = 0.466, $p < .001$.). A higher effect score (*i.e.*, greater effect of each experimental condition) was associated with a participant's higher verbal ability. Figure **1** portrays a scatter plot of the inferred relation between the phonologically similar effect score and PVTR score. The effect score of the visually similar condition was not correlated significantly with any measure. The effect score of the phonologically similar condition was correlated significantly and positively with the long-name condition (r_s = 0.614, p = .005).

Table 2: Performance of the Picture Memory Span Task in each Group

		Adults with ID (n=19)				Typical adults (n=18)			
		Me	***Q***	**Min**	**Max**	***Me***	***Q***	**Min**	**Max**
Score	Control	3.0	0.9	1.0	6.0	6.0	1.0	4.5	8.5
	Visually similar	2.0	1.0	0.0	3.5	5.0	0.7	2.5	9.0
	Phonologically similar	2.0	0.4	1.0	4.0	4.0	0.9	2.0	6.0
	Long name	2.0	0.5	1.0	5.0	4.5	0.5	2.0	7.0
Effect score	Visually similar	20.0	15.3	0.0	100.0	5.7	5.3	-10.0	33.3
	Phonologically similar	20.0	12.6	-20.0	33.3	23.2	7.9	-9.1	38.5
	Long name	9.1	10.0	-20.0	33.3	15.0	5.0	-9.1	38.5

Table 3: Each Average Rank of the Picture Memory Span Task in Two Groups

		Adults with ID (n=19)	Typical adults (n=18)
		Average rank	
Score	Control	3.45	3.56
	Visually similar	1.59	2.94
	Phonologically similar	2.26	1.56
	Long name	2.60	1.94

Note: In the score of the picture memory span task, a lower average rank denotes a lower performance within a group.

Table 4: Spearman's Correlation between Respective Measures in Adults with ID

	1	2	3	4	5	6
1 Chronological age	-					
2 PVTR score	-0.143	-				
3 RCPM score	-0.543*	0.424	-			
4 Visually similar effect score	0.216	-0.280	-0.078	-		
5 Phonologically similar effect score	0.045	0.603**	0.069	-0.234	-	
6 Long-name effect score	0.184	0.466*	0.083	-0.155	0.614**	-

*, p < .05; **, p< .01.

Finally, we calculated partial Spearman correlation between the PVTR score and each effect score, controlling for RCPM score to investigate the link between verbal ability and memory coding more clearly. For partial correlation, significant strong positive correlation was found between each effect score and the PVTR score (phonologically similar, partial r_s= 0.632, p = .005; long name, partial r_s = 0.476, p = .046).

DISCUSSION

This study investigated the memory strategy on serial recall in adults with general ID using the picture memory span task. According to earlier study, we specifically examined several recall effects such as VSE, PSE, and WLE. Few studies have examined the picture memory span task using the Japanese words. To confirm the validity of task conducted for this study, a control group comprising typical Japanese adults was examined. Performance on the picture memory span task of typical adults was significantly lower in both phonological similar and long-name conditions than in a control condition. These results apparently reflected the presence of PSE and WLE, *i.e*., typical adults tried to remember the presented pictures using the verbal code and rehearsal. Moreover, performance of the visually similar condition was not significantly different from the control condition in typical adults. This result indicates that visual images do not play an important

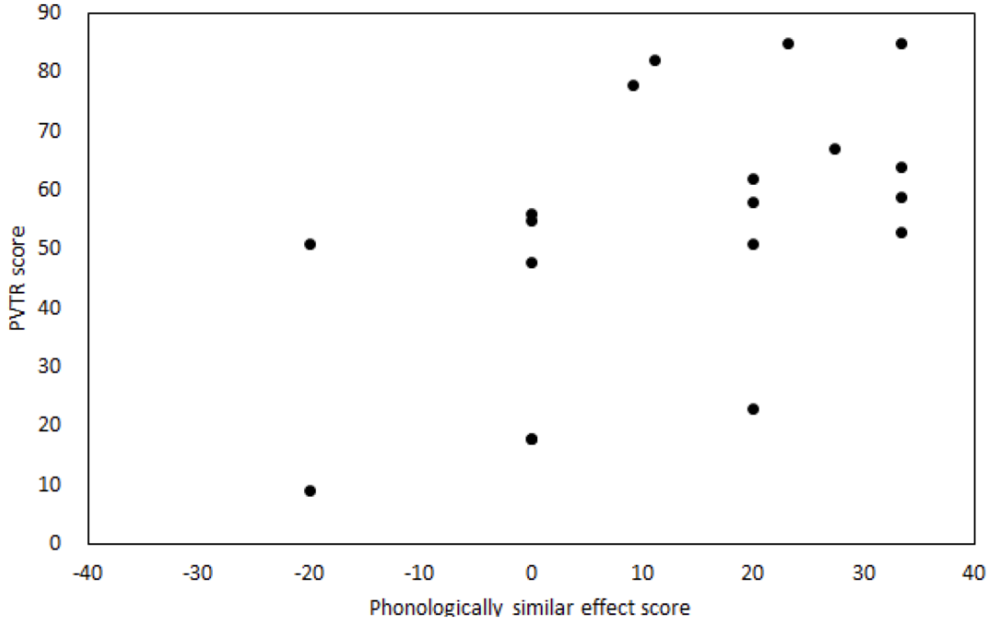

Figure 1: Scatterplot depicting the relation between the phonologically similar effect score and PVTR score in adults with ID.

role in the picture memory span task. Consequently, our typical adults reached final-stage of memory recall proposed by Palmar [4]. This result does not contradict the chronological age of typical adults in this study. Based on these findings, validity of the picture memory span task used for this study was confirmed.

In adults with ID, performance of the phonologically similar and visually similar condition was significantly lower than control condition. This overall trend suggests that our adult with ID group reached the third-stage of memory recall proposed by Palmar [4]. In other words, adults with ID of this study used not only visual strategy but also verbal strategy (*i.e.*, dual strategy stage). Henry [6] reported that children with ID for whom MA was older than six years used a dual strategy in the picture memory span task. The PVTR score, which is measured in this study, was convertible into the verbal mental age (VMA) using the test manual. To confirm the relation between the memory strategy and mental age, we calculated the VMA of each participant. The average VMA was 9 years and 3 months (M = 111.2 months, SD = 33.6), which is greater than six years. Consequently, it is reasonable to assume that features of memory coding of adults with ID do not contradict their level of intellectual development. In this study, the WLE were apparently not observed in overall performance of adults with ID. Some authors claimed that the WLE appears after the PSE in typical children [9]. Factors that determine the presence of WLE must be investigated.

The major finding of this study was that individual differences in verbal ability were interrelated with the degree of verbal strategy use in adults with ID. A higher effect score of phonological similarity and a long-name condition were associated with higher PVTR scores. Nonverbal ability evaluated using the RCPM score plays no important role in the picture memory span task. Results of partial correlation support this view. Some studies, however, produced results that do not accord with the results of the present study. As described in the *Introduction*, Henry [6] reported that nonverbal mental age, as evaluated by the pattern construction test, influenced the memory strategies used by children with ID. However, that study did not investigate the relation between verbal ability and memory coding. Similarly, we did not investigate the relation between performance on the pattern construction test and memory coding. It is necessary to examine the profiles of verbal and nonverbal skills in people with ID using comprehensive cognitive tests such as the Wechsler intelligence scale.

In the present study, participants were not forced to name the presented stimulus in the memory phase of the picture span memory task. Consequently, some participants with ID who showed PSE and WLE apparently *spontaneously* named the presented stimuli. Mitsuhashi *et al*. [10] reported that the degree of spontaneous naming strategy used to memorize presented stimuli might depend on a verbal short-term memory capacity in typical adults. It might be inferred that the same tendency can be found for adults with ID.

The degree of individual differences of the effect score under the visual similarity condition was apparently not different from the phonologically similar condition in adults with ID (See Table **2**). What factors were used to determine individual differences of the effect score under the visually similarity condition? One possibility is inhibitory dysfunction. Our simple observation indicates that participants for whom effect scores of the visually similarity condition were high seemed to respond more rapidly and tended to make more errors in this condition. This observation suggests that inhibitory dysfunction prevents the serial recall of persons with ID. The features of performance processes in the Picture memory span task should be investigated by specifically examining reaction times and eye movement.

LIMITATIONS

The small sample used for this study limits the generalizability of the results. It will be necessary to take larger-scale measurements and to confirm the reliability of these study results further. Moreover, it will be necessary to examine the memory strategies in a typical Japanese population with a CA or MA matched to those of participants with ID.

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DISCLOSURE STATEMENT

The authors have no conflict of interest related to this study.

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