

## Developing a Listening Span Test for Japanese Preschool Children as a Measurement of Working Memory Capacity

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The present study aimed to develop a listening span test (LST) for Japanese preschool children in order to provide an index for language-related working memory capacity. Our LST used verbally-presented sentences including target nouns which children were asked to recall. The LST scores showed a relatively high reliability and validity although some items were too difficult for the children to recall. With the replacement of some items, the LST could be a good measure of listening span for Japanese preschool children.

**Key words:** Listening Span Test, Working Memory Capacity, Preschool Children

For preschool children who have not learned written language, the working memory capacity is known to have a close relation with spoken language comprehension. Based upon the listening span test (LST) developed by Daneman and Carpenter (1980) as means of assessing people's ability to perform active processing of a stimulus while simultaneously buffering other information in working memory, Ishio and Osaka (1994) developed the Japanese LST for preschool children. However, their LST version displayed relatively low correlation between digit span test and LST ( $r = .34$  for LST1 and  $r = .07$  for LST2) for 43 preschool children with an average age of 6 years and 5 months. Therefore, the present study was intended to develop a newer LST for Japanese preschool children using a different testing and scoring approach.

### Construction of the LST

The newer version LST used only sentences constructed by three words in subject, object and verb order. Target words which children were asked to recall, were embedded in either subject or object in sentences (e.g., シカが橋を渡ります meaning 'A deer crosses a bridge' and カブトムシがスイカをなめています meaning 'A beetle licks a watermelon'). In order to establish three steps of difficulty level, we used three groups of sentences. The first group (8 sentences) was presented in single sentences with the children being asked to remember a target noun. The second group (16 sentences) was presented as two sentences together with the children being asked to remember two target words. The child received 1 point when s/he correctly recalled the two target words. The third group (24 sentences) was presented as three sentences including three target words. Again, the child

had to remember the three target words in order to score a single point. Thus, the total number of sentences was 48 and the maximum number of points was 24 (or 48 when considering all the target words as a single point). Hereafter, we will refer to these LSTs as the 24-point scale and the 48-point scale.

### Reliability of the LST

*Subjects:* Thirty-two preschool children (18 boys and 14 girls) participating in the present study were an average of 5 years and 7 months, ranging from 5 years and 1 month to 5 years and 11 months.

*Test-retest reliability.* The children were tested twice using the LST within a period of approximately three weeks. The Pearson's correlations of the same 24-point scale LST tested twice ( $M=12.44$  with  $SD=3.35$  for the first time and  $M=14.06$  with  $SD=3.42$  for the second time) were high at  $r = .78$  ( $n=32$ ,  $p < .001$ ) for the 24-point scale and  $r = .77$  ( $n=32$ ,  $p < .001$ ) for the 48-point scale. These correlations can be considered very high in comparison with Waters and Caplan (1996) which received  $r = .41$  in a test-retest reliability for the reading span test (RST). The correlations between the 24-point and 48-point scales ( $M=32.88$  with  $SD=5.73$  for the first time and  $M=34.37$  with  $SD=5.98$  for the second time) were  $r = .92$  ( $n=32$ ,  $p < .001$ ) for the first testing, and  $r = .90$  ( $n=32$ ,  $p < .001$ ) for the second testing. These two scales showed a very high correlation.

*Item difficulty.* Difficulty of items was calculated by assessing the correct answering percentages among 32 children. There were three sentences under 25% (correctly answered by less than 9 children). These target words were 'words' (18.8%), 'a picture' (18.8%) and 'a prince' (25.0%). These words seemed

to be too difficult for the preschool children.

**Cluster analysis:** Since all the correctly recalled items were recorded as 1 while incorrect items were 0 (i.e., 0-and-1 variables), the quantification theory type III was used to calculate category scores. Furthermore, using these scores of the three axes, a cluster analysis was conducted to classify all 24 items. As shown in Figure 1 of the dendrogram, three items of the forth, sixth and eighth in the third group seemed to be deviated from the others. These items should include some anomalous characteristics. Since the target word 'a prince' in the eighth item of the third group was also found to be difficult, this sentence should be replaced.

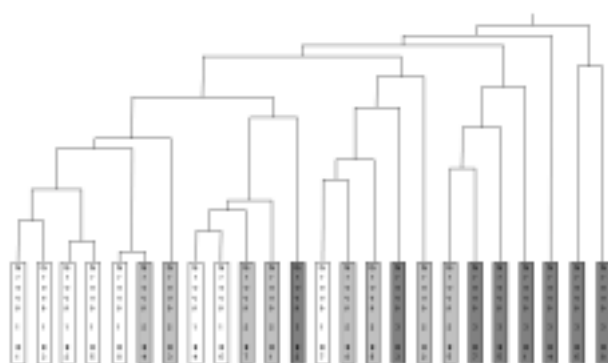


Figure 1. Classes of the LST 24 Question Items.  
 Note 1: n=32. Group 1: 8 single-sentence items. Group 2: 6 two-sentence items. Group 3: 6 three-sentence items.  
 Note 2: A cluster analysis was conducted using category scores of three axes calculated by the quantification theory type III.

### Validity of the LST

Four tests were conducted to the same 32 preschool children to examine validity of the LST. (1) *Digit Span test:* A child was required to repeat a sequence of numbers verbally presented by an examiner. These numbers included forward and backward repetition. (2) *Word span test.* A Child asked to recall animal names with two kana (morae in sound) in the same order orally presented by the examiner. The child received scores according to the number of animals s/he correctly repeated. (3) *Word knowledge:* a total of 80 pictures were presented to the child who was asked to identify name of an object in the picture (e.g., 'hand', 'glasses' and 'dog'). The child gets 1 point for each picture. (4) *Kana knowledge.* A kana symbol was shown to the child to read out loud. 14 kana symbols were used in this test. The child receives 1 pint for each successfully-read kana symbol.

The means, standard deviations and Pearson's correlations with the LST were reported in Table 1. All the tests showed significantly high correlations with the LST. Among them, word knowledge showed the highest correlation with the LST. Related to word memory, the word span test was significantly high. The LST seems to have a strong relation with lexical memory. In addition, both the forward and backward digit

span tests also showed a high correlation. Since these tests are related to memory span, the LST must be able to measure working memory capacity. Kana knowledge also showed significantly high correlation. Because kana symbols are written phonological representations, the LST may also be related to phonological aspects of acquiring written symbols.

Table 1. Pearson's correlation coefficients of variables with the listening span test

Variables	Max	M	SD	Correlation
Forward Digit Span Test	16	4.34	1.31	0.53 **
Backward Digit Span Test	14	2.53	1.29	0.41 *
Word Span Test	-	3.47	0.62	0.52 **
Kana Knowledge	14	9.59	4.21	0.53 **
Word Knowledge	80	59.32	10.00	0.77 ***

Note 1: n=32. \* p<.05. \*\* p<.01. \*\*\* p<.001.  
 Note 2: Max=maximum points. M=means. SD=standard deviation.

### Predicting the LST Scores

The digit span test, the word span test, kana knowledge and word knowledge were used to predict the LST by a multiple regression analysis. As shown in Table 2, a significantly predicting variable for the total LST scores was only word knowledge. Further regression analyses were conducted by braking down the LST scores into three sub-groups. The results of analyses found that only word knowledge in Group 2 significantly predicted the LST scores. Therefore, the condition in which two sentences were orally presented to retain the two target nouns seems to be the most distinguishable by word knowledge. It could be explained that the LST scores in Group 2 results from adequate memory loading for the preschool children (about 5 years and half) tested in the present study.

Table 2. Predicting the LST scores by multiple regression analysis

Tests	Total scores		Group 1		Group 2		Group 3	
	$\beta$	t value	$\beta$	t value	$\beta$	t value	$\beta$	t value
Word Span Test	0.16	1.09	-0.09	-0.13	0.25	1.50	0.12	0.56
Digit Span Test	0.01	0.09	0.30	1.42	-0.09	-0.50	-0.16	-0.69
Word Knowledge	0.60	3.70 ***	0.40	1.90 +	0.59	3.35 **	0.31	1.33
Kana Knowledge	0.15	1.01	-0.01	-0.04	0.08	0.51	0.26	1.20

Note 1: n=32. + p<.10. \*\* p<.01. \*\*\* p<.001.  
 Note 2:  $\beta$  refers to a standard partial regression coefficient.

### Summary

The LST developed in the present study seemed to have reasonable test-retest reliability. The validity of the LST was examined by different tests which were conducted on the same preschool children. The correlations were significantly high between the LST and all the other tests. Although some target words should be replaced by other items, the LST generally showed satisfactory reliability and validity as a means of a measurement for working memory capacity. However, it should be noted that the multiple regression analyses only indicated word knowledge as a significant predictor of the LST. Thus, the working memory capacity measured by the LST might include not only memory loading capacity but also higher cognitive activities related to lexical processing.