

## **Non-word repetition as the measurement for phonological working memory capacity of normal children in Japan**

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Introduction: Working memory represents the mechanism of the processing of the information in relation to perform of the task and the simultaneous storage, and which based on the verbal short term memory. In the working memory phonological loop is known to work as the functions to preserve the verbal information temporarily. The working memory study for its model and its anatomical findings made progress to the subjects of the child language impairment and adult aphasia. And the relevance between the verbal short term memory, and the acquisition of new phonological form consider as the structure of human cognition in a sense. Therefore, this mechanism is relevant to the learning of the new words for children. On the other hand, the learning new words is one of the very important process in the child development. In the English-speaking world non-word repetition was used as the measurement of the phonological working memory. In England Non-word repetition test was conceived by Gathercole, Willis, Baddeley and Emislie (*Memory*, 1994, Vol.2, 103-127). Similarly in America Dollaghan and Campbell (*Journal of Speech, Language, and Hearing Research*, 1998, Vol.41, 1136-1146) developed Nonword Repetition Test (NRT). They reported that Children's Test of Nonword Repetition (CNRep) is able to be useful to measurement of the phonological working memory. According to their conclusion, the CNRep was related to the new word acquirement. Moreover, CNRep has relevance to the comprehension of the syntax and reading skill consecutively. On the other hand, to compare the phonological rules of English language with Japanese language, the Japanese language is more simple in the phonological rules concern. It is because the distinctive feature in the phoneme consisted of the words don't have many. For example, Japanese have only five vowels (V) and thirteen consonants (C), and a syllable is made by these combined phonemes. In Japanese phonological rules, the basic structure of syllables is made of V or CV. There are about one hundred and forty in Japanese syllables. A word is constructed of mora in which includes some syllables as the Japanese phonological characteristics. On the contrary, as basic syllables of English are made of CVC, English syllables are about three thousand. For the differences of these phonological rules between English and Japanese, it may be different from the performance of non-word repetition test as phonological working memory. Indeed, in Japanese language it was considered that the learning disabilities of the reading and the spelling are infrequent compared with English language, it is because thought that Japanese phonological rules are very simple. Therefore to follow the Japanese phonological rule, original non-word repetition test need to be prepared and made to be standardized. This study was examined to normal children with reference to the phonological working memory, particularly, in verbal short-term storing ability and word acquisition of Japanese language. And the significances of non-word repetition in Japanese were investigated in relation to the language development. The target of this study was to investigate whether the non-word repetition test of Japanese language could be useful as a screening test to find out the language impairments in the early age. And we also consider our screening test to be standardized and establish as formal screening test from our study.

Methods: Subjects were 117 normal children from three years one month to six years one month who attended a public nursery school in Japan. They were divided semiannually into six groups in order of their age, that is a group of the early three years old (the age range= 3:01 ~ 3:05, the number of people =11), a group of the late three years old (the age range =3:06 ~ 3:11, the number of people =17 ), a group of the early four years old (the age range= 4:00 ~ 4:05, the number of people =23 ), a group of the late four years old (the age range =4:06 ~ 4:11, the number of people = 20 ), a group of the early five years old (the age range

= 5:00 ~ 5:05, the number of people = 17), and a group of the late five years old and over (the age range = 5:06 ~ 6:01, the number of people = 29). The tasks comprised of six contents: (1) the picture vocabulary comprehension, (2) the repetitions of ten words composed of the three and four syllables, (3) the repetition of non-words composed by the three and four syllables which included each ten, (4) naming of forty nouns and twenty verbs, (5) digit span, and (6) oral diadochokinesis. To investigate the vocabulary comprehension Picture Vocabulary Test (Ueno, Notuso, Inga, 1978) was used and vocabulary age was calculated. Then non-words repetition task was composed by three and four sound series followed the Japanese phonological rules. They were recorded by the flat accent of the female voice and they were set each subject in auditory presentation. The task was produced quickly a series of a complicated sound in which oral diadochokinesis task was used at the point of the production of articulation. Its sound of series of five productions made of k-pata I, k-pataka land k-nekobuta I. A series of sounds of k-nekobuta I which is meant as a cat and a pig in Japanese. In this study, it was used the phonological representations of the non-words in which same mora and syllables were included. Initially, the correlation between the each task was analyzed by the chronological age and/or by each group. Secondly, non-word repetition task was studied and compared with another task. Finally, the subjects' errors of the phonological features were analyzed in the test of the non-word repetition.

**Result:** The result was that the performance of non-word repetition correlated closely with the chronological age and vocabulary age, and related significantly to naming tasks and digit span. The difficulties of speech production such as unskilled speech articulation and error of the oral diadochokinesis were remain until the early five years old, however the group of late five years old children had no difficulties of the speech production. They were not relation to the performances of the non-word repetition. In the repetition tasks, each task was correlative. But the differences among individuals were larger in the non-word than the words. The differences of each group characteristics made clearly in the non-words of four syllables. The average correct answers in the non-words repetition task of four syllables were 5.1 in the group of the early three years old, 6.9 in the group of the late three years old, 7.4 in the group of the early four years old, 8.3 in the group of the late four years old, 8.5 in the group of the early five years old, and 9.0 in the group of the late five years old and over. The group of the early three years old had most little significant in the groups, and there were significant difference between the group of the late three years old and the group of the early five years old and over ( $p < .001$  in either case). And there were another great significant difference between the group of the early four years old and the group of the late four years old and over ( $p < .005$ ). We also analyze the subjects' errors of the phonological characteristics of a non-word repetition test. It had a particular way of the phonological errors were appeared the most in an initial sound, and it account for the percentage that the sound made an error was the only one. In the non-word repetition of three syllables, the initial error sounds took up were 53.1%, the second sounds took up were 31.3%, and the final sounds took up were 10.9%. In the non-word repetition of four syllables, the initial error sounds took up were 31.3%, the second sounds took up were 22.7%, the third sounds took up were 27.0%, and the final sounds took up were 19.1%. Furthermore, in the phonological distinctive features, the minimum error sounds appeared, which were similar to the original sound. But, only one contained semantic error. For example, [kaeru] took in place of [maeru], which [kaeru] meant frog in English.

**Discussion:** The result of the non-word repetition test in Japanese was showed that as the chronological age increased the performance of non-word repetition achievement became higher. And the difficulties of speech production as unskilled speech articulation were not relation to the performances of the non-word repetition. It was indicated that the phonological representation of temporal perception was going to make progress after three-year-old

subjects. Baddeley, Gathercole and Papagno (Psychological Review, 1998, Vol.105, 158-173) reported that the phonological loop in the working memory was specialized for the retention of verbal information over short periods of time, which holds information in phonological form of the words. Therefore they proposed that the function of the phonological loop was help to learn new words. In fact, in this study the performance of the non-word repetition test related significantly to naming tasks. It was made sure that non-word repetition test contributed to the index of the learning of the vocabulary. The test of non-word repetition in Japanese reflected to the differences of the phonological working memory capacity and their development of the phonological awareness. Generally a measure of the maximum length of sequence of digits was the most widely used as the measurement of the children's short term memory ability, and it was founded that 10% of children's between two years ten months and three years one month could achieve a digit span of four. And it was studied that the correlation between the two measure of verbal short term memory that was auditory digit span and non-word repetition (Gathercole and Adams, Developmental Psychology, 1993, Vol.29, 770-778). In the result of this study, the performance of both non-word repetition and digit span showed that there were individual variations of the group of early three years, but in the group from the late three years and over the performances of the non-word repetition correlate closely with their age. In the result of this study the average of correct answers in the four syllables of the non-word repetition task were 6.9 in the group of the late three years old. Therefore, as the first standard in the children of three years six months and up when the performance of the non-word repetition test of the four syllables was below around seven, it was considered that they had the difficulties of the verbal short term memory. On another analysis, in the subjects' errors of the non-word repetition test the phonological features were the only one error and most in an initial sound. And the component of the phonological distinctive features was similar minimum error sounds. As the second standard, when the phonological errors of the non-word repetition test were two and above, and/or the error of phonological distinctive features was large, it is necessary for these children to take more detailed investigation. Though the methods of the learning of new words in the children were various, it was considered that the verbal short term memory contributed to the learning of the words seriously in early period. Therefore, it was important that the ability of the verbal short term memory were investigated as early as possible in the each children. In the conclusion the non-word repetition test in Japanese was useful to detect and identify the children's language impairment, and to interfere in those children in early age. As there were individual variations in the group of early three years old, this non-word repetition test was useful to the children in late three years old and over sufficiently. In fact, the 31 subjects who was above mentioned as standards applied, that was the correct performances were below around seven, the phonological errors were two and above, and/or the error of phonological distinctive features was large. We chose 117 subjects from all, the 26 subjects (83.9%) were concerned by the child-care specialist about their development of the language and behavior. From that result, it was suggested that the non-word repetition test was useful to detect the child with language impairment as the screening test. We realized that the non-word repetition task of four syllables was too easy for the children of the five years old and over. In English it was reported that four syllables were appropriated for the test, but in Japanese, as the phonological rules were simple the series of the sound of the five syllables had better be prepared. The non-word repetition test should be composed of four syllables and five syllables and should be standardized for the children from three years six months and over. In Japan, as the investigation for the children's development as the part of the community care was prepared thoroughly, the non-word repetition test will be very useful as a screening test for detecting of the child with the language impairment in the investigation for the child of three years six month years old.