

Original Paper

## Nonword Repetition Tasks in Japanese as Clinical Markers for Discrimination between Specific Language Impairment and Typically Developing Children

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**Key words:** nonword repetition task, phonological working memory, SLI, typically developing children, clinical markers

### Abstract

**Purpose:** Nonword repetition (NWR) tasks could be used to discriminate between specific language impairment (SLI) and typically developing children (TDC) in English-speaking children. I propose to use NWR task in Japanese language and to establish a standard to discriminate SLI at a younger age.

**Method:** Participants were children who had attended nursery school. The 117 subjects ranged in age from 3-years, 1-month to 6-years, 1-month, and were thought to be TDC, but may have included some with SLI. They were examined to investigate their ability in phonological working memory. As well, an NWR task in Japanese was compared with different tasks associated with language development testing. These included a Picture Vocabulary Test (PVT), naming, digit span, and articulation errors.

**Results:** The NWR task correlated with age, vocabulary age, naming, and digit span. The group less than one-and-a-half-years-old showed individual variations. The mean percentage of correct answer in the NWR task of four syllables comprised almost 70% by age three-and-a-half. In addition, the subjects made phoneme errors only with one-syllable words, those being the least significant, i.e., replacing /t/ with /k/.

**Conclusion:** The results suggested that a Japanese NWR task is a useful clinical marker in discriminating between SLI and TDC.

### Introduction

Specific language impairment (SLI) is defined in both the ICD-10 and DSM-IV, as delayed language development, in spite of normal cognitive and social development. Leonard reported that children with SLI showed significant limitation in their language ability [1], yet factors usually accompanying language problems such as hearing impairment, low nonverbal intelligence test scores, and neurological damage were not evident. In the English-speaking world, SLI is considered to originate in disorders of phonological working memory [2]. In English-speaking children, nonword repetition (NWR) tasks are used as the clinical marker to discriminate between SLI and typically developing children (TDC) [3, 4, 5, and 6].

The Children's Test of Nonword Repetition (CNRep) was conceived in the United Kingdom by Gath-

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ercole, Willis, Baddeley, and Emislie [7]. They researched phonological working memory, which stores language in phonological code, and concluded that CNRep was related to new word acquisition and relevant to comprehension of syntax and reading skill consecutively. Similarly, Dollaghan, and Campbell developed the Nonword Repetition Test (NRT) in America [8].

Short-term memory (STM) has been referred to as working memory since the 1970s [9]. Baddeley and Hitch suggested that working memory represents the mechanism of information processing in relation to task performance and simultaneous storage. In addition, they proposed a multi-component model to explain the concept of working memory [10]. Working memory includes three components comprising a central executive that controls attention, the phonological loop, and the visuospatial sketchpad. The phonological loop is the function that temporarily preserves verbal information, responsible for encoding maintenance and manipulation of speech-based information. Furthermore, an articulation rehearsal mechanism acts upon the loop's realizations in concert. Baddeley reported that working memory is a system for holding and manipulating information during the performance of complex cognitive activities such as reasoning and active learning. Moreover, he said the temporal memory system, i.e. the auditory digit span and nonword repetition, underpinned coherent thought [11].

Investigation of models of working memory has made progress in the study of child language impairment and adult aphasia, and neuropsychological evidence of phonological working memory has been reported in research subjects [12]. In a sense, the relevance between STM and the acquisition of new phonological forms could be considered as the structure of human cognition. Therefore, STM ability is relevant to new word acquisition in children. Baddeley, Gathercole, and Papagno indicated that STM plays a key role in learning new words by generating a phonological representation of brief and novel speech events that mediate the creation of a phonological entry within long-term lexical storage [13]. Furthermore, Marton and Schwartz reported that in language comprehension, verbal working memory played an important role during language acquisition because it allowed the learner to analyze and determine the structural properties of the language to which they were exposed [14].

In a way, language has its own rules in every country. Therefore, Japanese phonological representation also has rules that are peculiar to the Japanese language. When phonological rules are compared between Japanese and English, Japanese is revealed as quite simple in its structure of syllable-composed words. The phonemes used in the Japanese language comprise only five vowels (V) and thirteen consonants (C), which are combined with each other as syllables. The basic structure of Japanese consists of about 140 V or CV syllables. A Japanese word is constructed of a unit, or *mora*, which includes a syllable and beat [15]. Conversely, basic English syllables are constructed of about 3000 CVC elements. I consider performance of a NWR task of phonological working memory capacity to be different in Japanese and English due to their very different phonological rules. Therefore, original and standard NWR tasks based on Japanese phonological rules need to be established.

The purpose of this study was to detect children with hidden SLI from TDC who had been to a nursery school, and had shown no signs of socially unacceptable behavior there. It was reported that SLI might be affecting about 7% of participants in the study [1]. I used an NWR task in Japanese as the clinical marker, and established criteria for screening tests that detect SLI in children.

## Methods

Participants: Japanese monolingual children (N=117), aged 3-years, 1-month to 6-years, 1-month, attending a public nursery school. The subjects were divided into six groups of half-year age-sets:

- (1) first half of their third-year (N=11, 3-years, 1-to-5-months)

- (2) second half of their third-year (N=17, 3-years, 6-to-11-months)
- (3) first half of their fourth-year (N=23, 4-years to 4-years, 5-months)
- (4) second half of their fourth-year (N=20, 4-years, 6-to-11-months)
- (5) first half of their fifth-year (N=17, 5-years to 5-years, 5-months)
- (6) second half of their fifth-year and up (N=29, 5-years, 6-months to 6-years, 1-month)

Procedure: Language developmental tasks comprising four elements involved a Picture Vocabulary Test (PVT) for vocabulary comprehension, the naming of forty nouns and twenty verbs for individual vocabulary, digit span as another short-term memory task, and oral diadochokinesis testing for functional dysarthria along with oral diadochokinesis for speech-motor skills. In the oral diadochokinesis task, each subject was instructed to pronounce a series of phonemes quickly, five times. The repetition tasks included words and nonwords composed of three-to-four syllables or '*mora*'. An NWR task was administered during which subjects repeated 20 original nonwords based on Japanese phonological rules (see Table 1). Both repetition tasks were given to each subject for one word, and then carried on to words and non-words in mixed sequence. Repetition tasks were recorded on a portable minidisk recorder in a flatly accented female voice, with the words and nonwords presented at intervals of five seconds. The phonological representation of the non-words used in this study matched in number the *mora* and syllables. The materials comprised; 'it.figo'(strawberry), 'megane'(glass), 'tsukue'(desk), 'usagi'(rabbit), 'kaeru'(frog), 'empitsu'(pencil), 'nokogiri'(saw), 'himawari'(sunflower), 'jimauma'(zebra), and 'takenoko'(bamboo shoot). Three-syllable clusters of nonwords comprised: 'animo', 'kamura', 'tekama', 'nakumi', 'kunome', 'kajasu', 'kebutji', 'maeru', 'pakona', and 'utatji'. Four-syllable clusters of nonwords comprised: 'kanakuto', 'kisemiji', 'ritakone', 'kobotsuto', 'ketakamu', 'enomoke', 'tatfikoji', 'amitaji', 'kanoposu', and 'kimakate'.

Table 1 A repetition task in Japanese words and nonwords  
This showed examples of word and nonword in Japanese language

words	nonwords
3 syllables (3 mora) [usagi] means a rabbit [kitsune] means a fox	3 syllables [animo] [kunome]
4 syllables(4 mora) [nokogiri] means a saw [jimauma] means an zebra	4 syllables [enomoke] [kanakuto]
*2syllable(3 mora) [kitte] means a stamp	

Data analysis: Each subject's repetitions were transcribed from their recorded production and analyzed. First, the correlation between each task was analyzed according to the subjects' chronological ages (CA) and, or by separate age-set groups. Next, the NWR task was compared with another task in each group. Finally, phonological features of errors produced by each subject in the NWR task were analyzed for the number and position of errors, and distinctive phonemic features.

## Results

CA and the age of vocabulary comprehension (VA) by PVT correlated significantly ( $r=0.72$ ,  $p<.001$ ). The performance of both repetition tasks correlated closely with CA (non-words:  $r=0.41$ ,  $p<.001$ ; see Fig. 1a and words:  $r=0.35$ ,  $p<.001$ ; see Fig. 1b). However, the performances of word repetitions in

children older than the group in the second half of their fourth-year did not correlate and from that age, it became difficult to detect hidden language impairment in subjects. The performances of the NWR task correlated to naming tasks in nouns ( $r=0.38$ ,  $p<.001$ ) and verbs ( $r=0.43$ ,  $p<.001$ ; see Fig. 2a and Fig. 2b). Furthermore, they also correlated closely with digit span ( $r=0.36$ ,  $p<.001$ ; see Fig. 3). On the other hand, the performance of the NWR task did not correlate with either immature articulation and/or functional dysarthria, or the difficulties of oral diadochokinesis as speech-motor skill. Unskilled speech occurred in subjects from the first half of their third-year until the first half of their fifth-year. However, by the second half of their fifth-year, subjects had no difficulty in speech production.

Although both repetition tasks were correlative, the differences among the subjects were higher for nonwords than words (see Fig. 4). The differences in each group's characteristics were clearest for nonwords of four syllables (see Fig. 5a and 5b). When using four syllables, the group in the first half of their third-year averaged 5.1(SD3.1) correct answers. The average number of correct answers for the group in the second half of their third-year was 6.9(SD2.5). The average number of correct answers for the group in the first half of their fourth-year was 7.4(SD2.2). The average number of correct answers for the group in the second half of their fourth-year was 8.3(SD2.1). The average number of correct answers for the group in the first half of their fifth-year was 8.5(SD2.1). The average number of correct answers for the group in the second half of their fifth-year and over was 9.0(SD2.0). The results for subjects with hidden language impairment affected each group's average number of correct answers. In ANOVA, the group in the first half of their third year scored least significant of all, but there was a significant difference between the group in the second half of their third-year and the group in the first half of their fifth-year and over ( $p<.001$ ). As well, there was a significant difference between the group in the first half of their fourth-year and the group of the second half of their fourth-year and over ( $p<.005$ ).

When the distinctive phonemic features of the errors were analyzed, only one syllable produced by the subjects was significant (see Fig. 6). The distinctive phonemic features of the errors were minimal phonemes,

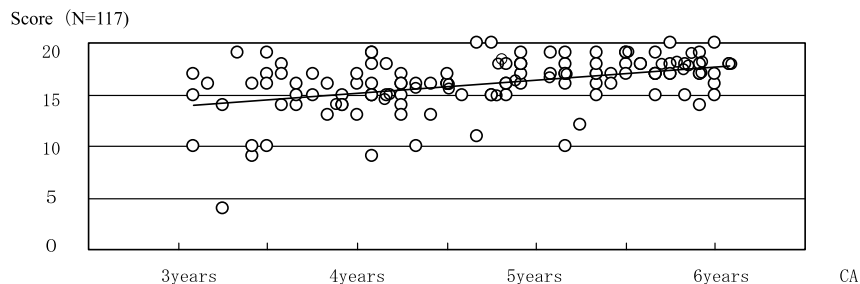


Fig. 1a

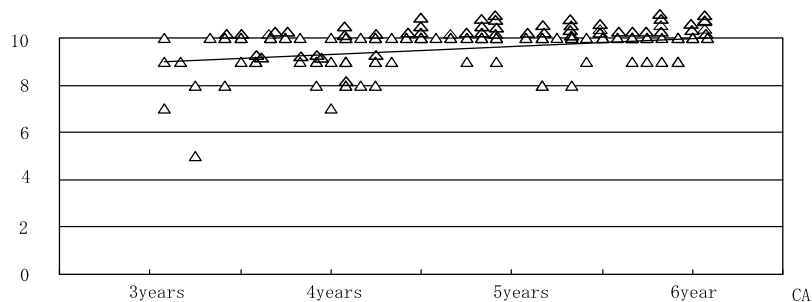


Fig. 1b

Fig. 1 The performance of both repetition tasks correlated closely with CA (non-words:  $r=0.41$ ,  $p<.001$ ; see Fig. 1a and words:  $r=0.35$ ,  $p<.001$ ; see Fig. 1b)

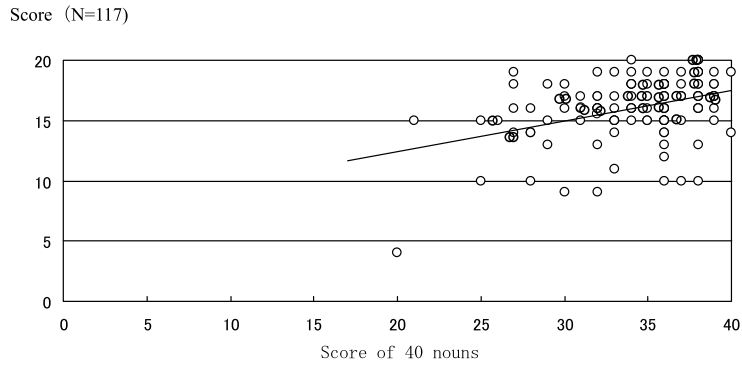


Fig. 2a

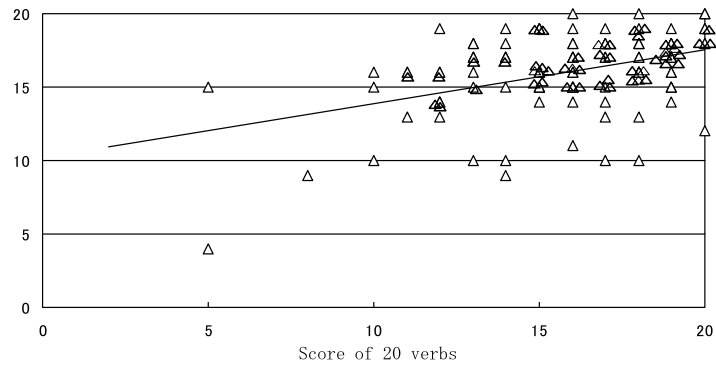


Fig. 2b

Fig. 2 The performances of the NWR task correlated to naming tasks in 40 nouns ( $r=0.38$ ,  $p<.001$ ; see Fig. 2a) and 20 verbs ( $r=0.43$ ,  $p<.001$ ; Fig. 2b)

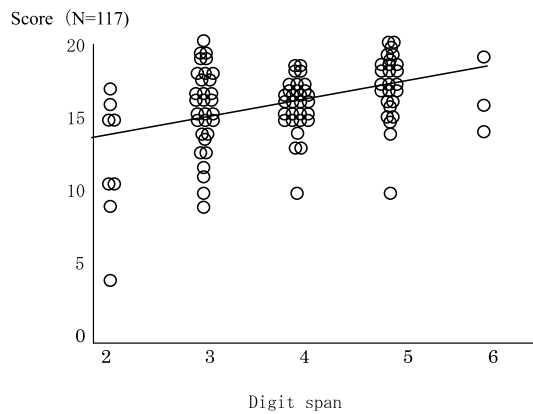


Fig. 3 The performances of the NWR task correlated with digit span ( $r=0.36$ ,  $p<.001$ )

similar to the original spoken sound. For example, the initial /p/ was substituted with /k/ or /t/, /t/ with /k/, and /k/ with /t/. The middle /p/ was substituted with /k/ or /t/, /t/ with /k/ or /g/ or /b/ , /m/ with /b/ or /k/, /n/ substituted /m/ or /g/ or /k/ , and /s/ with /ʃ/ or /tʃ/, /t/, or /n/. The final /t/ was substituted with /k/ or /tʃ/, /k/ with /t/, /g/, or /tʃ/ and so on (see Table 2).

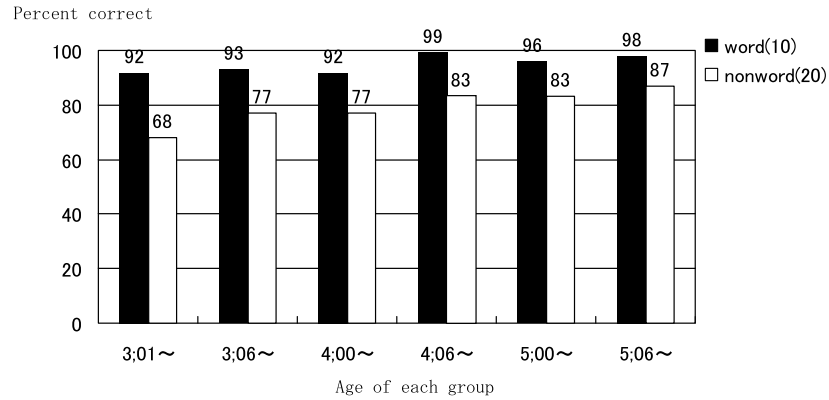


Fig. 4 Percent correct answers of repetition task in 10 words and 20 non-words

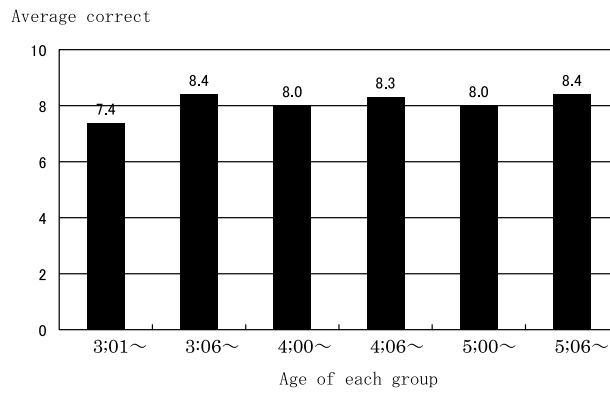


Fig. 5a

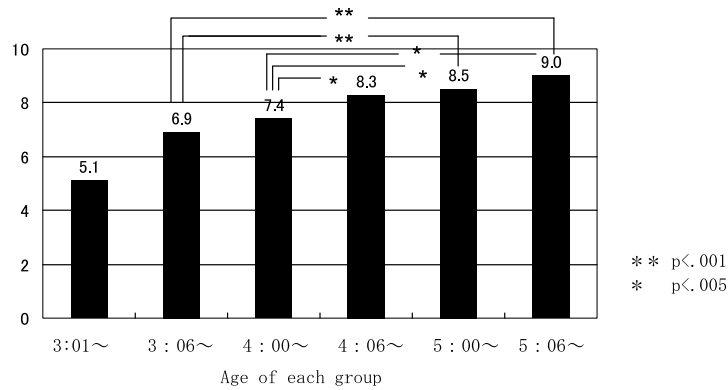


Fig. 5b

Fig. 5 In the NWR task average scoring of 3 syllables with each age group (see Fig. 5a), and 4 syllables (see Fig. 5b). \*\* indicate significant correlation ( $p < .001$ ), \* indicate significant correlation ( $p < .005$ ) in ANOVA

Discussion

Learning words is a significant problem in childhood development. Words are the foundation of language and it is necessary to learn our native language to make a living. Numerous studies report that phonological working memory supplements the information processing of temporary speech-sound representations, and serves as the basis for long-term retention of novel words. Gupta, MacWhinney, Heidi, and Sacco reported that the relationship between word learning, nonword repetition, and immediate serial recall was similar[16].

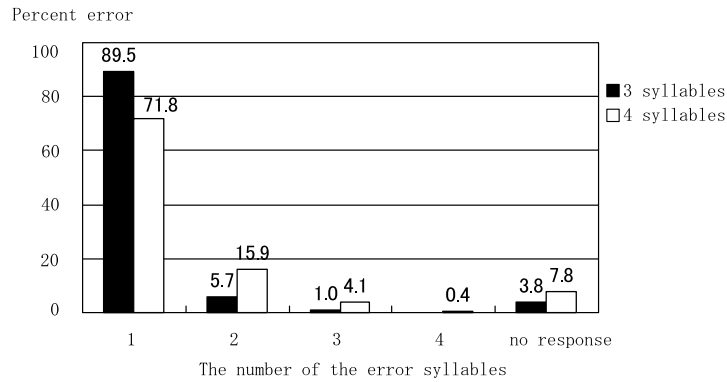


Fig. 6 Percentage of the errors at each number of the error syllables in NWR task

Table 2 The distinctive phonemic features of the errors by position in NWR task.

INITIAL	MIDDLE	FINAL
p/k, t	p/k, t	
t/k	t/g, k, b	t/k, tʃ
k/t, ts, tʃ, r, p	b/t, g, r, k	k/tʃ, t, g
m/k (semantic error)	m/b, k	m/b, n, g, d
	n/g, m, r, k	n/r
	s/n, t, ʃ, tʃ	ʃ/tʃ
	tʃ/k, s	tʃ/ʃ, k
	ts/p, tʃ	r/d

They concluded that it was a fundamental aspect of the cognitive system while studying a subject with early focal lesions. NWR tasks have been used to examine children’s capacity for phonological working memory, which retains words in a phonological code [17].

The results in this study showed that as CA increased, performance in an NWR task rose. In addition, it indicated that the phonological representation of temporal perception improves in subjects from their third birthday. Subjects of the group in the first half of their third-year differed greatly from other groups, in terms of individual variation. Performance in the NWR task was closely correlated with subject age in the group in the second half of their third year. It suggested that phonological working memory developed in concert with the development of phonological representation and neurological development. The group in the first half of their third year failed to develop sufficiently, not only their language abilities but also attention and other cognitive activities. It might be thought that the individual variations within the group in the first half of their third year were affected by the central executive ability to unite the other components of working memory. Munson, Edwards, and Beckman examined subjects between 3-and-6 years of age and reported that accuracy in NWR continues to improve with age [18]. Furthermore, their results showed that performances of NWR tasks related significantly to naming tasks with both nouns and verbs. It was clear that NWR tasks contribute to the predictability of vocabulary development. In addition, it was confirmed that NWR tasks reflect the differences between phonological working memory capacity and the development of phonological representation. The children with low performances in the NWR task were poor at naming tasks.

Gathercole reported on the phonological loop as a language-learning device [2]. She proposed that the function of the phonological loop was not to store words, but to help learn new words. It is the basis of language acquisition, by which children learn words. Each word is realized by its meaning and a form that consists of a sound structure. If a child’s capacity to be receptive to a word form is not satisfactory, the child

cannot learn it. Therefore, the capacity of the phonological working memory is associated with learning words. Gathercole, Hitch, Service, and Martin showed lexical knowledge and phonological working memory played significant roles in the long-term learning of the sounds of new words [19]. Although the method of learning new words among children varies, the phonological working memory is critical to the learning of words during early childhood. Therefore, it was important that the phonological working memory skill of each child be investigated as early as possible. In the results of this study, the performance of the NWR task correlated with CA and the naming tasks. It also indicated the capacity to learn of new words in the Japanese language, based on the phonological working memory system.

Generally, a measure of the maximum length of a sequence of digits is used as the measurement of children's STM ability, and it has been established that 10% of children aged 2-years, 10-months to 3-years, 1-month, could achieve a digit span of four. Gathercole proved this correlation using the auditory digit span and NWR as two measures of STM [2]. However, figures used in the digit span task have a meaning in themselves. There might be differences between individuals with and without a working knowledge of figures. Therefore in my view, digit span is not an appropriate stimulus to deal with temporal information. Moreover, word similarity in the NWR task is an effective method to examine development of the phonological representation of words. I believe the NWR task has value in recognizing hidden language impairments that I suspect may well be SLI.

Interestingly the task of speech-motor skills as functional dysarthria and oral diadochokinesis has no significant relationship to the NWR task. Munson et al. found that the extent of speech-motor development did not predict the effect of phonotactic probability on nonword repetition accuracy [17]. Similarly, I found speech-motor skills were not a suitable index to detect the children with hidden language impairments.

The most important purpose of this study was to establish screening criteria for detecting children with hidden language impairments. In the results of this study, non-words were a better indicator than words in the repetition tasks, and four syllables were more effective than three syllables in the NWR task. Therefore, I found that NWR task with four syllables to be useful in distinguishing between SLI and TDN. The average numbers of correct answers in the four-syllable NWR task was 6.9 for the group in the first half of their third year. Children with hidden language impairments that I suspect may well be SLI were included in this value. For this reason, one may consider children scoring below 6.9 to have difficulties with phonological working memory in the second half of their third year. In addition, I presumed that in the first half of their fourth year, subjects scoring below 7.4 were children with SLI. Similarly, those in the second half of their fourth year scoring below 8.3 were possibly children with SLI, as were those in the first half of their fifth year scoring below 8.5, and those in the second half of their fifth year and over, scoring below 9.0. I did not adopt standard deviation (SD) as part of the criteria, because the children with SLI are not passed over by introduced low criteria (for instance as  $-1SD$ ). In another analysis, subject error in the NWR task comprised only one syllable. Moreover, the component with distinctive phonemic features produced only minimal error and a similarity in phoneme substitution. I attempted to standardize the NWR task using the Japanese language when considering these results (see Fig. 7).

## Conclusion

The results of this study show that an NWR task of four syllables is effective in detecting children with hidden SLI. However, the target of this analysis was children over 3-years, 6-months, because of individual variation among the group in the first half of their third year. In Japan, the investigation of children's envelopment by community care has been thoroughly prepared. I believe that this NWR will be useful in detecting SLI from the age of three-and-a-half-years. I delineated a screening format to detect children with



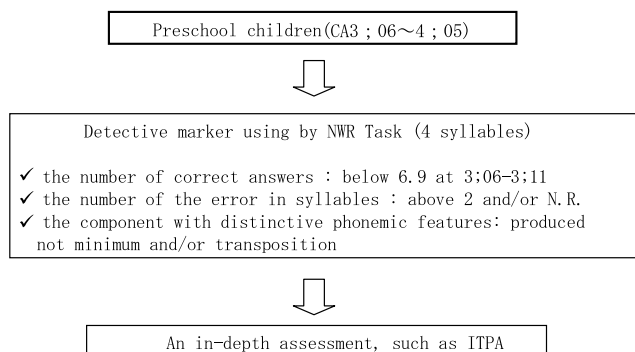


Fig. 7 The format of the screening test to detect the children with hidden SLI

SLI. Moreover, if subjects fit these criteria, it is advisable for them to undergo an in-depth assessment, such as the Illinois Test of Psycholinguistics Abilities. When an NWR task of four syllables was applied with preschool children, hidden SLI had affected the way they were treated by others in some way at an early stage. If children with SLI could be detected in preschool, it would be possible to prevent the problems caused by learning disability after entrance into school. The literature reports that ability in phonological working memory has relevance to reading achievement [20, 21].

The results suggest that the NWR task is a useful screening test in detection of children with language developmental disorders like SLI. A problem that needs to be solved in further research is that the four-syllable NWR task is too easy for children above five years of age, and thus interferes with accurate detection of SLI from that age onward. In English, it has been reported that three or four syllables were appropriate for the test [22]. However, in Japanese, the phonological rules are simpler, so a series employing five syllables should be prepared.

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