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Working and Phonological memory in dyslexia and SLI children in Indonesia: preliminary studies.

Rexsy Taruna[1*], Auliya Syaf[1*]

1. *University of Abdurrab, Pekanbaru, Indonesia*

Abstract

This research aimed to identify the working and phonological memory profile and whether these differ in severity in dyslexic and SLI children who were identified with dyslexia in Indonesia. In experiment 1, the WISC subtest digit span had been administered to obtain information about phonological memory ability in every child. Both groups (SLI and DD+SLI) showed the same degree of severity in under average phonological memory, with a non-significant trend to greater deficit in SLI+ based on poorly developed specification. In experiment 2, the performance of children with SLI and dyslexia without co-morbidity was compared on tests of working memory and executive function. Both groups showed significant impairment in both numbers forwards and reversed, but children with SLI were significantly worse on numbers reversed than the children with dyslexia, indicating a greater difficulty in planning and executive function in children with SLI.

Keywords: Dyslexia, specific language impairment, phonological memory, executive function, WISC

* *Correspondence to:*
Rexsy Taruna, Speech Therapist. Psychology Center University of Abdurrab, Pekanbaru/ E: rexsy.speechtherapist@gmail.com
Auliya Syaf, Educational Psychologist. Faculty of Psychology, University of Abdurrab, Pekanbaru. E: auliya.syaf@univrab.ac.id

INTRODUCTION

The outcome of several studies (Badian, 1998; Mann &Liberman, 1984; Gathercole & Baddeley, 1993; Gathercole, Willis, Emslie, & Baddeley, 1992) show that phonological memory contributes to the reading development of dyslexia children and language development of specific language impaired (SLI) children. Verbal memory span is often known as phonological memory or the phonological loop. This ability is one of the components of working memory (Baddeley, 2000). Verbal memory span involves the ability to listen to auditory information and then repeat this verbally. Baddeley, Gathercole, & Papagno (1998) proposed that verbal memory span (phonological memory) deficit has an effect on language learning (listening, speaking, reading, and writing), and phonological deficit has been the consensus as a marker (or proximal cause) of dyslexia (Catts, Adlof, Hogan, & Weismer, 2005; Fletcher, Lyon, Fuchs, & Barnes, 2007; Shaywitz, 2003; Snowling, 2000; Uhry, 2005).

Dyslexia (diagnosed on the basis of reading and spelling problems) can occur with or without specific language impairment (listening and/or speaking problems). If dyslexia occurs without specific language impairment (SLI), then language abilities such as semantic, syntax, morphology, and discourse ability are within the normal limits. It is different when dyslexia is comorbid with specific language impairment, then overall language abilities such as phonology, semantic, syntax, morphology, and discourse (pragmatic) would be disturbed. Some researchers also showed the risk of dyslexia is increased significantly in children by a diagnosis of speech sound disorder (phonological representation problem) and specific language impairment comorbidity (Lewis, Freebairm, Taylor, 2000, Lewis, Freebairm, Taylor, 2000). Verbal memory span (phonological memory) deficit in dyslexia and specific language impairment was recognized to be the profile for both populations, therefore the hypothesis which was submitted was (1) verbal memory span deficit is also the profile of Indonesian children dyslexia and specific language impairment, (2) there will be no difference in the degree of severity of the verbal memory span deficit on the dyslexia as compared with specific language impairment with dyslexia comorbidity.

METHOD

Participants

Participants in the research were ten children (N=10) recruited from the therapy center in Pekanbaru, Indonesia, including nine boys (9) and a girl (1). They were divided into two groups; (1) dyslexia group, and (2) specific language impairment group with dyslexia comorbidity. Children in both the dyslexia and specific language impairment group with dyslexia comorbidity had the diagnostic report of educational psychologists and speech therapists.

Instrument

Data used in the research was secondary data which extracted from the participants' diagnosis report. Information about verbal memory span ability was found from the WISC subtest digit span results (forward and backward). It assesses children's ability to memorize new information, hold it in short-term memory, concentrate, and manipulate that information to produce some result or reasoning processes. WISC (Wechsler, 1974) is the standard intelligence test instrument in Indonesia to measure intellectual ability in verbal and performance subtests.

RESULT

Descriptive analysis

Ten participants in the research have been divided into 2 groups, a) dyslexia and b) specific language impairment group with dyslexia comorbidity (Table 1).

Table 1. Participant description

	Dyslexia (n = 5)			**SLI + Dyslexia (n = 5)**		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**
Age	9.40	1.95	5	9.00	1.58	4

Statistical Analysis

In terms of analysis, an independent samples t-test was conducted to test if there were differences in the score between the two groups. Before the statistic samples test analysis was conducted, the data were checked in a data normality and homogeneity test. Conclusions of the score results and hypothesis test results are presented on the table 2, 3 and 4.

Table 2. Mean (Scaled score) and SD

	Dyslexia (n = 5)			**SLI + Dyslexia (n = 5)**		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**
Digit span	7.2	.84	2	5.6	2.30	6

Table 3. Mean (raw score) and SD

	Dyslexia (n = 5)			SLI + Dyslexia (n = 5)		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**
Forward	4.40	.55	1	3.40	1.95	5
Backward	2.80	.45	1	2.00	1.23	3

Table 4. Hypothesis test statistical analysis result

Statistical analysis	Sig. (2-tailed)
Normality test	Dyslexia (.314); SLI + Dyslexia (.685)
Homogeneity test	.802
Independent samples test	.182

DISCUSSION

Analysis of the digit span scores of both groups children showed there was no significant difference between the groups, although the mean score of the dyslexic group was higher, and the performance of the SLI+ children more variable. It seems likely that the lower memory span in children with SLI+ is related to their deficits in language acquisition, which are typically more severe than the milder deficits identified in spoken language in dyslexia. This study concludes that verbal memory span deficit is the profile of the Indonesian dyslexia population including those with specific language impairment. Various researchers internationally also have stated the same with a similar pattern of results (Pennington, 2009; Flanagan & Kaufman, 2009).

This study has identified that there is a non-significant difference between forward digit span and backward digit span in dyslexia group compared to SLI + dyslexia group (table 3). However, it seems that the raw score in forward digit span is always higher than the raw score in backward digit span at both groups. This may happen because backward digit span needs a more complex manipulation rather than forward digit span. Although the raw score of forward digit span is always higher than the raw score

of backward digit span, interpretation is normally based on the combined raw score of forward digit span and backward digit span to derive the scaled score. This practice, however, can omit important information in the process of data analysis important for clinical practice (Reynolds, 1997; Banken, 1985). This is related to the working memory theory proposed by Baddeley (2000). Some experts state that forward digit span is related more to measuring the ability of phonological memory (phonological loop), meanwhile backward digit span is related more to measuring the ability of central executive (Alloway, Gathercole, Kirkwood, & Elliot, 2009). If dyslexia is a learning disorder based on phonological processing, it might be assumed that the raw score on forward digit span should have been lower than the raw score on backward digit span. Moreover, Swanson (1994) also stated that dyslexia is related more to the deficiency in forward digit span rather than the deficiency in backward digit span.

In their study, Jap, Borleffs, &Maassen (2017) have also identified that there are differences in ability in digit span in children without dyslexia (typical) when compared with children at risk of dyslexia in Indonesia (Table 5). These differences did not reach significance in this group, at either Grade 1 or grade 2, but a small effect size was identified for digits forward at both grade levels.

Table 5. t test results of typical readers and at-risk readers (Standard Indonesia) from Jap et al., 2017.

Component	**Typical (n = 55)**		**At-risk (n = 9)**		***t* test**
	Mean	SD	Mean	SD	*t*
Forward	5.09	0.89	4.78	1.09	0.82
Backward	3.06	0.89	3.00	0.71	0.21

EXPERIMENT 2.

In order to establish whether the difficulties identified relate more to dyslexia than SLI, a 2nd experiment was undertaken with further groups of children, this time without co-morbidity.

INTRODUCTION

Verbal Memory Span (VMS) is often known as phonological memory or the phonological loop. VMS is a part of the working memory system (Baddeley, 2000) and is defined as the ability to hear sequential sounds through the auditory system and repeat them verbally. It differs from working memory (WM), which is the more complex capability to manipulate the received information (Baddeley, 2000). Based on clinical evaluation, those memories can be distinguished in two ways; (1) memory for numbers forward is evaluated to measure the capability of VMS; (2) memory for numbers reversed is evaluated to measure the capability of working memory or central executive (Vance, 2008; Alloway, Gathercole, Kirkwood, & Elliot, 2009).

Both these capabilities are important for learning oral and written language (Gathercole & Baddeley, 1990) with important implications for our understanding of the role of memory in children with language-based learning disability. Archibald and Gathercole (2006), for instance, reported that children with developmental language disorder or SLI (SLI) have problems with both VMS and WM, and children with specific learning disability (for example, developmental dyslexia or DD) are also found to have trouble with their VMS and WM (Giofre et al., 2016).

The objectives of this study are:

(1) to identify VMS and WM profiles in the SLI Group and DD Group;
(2) to compare the capability of VMS and WM in the SLI Group and DD Group;
(3) to compare the capability of VMS and WM between the SLI Group and DD Group.

The hypotheses of this study as follows;

(1) A VMS problem is the profile for children with SLI and DD;
(2) the problem of WM is the profile of SLI, not for DD;
(3) there is no significant mean difference between VMS and WM in the SLI Group, whereas it occurs in DD Group;
(4) there is no significant difference of VMS between the SLI Group and DD Group;
(5) there is a significant difference of WM between SLI Group and DD Group.

The specific questions asked in this study are:

1. Is the problem of VMS and WM the profile for the following groups of Indonesian children:
   a) SLI
   b) DD

2. Is there any significant mean difference between the VMS and WM in Indonesian children with the following profiles?

c) SLI
d) DD

3. Is there any significant mean difference between VMS and WM in Indonesian children with SLI and DD?

METHODS

Participants

In this study, the participants are divided into two groups: (1) SLI Group (n= 5 male children); and (2) DD Group (n=5 male children). The ten children were recruited from the Psychology Center University of Abdurrab Pekanbaru (Riau, Indonesia). The children (n=10; male) in this study were recruited based on the following criteria:

1. Developmental dyslexia without comorbid conditions (reading score 2 SDs below the mean, the IQ verbal and IQ performance greater than 85).
2. Developmental language disorder (SLI) without comorbid conditions (language score 2 SDs below the mean, IQ performance greater than 85).
3. Both criteria above can be seen from the diagnostic report on each child.

Materials and Procedure

The ten boys who were recruited (different subjects from Experiment 1), based on the above criteria, were scheduled for assessment of the capability of number memory forward and number memory reversed using TAPS-3 or Test of Auditory Processing Skill (Martin & Brownell, 2005). Unlike the WISC, TAPS has been designed to be administered by non-psychologists. Each child was assessed using TAPS-3 individually, and the assessment as well as the interpretation was conducted by the speech therapist. After each child is assessed, the speech therapist will change the raw score on each subtest (number memory forward and number memory reversed) to become a scaled score.

RESULTS

The ten boys were assessed using the Test of Auditory Processing Skills (TAPS-3) on the capability of number memory forward and number memory reversed subtest. Based on the analysis, the following results were obtained from a series of t tests comparing the 2 groups: (1) there is no mean difference between NMF and NMR in the SLI Group; (2) there is a significant mean difference between NMF and NMR in the DD Group; (3) there is no NMF mean difference between SLI Group and DD Group; (4) there is a significant difference of NMR mean in SLI Group and DD Group (table 2.1 and 2.2).

Table 2.1. Comparison of performance in the test of number memory forward and reversed (in-group)

Group	NMF	NMR	Levene's Test for Equality of Variances	Sig. (2-tailed)
	Mean (SD)	Mean (SD)		
SLI	4.4 (.547)	4.4 (1.51)	.237	1.00
DD	4.4 (.894)	7.6 (.547)	.532	.000

Table 2.2 Comparison of performance in the test of number memory forward and reversed (out-group)

Variables	SLI (n = 5)	DD (n= 5)	Levene's Test for Equality of Variances	Sig. (2-tailed)
	Mean (SD)	Mean (SD)		
Age	8.4 (.547)	8.2 (.447)		
Number memory forward (NMF)	4.4 (.547)	4.4 (.894)	.532	1.00
Number memory reversed (NMR)	4.4 (1.51)	7.6 (.547)	.237	.002

RESEARCH QUESTION 1A

Is the problem of VMS and WM the profile of Indonesian children with SLI?

Answer:
The problem in VMS and WM is the profile of Indonesian children with SLI. The mean (scaled score) in the SLI Group is 4.4 (2 SDs below the mean) on the NMF subtest and 4.4 on the NMR subtest (2 SDs below the mean).

RESEARCH QUESTION 1B

Is the problem of VMS and WM the profile of Indonesian children with DD?

Answer:
VMS and WM problems are the profile of Indonesian children with DD. The mean (scaled score) in DD Group is 4.4 (2 SDs below the mean) on NMF subtest and the mean on NMR subtest is 7.6 (1 SDs below the mean). Although VMS and WM are the profile of Indonesian children with DD, there are differences in terms of severity from children with SLI. On the NMF subtest, the scaled score is 2 SDs below the mean, while the scaled score on NMR subtest is 1 SDs below the mean.

RESEARCH QUESTION 2C

Is there any significant mean difference between VMS and WM in Indonesian children with SLI?

Answer:
There is no significant mean difference between VMS and WM in Indonesian children with SLI; where $p > 0.05$.

RESEARCH QUESTION 2D

Is there any significant mean difference between VMS and WM in Indonesian children with DD?

Answer:
There is a significant mean difference between VMS and WM on Indonesian children with DD; where $p \leq 0.05$.

RESEARCH QUESTION 3

Is there any significant mean difference between VMS and WM in Indonesian children with SLI and DD?

Answer:
There is no significant difference in NMF mean between the SLI Group and DD Group; where $p > 0.05$. However, there is a significant difference in NMR mean between the SLI Group and DD Group; where $p \leq 0.05$.

DISCUSSION

In this preliminary study, the researcher found that the problem in VMS and WM is the characteristic profile for Indonesian children with a diagnosis of SLI. These findings correspond to various studies in developing countries, for example the study of Archibald and Gathercole (2006). Moreover, it seems that the compatibility with these study results is also found in the DD Group, where the problems of VMS and WM are characteristic of Indonesian children with DD, but the capability of WM (1 SD below the mean) is better than the VMS capability (2 SDs below the mean). The results of this study correspond to the research by Giofre et al., (2016) and Swanson (1999), which identify that problems in VMS and WM are characteristic of children with DD, and more specifically that WM capability in children with DD is better than their VMS capability.

Various researchers have argued that WM is more relevant for listening comprehension and reading comprehension than decoding (for instance, Pennington, 2009; Oakhill, Cain, & Bryant, 2003), and we know that the main symptom of DD is a problem with decoding (IDA, 2002). Based on this, it makes sense for researchers to hypothesize that the capability of WM on DD should be better compared to VMS capability. If children with DD have trouble with WM (2 SDs below the mean), not only reading, but also all academic fields will be affected (Swanson & Sache-Lee, 2001), and it seems to be related to other conditions, for example DD is comorbid with ADHD (Savage, Lavers, et al., 2007).

OVERALL DISCUSSION.

In experiment 1, we established that both children with Dyslexia and those with Dyslexia plus SLI showed impairments in both digit span forward and backward, with the greatest deficits in those children with co-morbid SLI and dyslexia. The question arises, whether this relates more to the SLI or the Dyslexia component? In order to unravel the relative contributions of the 2 developmental disorders, a 2nd experiment was conducted, in this case using children with no evidence of comorbidity, and comparing dyslexic and SLI groups. The results of the 2nd study indicated that both groups showed problems in numbers forward, but the dyslexic group, although impaired in numbers reversed, showed significantly less impairment than the SLI group. This suggests that SLI has a more deleterious effect on executive function than dyslexia, although it is likely that both groups will show some level of impairment.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH.

The current studies have limitations in terms of the sample size which is not representative of the dyslexic population in Indonesia. Further statistical differences between the groups could emerge when a larger sample is employed. Therefore, a representative sample which can represent the dyslexia population and specific language impairment in Indonesia is needed for further study in order to generalize these results. Studies that

examined the longitudinal impact of these differences over time would be the most useful. Nevertheless, this could be an important preliminary study in a country where statistical research has traditionally been limited.

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