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Original Research

Phonological Memory And Phonological Awareness In Children: A Meta-Analysis

Rexsy Taruna[1*]

[1] Speech Therapy Program STIKes Mercubaktijaya Padang, Indonesia

ABSTRACT

Background: *Phonological memory skills have been widely documented to have an effect on phonological awareness performance, but with varying effect sizes. This meta-analysis aims to determine the summary effect size as a reference when considering phonological awareness interventions.*

Methods: *For identification and selection of articles involved in this study, refer to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The database used to search for articles in PubMed. The inclusion criteria used in this study were articles published from 2013 to 2022, free full-text, and the subjects involved in the study did not have neurodevelopmental disorders.*

Results: *Twelve articles were involved in data synthesis. The average sample in the study ranged from 4 years 2 months to 9 years 8 months. Ninety-one percent of the articles used a norm-referenced test to measure phonological memory abilities, while 66.6% used a norm-referenced test to measure phonological awareness abilities. The summary effect size on the relationship between phonological memory and phonological awareness is 0.433 (p <0.001).*

Conclusion: *Professionals should consider the level of phonological memory ability in phonological awareness interventions.*

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CONTACT
Rexsy Taruna
✉
rexsytaruna@mercubaktijaya.ac.id
Prodi Terapi Wicara STIKes Mercubaktijaya. Surau Gadang, Nanggalo, Padang City, West Sumatra 25173.

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INTRODUCTION

Phonological awareness is the ability of an individual to be aware of and use the phoneme systems that represent words in a language (Mather & Wendling, 2012). This ability develops at preschool age and becomes one of the most crucial abilities in the development of children's literacy at school age for two reasons. First, phonological awareness was recognized as the strongest predictor in predicting word recognition acquisition and spelling development in elementary school-aged children (Hulme & Snowling, 2009).

In fact, the International Dyslexia Association, (2010) explains that deficits in components of language, such as phonology, are recognized as a major cause of word recognition deficits and spelling problems in children with dyslexia. Second, previous studies have consistently found that phonological awareness interventions significantly

affect word recognition and spelling abilities (Soto et al., 2019) (Taruna, 2022). Referring to the findings of the NRP, (2000) it was explained that many children benefited from phonological awareness interventions, with different variations in the duration of the intervention (5 to 18 hours). However, a significant benefit was obtained by preschoolers over older children (NRP, 2000).

On the basis of previous findings, it is very important to know that the identification and intervention of phonological awareness as early as possible are highly recommended for children at risk of dyslexia (Reid, 2009). In addition to the risk of dyslexia that can be identified through the results of phonological awareness examinations at preschool age, professionals can also assign children with speech sound disorder (SSD) or specific language impairment (SLI) with comorbid speech sound disorder to be children at risk of dyslexia (Anthony et al., 2011). Many studies have explained that phonological awareness interventions are not only effective for children in the typical developmental group (TD) and children at risk of dyslexia (without SLI and SSD), but also many studies reveal that phonological awareness interventions are also effective in using in children at risk for dyslexia who have SLI or SSD (Otaiba et al., 2009).

Furthermore, Al-Otaiba et al., (2009) explained that despite having published effective phonological awareness interventions for children at risk of dyslexia who have SLI or SSD, there is little evidence explaining whether given phonological awareness interventions can make children read normally like children with TD. According to various studies, the ability of phonological awareness is strongly influenced by the ability of phonological memory (Oakhill & Kyle, 2000). At the same time, deficits in phonological memory are one of the main symptoms in children at risk of dyslexia who have SLI or SSD (Norbury et al., 2008) (Pennington, 2009) (Taruna & Syaf, 2018).

On this basis, it is assumed that the deficit in phonological memory significantly affects the phonological awareness intervention. Therefore, it is important for professionals to identify the effect of phonological memory on phonological awareness.

MATERIALS AND METHOD

Electronic databases such as PubMed are used to identify articles related to the relationship between phonological memory and phonological awareness in children. The keywords and terms used to identify the articles in this study are *phonological memory, phonological short-term memory, phonological awareness,* and *children*. The inclusion criteria used to determine which articles are included in the data analysis are: articles published from 2013 to 2022, free full-text, and subjects in the study were children without neurodevelopmental disorders.

Identifying Study Statistics and Calculating Effect Sizes

The total sample, correlation coefficient, p-value, age, instrument type, and language used by the subject were then identified. After the total sample and correlation coefficient are identified in each study, the next step is to calculate the effect size (correlation coefficient to Fisher's Z-transform) in each study and calculate the summary effect. Both of these are used to test hypotheses in the meta-analysis.

In addition to the effect size and summary effect, another analysis was carried out, namely the heterogeneity test, which aims to test whether the effect sizes of each study used in the correlation meta-analysis are the same or different.

RESULTS

Four hundred and seventy-one articles were identified at publication (Figure 1). After screening based on articles published from 2013 to 2022, 250 articles remained. Then, 124 of the 250 articles are free to read (free full-text). Finally, out of 124 articles, only 12 articles could be included in the analysis. This is because 112 articles in the study had subjects with neurodevelopmental disorders.

Description of Included Studies

Table 1 summarizes the characteristics of the articles included in this meta-analysis study, consisting of authors, age, instrument, total subjects, correlation coefficient, p-value, and the language used by each subject in the study. Based on the 12 articles involved in this study, the languages used by the subjects consisted of Indonesian, English, Spanish, Brazilian, and Dutch. The total sample of the 12 articles varied greatly, with the smallest sample size being 33 subjects and the largest sample being 973 subjects. The smallest average age of the 12 articles is 4 years and 2 months, while the highest average age is 9 years and 8 months.

Based on 12 articles, 11 articles (91.6%) used a norm-referenced test-type instrument to measure phonological memory ability. Then, only 8 articles (66.6%) used a norm-referenced test-type instrument to measure phonological awareness ability. All articles have a positive correlation between phonological memory and phonological awareness, with the smallest correlation coefficient r = 0.26 ($p < .05$), and the highest correlation coefficient being r = 0.78 ($p < .01$).

Table 1. Article Characteristics

Author	Language	Age	PM Instrument	PA Instrument	Sampel Size (N)	r	Quality
Schaar et al., (2017)	Dutc	6.1	Verbal Short-Term Memory; Informal Test	Phoneme Isolation; Informal Test	973	0.41***	Medium effect size
Jap et al., (2017)	Indonesia	6.4	WISC-R; Norm-Referenced Test	Phoneme Deletion; Informal Test	139	0.26*	Small effect size
Child et al., (2019)	English	7.5	Working Memory Test Battery for Children; Norm-Referenced Test	Comprehensive Test of Phonological Processing; Norm-Referenced Test	233	0.51***	Large effect size
Cardoso et al., (2013)	Brazil	7.7	CONFIAS; Norm-Referenced Test	Teste de memória de trabalho; Norm-Referenced Test	40	0.78**	Very large effect size

González-Valenzuela et al., (2016)	English	6.6	Test of Phonological Short-Term Memory; Norm-Referenced Test	Test of Reading and Writing in Spanish; Norm-Referenced Test	116	0.28**	Small effect size
Murphy et al., (2020)	Brazil	7.2	Short-Term Memory; Informal Test	Phonological Assessment Battery; Norm-Referenced Test	100	0.34*	Medium effect size
Bernabini et al., (2021)	English	9.8	WISC-IV; Norm-Referenced Test	NEPSY-II Battery; Norm-Referenced Test	97	0.52***	Large effect size
González-Valenzuela et al., (2021)	Spanish	6.5	Test of Phonological Short-Term Memory; Norm-Referenced Test	LEE Test; Norm-Referenced Test	116	0.27**	Small effect size
Georgiou et al., (2021)	English	6.4	WISC-III; Norm-Referenced Test	Comprehensive Test of Phonological Processing; Norm-Referenced Test	126	0.38**	Medium effect size
Abel and Schuele, (2014)	English	5.0	Children's Test of Nonword Repetition; Norm-Referenced Test	Phonological Awareness Task; Informal Test	35	0.39*	Medium effect size
Bonacina et al., (2019)	English	4.2	Comprehensive Test of Phonological Processing; Norm-Referenced Test	Comprehensive Test of Phonological Processing; Norm-Referenced Test	33	0.33*	Medium effect size
Verhoeven et al., (2016)	Dutc	5.3	WISC; Norm-Referenced Test	Phoneme Segmentation Task; Informal Test	169	0.42*	Medium effect size

Note:
**p < 0.05, ** p < 0.01, *** p < 0.001*
PA (phonological awareness); PM (phonological memory)

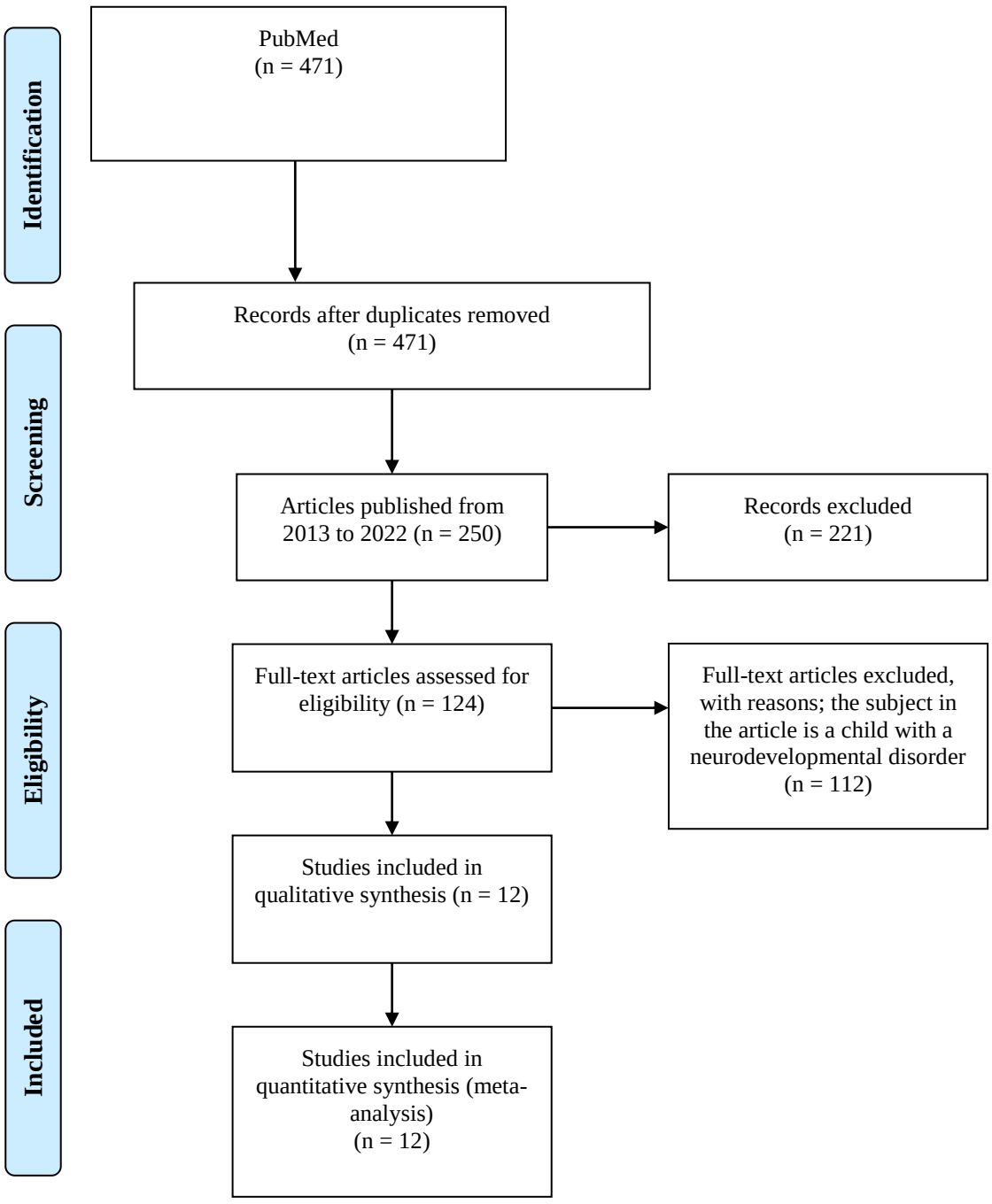

Figure 1. Flowchart of the selection of studies

Data Synthesis

Effect Size and Summary Effect Size

Table 2 and Table 3 summarize the results of the transformation of the correlation coefficient into effect size and the transformation of effect size in each study into a summary effect size. Referring to the results of the transformation, it can be concluded that the vulnerable effect size in the 12 studies ranged from Zr = 0.266 to Zr = 1.045. That is, the effect sizes in the 13 studies ranged from small effect sizes to very large effect sizes.

Then, based on data synthesis using the continuous random effect, or DerSimonian-Laird with a 95% confidence interval, it is known that the summary effect size is 0.433 (p <0.001). Referring to the summary effect size, it can be concluded that there is a significant relationship between phonological memory and phonological awareness with a medium effect size.

Table 2. Correlation Coefficient to Fisher's Z-transform

Author	N	r	Zr	VarZr
Schaar et al (2017)	973	0.41***	0.436	0.001
Jap et al (2017)	139	0.26*	0.266	0.007
Child et al (2019)	233	0.51***	0.563	0.004
Cardoso et al (2013)	40	0.78**	1.045	0.027
González-Valenzuela et al (2016)	116	0.28**	0.288	0.009
Murphy et al (2020)	100	0.34*	0.354	0.010
Bernabini et al (2021)	97	0.52***	0.576	0.011
González-Valenzuela et al (2021)	116	0.27**	0.277	0.009
Georgiou et al (2021)	126	0.38**	0.400	0.008
Abel and Schuele (2014)	35	0.39*	0.412	0.031
Bonacina et al (2019)	33	0.33*	0.343	0.033
Verhoeven et al (2016)	169	0.42*	0.448	0.006

**p < 0.05, ** p < 0.01, *** p < 0.001*

Tabel 3. Summary Effect Size

Estimate	Lower bound	Upper bound	Std. error	p-value
0.433	0.351	0.516	0.042	< 0.001

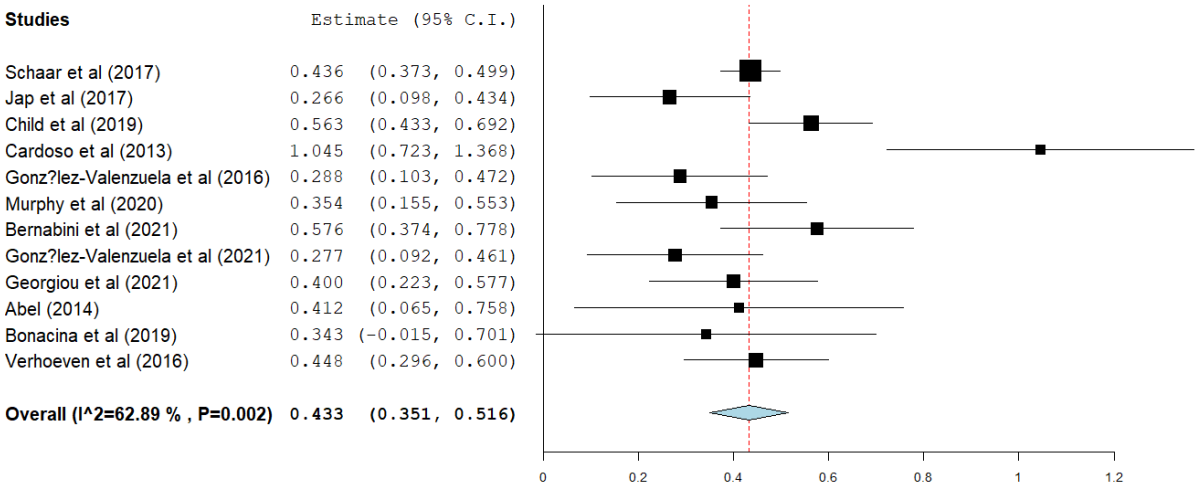

Figure 2. Forest plot of the correlation phonological memory and phonological awareness

Hetorogeneity and Moderator Analysis

Based on the results of the analysis using DerSimonian-Laird with a 95% confidence interval, the results obtained Q = 29,644 ($p < 0.05$) (Table 4). So, it can be concluded that the effect size in each study used in the meta-analysis is different (heterogeneous).

Table 4. Hetorogeneity

tau^2	Q (df=12)	Het. p-value	I^2
0.011	29.644	0.002	62.893

DISCUSSION

This meta-analysis explains that there is heterogeneity in each study, explaining the size of the effect of the relationship of phonological memory on phonological awareness abilities. This heterogeneity ultimately affects the understanding of professionals regarding the influence of phonological memory on phonological awareness. After synthesizing data from 12 articles, we obtain information that phonological memory ability has a significant effect on phonological awareness ability, with a summary effect size of 0.43 ($p < 0.001$). The effect size of 0.43 means that the ability of phonological memory influences the ability and development of phonological awareness at the medium level.

The more developed the ability of phonological memory is, the more this will be a considerable basis in improving and developing phonological awareness skills, which will ultimately affect word recognition and spelling abilities. Conversely, the lower the ability of phonological memory, the will be obstacles in phonological awareness interventions. Based on the clinical hypothesis, phonological memory is an interdependent variable with phonological awareness because of the underlying phonological representation of both (Cunningham et al., 2021).

These findings can basically be used as a reference for clinical practice in order to provide phonological awareness interventions. When a professional provides a phonological awareness intervention, the professional should consider the level of phonological memory ability. This is in line with Schaar et al., (2017) who studied 973 children with an average age of 6 years and 1 month. The results of this study explained

that phonological memory had a significant effect on phonological awareness skills ($r = 0.41$; $p < .001$).

Besides phonological memory having an impact on phonological awareness, phonological memory also has a significant effect on vocabulary development (Baddeley, 2003). Furthermore, vocabulary skills also affect phonological awareness skills (Dufva et al., 2001). High-frequency words are easier to process on phonological awareness tasks when compared to low-frequency words (Trola et al., 1996).

In addition, many studies explain that children who have vocabulary deficits, such as those with specific language impairments (SLI), are at high risk of having a phonological awareness deficit that triggers word recognition and spelling problems. (Bishop & Snowling, 2004; Catts et al., 2005; McArthur et al., 2000).

CONCLUSION

The findings in this meta-analysis can be used as a reference in considering the level of phonological memory when professionals provide phonological awareness interventions. Professionals must consider the number of syllables in phonological awareness tasks, both in assessment and intervention. Then, for the next study, it is recommended to use more than one database and identify moderator variables that function as variables that weaken or strengthen the relationship between phonological memory and phonological awareness.

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