

Effects of a Rhythm Development Intervention on the Phonological Awareness in Early Childhood

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Abstract. The study examines how the rhythm skills improvement in kindergarten children affects the phonological awareness. Furthermore, how the concepts about print, phonological short term memory and graphomotor skills influence the phonological awareness. To answer these questions, we used an intervention of rhythm and movement activities. The participants (N=55 preschool children in Greece) were divided into two groups (experimental and control). Children were assessed on measures for nonverbal intelligence, phonological awareness, phonological short-term memory, concepts about print and graphomotor skills.

The statistical analysis of the data includes mixed models with random effects that investigate statistically significant relationships between the variables under consideration. More specifically, the analyses showed that the intervention had a highly statistically significant effect on the phonological awareness, and that the time-varying covariate “concepts about the print” and “phonological short term memory” were highly significant parameters that affect the phonological awareness. In addition, specific graphomotor skills were also significant predictors for the dependent variable.

The study emphasizes a way to improve phonological awareness through rhythm development in early childhood and shows a connection with the graphomotor skills, as an attempt to help children with handwriting, reading and writing difficulties.

Keywords: Early Childhood Intervention, Phonological Awareness, Rhythm Development, Graphomotor Skills, Mixed Models

1. Introduction

1.1. Rhythm Contribution to Language and Literacy Development

Rhythm constitutes a significant element in the time construction process because it combines sequence (before, after), duration (short and long time interval), pause (between two time intervals), and speed (slow, fast) [1]. Asking children to move according to given music and rhythm patterns and then to reproduce the patterns that they heard are procedures which enable them to estimate time sequence, duration and speed.

Time and space and their related concepts constitute significant precursors for literacy acquisition. Specifically, reading is accomplished by the production of the phonological elements of the language in a given space and according to a particular rhythm pattern. Writing is the distribution of the grapheme representation of the sounds in a given space [2]. Writing is related to children’s graphomotor skills, such as fine motor manipulation, figure reproduction, which also have been found to be significant for children’s literacy development [3]. It appears that reading and writing require a young student to have developed basic spatial concepts as well as being able to perceive time and rhythm both visually, audible and graphically.

1.2. Rhythm Relation to Kindergarteners’ Phonological and Reading Development

Early childhood is considered crucial for children’s literacy acquisition and for the development of its related skills, such as rhythm, time and space. Research findings have shown that kindergarteners’ music and rhythm perception and reproduction abilities are related to several dimensions of early literacy development. For example, Anvari, Trainor, Woodside and Levy [4] found that kindergarteners’ music skills are correlated significantly with both phonological awareness and early reading development. Moreover, Degé and Schwarzer [5] found significant correlations between kindergarteners’ phonological awareness and pitch perception, rhythm perception, tone length perception and rhythm reproduction. Working memory was also a factor related to both rhythm perception and rhythm reproduction.

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A common outcome of the previously mentioned studies is the significant relation between rhythm skills and phonological awareness. Kindergarten teachers may implement rhythm activities. These activities should encourage children to use movement to develop spatial and time concepts [6]. Moreover, short-term memory constitutes a significant factor that teachers should bear in mind when implementing rhythm activities since it is related to the degree children remember and reconstruct activity rhythm structures [5], [7].

1.3. The Problem and the Purpose of the Study

Despite the reported utility of rhythm activities in early phonological development, the relevant research in this field is still sparse. The few available studies have shown that music training and rhythm reproduction tasks can improve children's phonological awareness and are also predictive of children's later reading performance [8], [9]. Therefore, the question about the degree that rhythm interventions can contribute to kindergarteners' phonological awareness merits further investigation. Furthermore, according to our knowledge, none of the intervention studies mentioned above examined concurrently the degree to which rhythm intervention can affect other literacy skills, such as early reading skills, graphomotor skills and phonological short-term memory.

The purpose of the present study was twofold; firstly, to examine how the rhythm development through the intervention affects phonological awareness in kindergarten children, and, secondly, to test if phonological short term memory, early reading skills and graphomotor skills influence the development of phonological awareness.

2. Materials and Methods

2.1. Participants

The sample consisted of 55 kindergarten children in Greece (mean age 66.73 months, SD 7.11, 38.2% were girls). The participants were randomly placed into one of the two groups, namely control (N=28) and experimental (N=27).

2.2. Intervention

The intervention lasted for four weeks in an intensive program that was created by the researchers. The program activities were implemented three times per week by two fully trained research assistants. Rhythm and movement activities aimed at helping children understand the concept of rhythm (succession and duration of the rhythm), distinguish among different auditory stimuli, graphically reproduce rhythms and learn how to play rhythmic patterns.

2.3. Material and Measures

Prior to the intervention, the children were assessed on a nonverbal intelligence test [10]. Additional control variables included age and gender. Furthermore, three graphomotor skills, namely writing space orientation, handwriting control and figure reproduction, were assessed by the SPGS scale [11]. These factors, from the total of six factors that the scale measures, were considered as more relevant control measures for the relation between phonological awareness and rhythm development that is examined in the current study and, thus, they were included as independent variables in the statistical models.

In addition, the Stambak's scale was used [12] consisting of three subtests namely, understanding of a particular spontaneous tempo, reproduction of rhythmic structures and comprehension of the rhythm symbolism. The scores were used to confirm that the rhythm development intervention improved the scores of the experimental group.

Moreover, prior to and at intervention completion, participants were assessed on a) the "concepts about print" scale (24 items) to assess children's early reading skills [13] and b) the scale of Porpodas [14] to assess the phonological awareness (three subtests of 24 items each) and the level of phonological short-term memory (two subtests with 16 and 24 items respectively). The concepts about print and the phonological short-term memory served as time-varying covariates in the statistical models used, whereas the phonological awareness was the dependent one.

3. Results

Two independent samples t-tests showed that the two groups (control and experimental) were equivalent in terms of mean age ($t=-1.23$, $df=53$, $p\text{-value}=0.22$), mean nonverbal intelligence ($t=1.39$, $df=53$, $p\text{-value}=0.17$) and Stambak's rhythm test mean scores ($t=-1.54$, $df=49$, $p\text{-value}=0.13$, $t=-0.55$, $df=49$, $p\text{-value}=0.61$ and $t=-1.01$, $df=49$, $p\text{-value}=0.32$ respectively).

Moreover, the distribution of the gender into the two groups was not significantly different ($X^2=0.53$, $df=1$, $p\text{-value}=0.467$). The descriptive statistics of age, nonverbal intelligence and graphomotor skills are given in Table 1.

Table 1: Descriptive Statistics; mean (standard deviation) of measures prior to intervention

| | <i>Age in months</i> | <i>Nonverbal Intelligence</i> | <i>Writing space orientation</i> | <i>Handwriting control</i> | <i>Figure reproduction</i> |
|--------------|----------------------|-------------------------------|----------------------------------|----------------------------|----------------------------|
| Control | 65.67(8.07) | 19.00(5.32) | 4.71(1.07) | 1.43(1.00) | 4.50(2.85) |
| Experimental | 67.93(5.87) | 16.89(5.90) | 4.41(1.08) | 1.70(0.72) | 5.00(2.00) |

In addition, the mean values of the phonological awareness of the two groups did not differ significantly prior to the intervention (Levene's test for equality of variances: $F=12.75$, $p\text{-value}<0.01$, $t=1.73$, $df=31.02$, $p\text{-value}=0.094$). The mean values of the phonological awareness are presented in Table 2.

Table 2: Descriptive Statistics; mean (standard deviation) of pre and post scores on Phonological awareness, Concepts about print and Phonological short term memory

| | <i>Phonological awareness</i> | | <i>Concepts about print</i> | | <i>Phonological short term memory</i> | |
|--------------|-------------------------------|-------------|-----------------------------|-------------|---------------------------------------|-------------|
| | Pre | Post | Pre | Post | Pre | Post |
| Control | 10.14(5.30) | 10.93(7.42) | 10.14(5.30) | 10.93(7.42) | 22.83(7.84) | 22.50(7.36) |
| Experimental | 11.52(2.79) | 15.67(2.93) | 11.52(2.79) | 15.67(2.93) | 25.30(5.86) | 33.31(3.72) |

The first aim of the current study was to examine whether the intervention has a significant effect on kindergarteners' phonological awareness. For this purpose, we used mixed models with random effects, since participants are declared to be randomly selected from the larger population to which we want to generalize. In addition, we tested the model fit of different covariance structure types of the random coefficients by considering the unstructured covariance matrix and the compound symmetry of the covariance structure. In both models we used age, nonverbal intelligence, writing space orientation, handwriting control and figure reproduction as control variables, and group, trial (before and after intervention) and the interaction between group and trial as explanatory variables. For the comparison purposes, we used the AIC and BIC indices, given in Table 3.

Table 3: Model comparison indices for the mixed effects models

| <i>Model</i> | <i>Unstructured</i> | <i>Compound symmetry</i> |
|----------------------------------|---|---|
| AIC | 517.6 | 517.2 |
| BIC | 522.7 | 520.6 |
| Null Model Likelihood Ratio Test | $X^2=17.76$, $df=2$, $p\text{-value}<0.001$ | $X^2=16.15$, $df=1$, $p\text{-value}<0.001$ |

The compound symmetry covariance structure shows slightly lower values of AIC and BIC, thus it is preferred over the unstructured covariance structure. Furthermore, the null model likelihood ratio test determines whether it is necessary to model the covariance structure of the data, which is highly statistically significant in both models. According to these results, we chose the model with the compound symmetry structure of the covariance matrix to inference on the data. We used the residual maximum likelihood estimation method of the variance parameters, which is generally preferred to the ANOVA estimates [15]. The results of the chosen model are given in Table 4. The effect of the intervention is statistically significant (group: $F=5.56$, $p\text{-value}<0.05$). Moreover, the interaction between group and trial is also highly statistically significant; the experimental group had significantly higher improvement on the phonological awareness compared to the control group ($F=16.87$, $p\text{-value}<0.001$). In addition, the effect of the handwriting control was found to be highly significant ($F=9.04$, $p\text{-value}<0.01$). Note that both age and nonverbal intelligence were insignificant explanatory variables.

Table 4: Model results; Type 3 test of fixed effects. Dependent variable: phonological awareness

| <i>Effect</i> | <i>F</i> | <i>p-value</i> |
|-------------------------------------|----------|----------------|
| Group (control, experimental) | 5.56 | <0.05 |
| Trial (before, after intervention) | 15.93 | <0.001 |
| Interaction between group and trial | 16.87 | <0.001 |
| Age | 0.02 | 0.895 |
| Nonverbal intelligence | 2.22 | 0.146 |
| Writing space orientation | 0.32 | 0.577 |
| Handwriting control | 9.04 | <0.01 |
| Figure reproduction | 1.20 | 0.282 |

With regard to which factors influence the phonological awareness, we used a causal mixed effects model with random effects and compound symmetry of the covariance structure. In this model, we used the same covariates as in the previous model, as well as the time varying covariates “concepts about print” and “phonological short term memory” (see Table 2). Also, the interactions between the two time varying covariates and the group were assessed. To gain parsimony of the model, we used backward elimination of the insignificant effects. The results of the final model are given in Table 5.

Table 5: Causal model results; dependent variable Phonological awareness

| <i>Effect</i> | <i>F</i> | <i>p-value</i> |
|--|----------|----------------|
| Group | 17.07 | <0.001 |
| Trial | 6.53 | <0.05 |
| Interaction between group and trial | 1.19 | 0.284 |
| Writing space orientation | 6.00 | <0.05 |
| Concepts about print | 34.60 | <0.001 |
| Interaction between group and concepts about print | 9.95 | <0.01 |
| Phonological Short term memory | 25.99 | <0.001 |

According to the results of Table 5, the most significant explanatory variables are the group, the concepts about print and the phonological short term memory (all p-values are less than the significance level 0.001). Given that these variables were included in the model, handwriting control was excluded from the analysis as insignificant, whereas the graphomotor factor “writing space orientation” was added ($F=6.00$, $p\text{-value}<0.05$).

4. Discussion

The aim of the present study was to examine whether rhythm skills improvement through an intervention in kindergarten children affects phonological awareness and, moreover, whether concepts about print, phonological short term memory and graphomotor skills influence the phonological awareness.

The results showed that the rhythm intervention highly enhanced the phonological awareness of kindergartners. This result is in accordance to those of previous studies [4], [5], [16]. Moreover, the graphomotor skill namely “handwriting control” was a significant factor. This result might be explained by the fact that rhythm constitutes a significant element of handwriting control; thus phonological awareness and handwriting control can both be positively influenced by the proposed intervention. To the knowledge of the authors, there are no other studies that examine the correlation of graphomotor skills with rhythm development and phonological awareness.

Furthermore, the causal model that was used, aimed at testing which explanatory variables (besides the intervention) influence the phonological awareness. It seems that the intervention has a significant impact on the concepts about print scores. The results confirmed a strong relation between concepts about print scores and phonological awareness, both influenced by the rhythm intervention, which is in conjunction with the results of previous studies [8], [9]. Moreover, according to the results of the present study, rhythm activities can improve young children’s phonological short term memory which in turn seems to be an important factor for children’s phonological awareness. These results do confirm the significant relation between phonological short term memory and children’s phonological awareness that has been found in related studies [17], and they further show that rhythm is a factor that can influence both of these skills significantly.

5. Conclusion

The current study highlighted that, besides phonological awareness, the rhythm intervention can improve additional skills which are important for literacy development. Including rhythm activities in the daily school program can provide an effective literacy developmental educational strategy for kindergarten children.

Further research needs to be done to examine the impact of rhythm on other literacy skills such as reading and writing in early childhood.

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7. References

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