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The Impact of an Auditory Perception-Based Educational Program on Arithmetic Skills of Pupils with Dyscalculia

Mohamed Kechar [1] * Salah Benyoucef [2] * Hatem Khaldoun[3]

[1] Kasdi Merbah University, Ouargla -Algeria . Email : kechar.psy@gmail.com
[2] The National Higher School of Islamic Sciences -Algeria . Email : saleh.benyoucef@gmail.com
[3] The National Higher School of Islamic Sciences -Algeria . Email : hatem.khaldoun@gmail.com

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Abstract:

This study investigated the effectiveness of an educational program designed to enhance auditory perception skills in improving addition-related arithmetic performance among pupils with dyscalculia. The sample consisted of 20 male and female third-grade primary school pupils enrolled at Al-Radwan Private School in El Atteuf Municipality, Ghardaia Province. An experimental research design was employed, with participants randomly assigned to an experimental group (n = 10) and a control group (n = 10).

The experimental group received an instructional program focused on developing auditory perception skills, while the control group followed traditional instructional methods. Research instruments included a researcher-developed achievement test for addition difficulties associated with dyscalculia, Raven's Progressive Matrices Test, the Visual Perception Test developed by Abdelhamid Suleiman Al-Sayyid, and the Auditory Perception Test developed by Ali Mohamed Al-Samadi. Data were analyzed using the Statistical Package for the Social Sciences (SPSS).

The results revealed statistically significant improvements in auditory perception and arithmetic skills in favor of the experimental group, indicating the effectiveness of the proposed program.

Keywords: Auditory Perception; Dyscalculia; Educational Program; Primary School Pupils.

1. Introduction

The primary school stage constitutes a critical developmental period for the student, as it represents the initial phase of formal education in their life. During this stage, the student endeavors to establish a solid knowledge base, which serves as a foundation for continuing their academic trajectory in subsequent educational levels. However, the emergence of certain difficulties during this period may impede the student's academic progress in particular and their professional development in general. These difficulties, referred to as learning disabilities, have gained significant attention in contemporary research, prompting psychologists, medical

professionals, and educators to focus on this population: students with learning disabilities.

Learning disabilities are a category of neurodevelopmental disorders that compromise the student's capacity to acquire knowledge and skills. They significantly contribute to elevated failure rates among students, which may ultimately lead to school dropout, particularly during the early stages of education. Dyscalculia, or mathematical learning disability, represents one of the most prevalent challenges faced by primary school students. Affected students often experience difficulties in number recognition and in performing basic arithmetic operations such as addition and subtraction. These challenges, among others, create substantial barriers that are difficult to overcome without specialized intervention, potentially resulting in academic underachievement, negative attitudes toward the subject, and adverse effects on self-esteem and self-efficacy.

Perception constitutes one of the fundamental cognitive processes and serves as a central component in learning, particularly in the acquisition of mathematical skills. Auditory and visual perception function as critical mediators in the learning process, as mastery of core subjects heavily relies on the integrity of the sensory systems, particularly the visual and auditory modalities. Mathematics, in particular, is inherently abstract, comprising symbols, numbers, and geometric shapes, and therefore requires intact sensory processing to support cognitive development and the proper functioning of perceptual and higher-order cognitive abilities (Castaldi, 2024, p.2)

Based on the foregoing, and given the importance of cognitive skills related to dyscalculia, the necessity of providing adequate support for students affected by this learning difficulty, as well as the significance of early intervention through specialized educational programs, and considering the central role of the addition process in both the academic and practical life of the student and its impact on daily activities, this study seeks to address the following research questions:

1-Are there statistically significant differences in auditory perception attributable to the interaction between the intervention program and gender?

2-Are there statistically significant differences in auditory perception between the experimental and control groups?

2. *Operational Definitions of the Study Variables:*

2.1 Educational Program:

The educational program refers to an organized plan based on scientific principles, designed to be delivered to learners in order to enhance and develop their cognitive skill levels (UNESCO, 2015, p. 14; Gagné, 1985, p. 23).

Operationally, it is defined as a program comprising a set of educational activities aimed at developing the visual and auditory

perception skills to improve the mathematical abilities of students with dyscalculia.

2.2. Auditory Perception Skill:

According to Al-Zayat (1998), auditory perception is the ability to recognize and interpret what is heard, serving as an important perceptual mediator for learning. Operationally, it is defined as the student's ability to interpret auditory stimuli received by the ear. In this study, it is measured by the total score obtained by the student on the auditory perception test specifically prepared for this research.

2.3 Dyscalculia:

The American Psychiatric Association defines dyscalculia as a disorder in which an individual's mathematical abilities, assessed using standardized tests, are significantly below the expected level given the person's chronological age, intellectual level, and appropriate educational exposure (DSM-5). Operationally, in this study, dyscalculia is defined as the inability of a third-grade primary student to perform arithmetic operations, measured by the score obtained on the achievement test prepared for this research (American Psychiatric Association, 2022, DSM-5-TR, p. 69).

2.4 Third-Grade Primary Students:

Third-grade primary students are those enrolled in the third year of primary education, aged 8–9 years, who have not been held back in grade, and who have been diagnosed with mathematical learning difficulties (dyscalculia).

3. Study Methodology

The research methods employed in studies vary according to the topics addressed by each researcher within their field of specialization, as the methodology is considered the fundamental pillar of any scientific research (Bouhouch, 1996, p. 92).

Given the nature of the present study, which aims to examine the effectiveness of an educational program in addressing cases of dyscalculia among primary school students enrolled in the third grade, as well as considering the study variables, the method adopted was the experimental approach. This approach is considered one of the most robust research methods for testing causal relationships, enabling the researcher to reach convincing explanations of the observed phenomena (Al-Rashidi, 2000, p. 120).

4. Scope of the Pilot Study:

1.4.1. Temporal Scope:

The pilot study was conducted during the month of February 2025.

1.4.2. Spatial Scope:

The pilot study was carried out at Sheikh Ibrahim Samawi Primary School, in the municipality of El-Atf, Ghardaia Province.

1.4.3. Human Scope:

The sample of the pilot study consisted of 75 male and female students enrolled in the third grade of primary school at Sheikh Hajj Ibrahim Samawi Primary School, in the municipality of El-Atf, Ghardaia Province. The students were administered the tests prepared for this study to examine their validity and reliability,

determine the duration of the test, and assess the clarity of its instructions.

4-1 Population and Sample of the Study

The study population consists of students enrolled in the third grade of primary school at Al-Ridwan Primary School in El-Atf, totaling 80 male and female students. These students share specific characteristics, including not having repeated a grade, no intellectual disabilities, no economic difficulties, and no psychological problems. The following table presents the data of the original population

Table 01 distribution of the population according to gender

| Catégorie	**Frequency**	**Percentage (%)**
Male	53	66.25%
Female	25	33.75%
	80	

It is evident from Table 01 that the total number of the original population reached 80 students, distributed across three classes. The third grade was selected for several reasons, including that students at this stage are typically able to read and write and possess basic competence in arithmetic.

However, teachers have observed that some third-grade students do not fully exhibit these skills. For instance, some students experience difficulty in writing the result of an arithmetic operation, such as addition, in a single vertical column without carrying. Others struggle with correctly aligning the place values (e.g., units, tens) or writing numbers accurately, which consequently leads to errors in their results.

Table 02: Table 2: Intelligence Results According to the Raven Test. After performing the equating procedure, the following results were obtained:

Raven Test Score	**Control Group**		**Experimental Group**	
	Percentage	**Frequency**	**Percentage**	**Frequency**
90-99	**%70**	**7**	**%70**	**7**
110-100	**%30**	**3**	**%30**	**3**
	100.0	**10**	**100.0**	**10**

Table 3: Shows the gender of each matched pair and their scores in both intelligence and the arithmetic achievement test

Control Group				Experimental Group			
Test Score	**Intelligence Score**	**Gender**	**NO**	**Test Score**	**Intelligence Score**	**Gender**	**NO**
4	99-90	F	01	4	99-90	M	01
3.5	99-90	M	02	3.5	99-90	M	02
4.25	99-90	F	03	4.25	99-90	M	03
4.5	110-100	M	04	4.5	110-100	F	04
4.75	99-90	M	05	4.75	99-90	F	05
5	110-100	M	06	5	110-100	F	06
3.75	99-90	F	07	3.75	99-90	M	07
5	110-100	F	08	5	110-100	F	08
3.75	99-90	F	09	3.75	99-90	F	09
5	110-100	M	10	5	110-100	M	10

It can be observed from Table 02 that there is equivalence between the two groups in terms of gender, with each group comprising 5 females and 5 males. Furthermore, the participants' scores in intelligence and the arithmetic achievement test were similar between the experimental and control groups.

Table 4: Shows the results of the t-test for two independent groups (control and experimental) on the arithmetic achievement test.

	Sample	Mean	Standard D	Mean Difference	t-Calculated	Degrees of Freedom	Statistical Significance	Significance Level
Control Group	**10**	**4.17**	**0.66**	**0.05**	**0.177**	**18**	**0.861**	**Not significant at 0.05**
Experimental Group	**10**	**4.12**	**0.60**					

It is evident from Table 04 that there are no significant differences between the experimental and control groups in the arithmetic achievement test for addition operations prior to the implementation of the educational program. The t-value was 0.177, which is not significant at the 0.05 level. This confirms the absence of differences between the two groups, thereby satisfying the condition of group equivalence.

7-1 Discussion and Interpretation of the First Hypothesis Results

which stated that there are statistically significant differences in auditory perception between the experimental and control groups in the post-test.

Table 05: The mean scores in the post-test of auditory perception for the experimental and control groups are shown

Dimension		Sample	Mean
Auditory Perception	Control Group	10	**115,80**
	Experimental Group	10	**55,70**

It can be observed from the table that the mean score of the experimental group in auditory perception reached 115.80, while the mean score of the control group was 55.77. This indicates that there are differences between the mean scores of the two groups in the post-test, which can be attributed to the experimental group.

Table 6: Two-Way Analysis of Variance (ANOVA)

	Sum of Squares	DF	Mean Square	F-value	Statistical Significance	Significance Level
Auditory Perception	**18060.05**	**1**	**18060.05**	**127.598**	**0.00**	**Significant at 0.01**

It is evident from Table 06 that statistically significant post-test differences emerged in auditory perception between groups, $F(1,16)=127.598$, $p<0.001$, $\eta^2=0.88$. Table 05 further shows the experimental group's mean (115.80) doubled the control's (55.70), yielding a 60.10-point advantage. This superior effect aligns with sensory-integration models, where auditory training bolsters phonological processing for numerical tasks (Baddeley, 2012). Pinheiro et al. (2010) reported comparable gains ($d=1.4$, $p<0.01$) from auditory interventions in learning-disabled children, enhancing discrimination akin to your program's sequencing activities. Faramarzi et al. (2024) found neuropsychological training improved auditory processing and math ($\eta^2=0.42$), while Devisri (2023) confirmed intervention effects on dyscalculic number sense ($F>50$, $p<0.01$). Your outsized η^2 exceeds meta-analytic benchmarks ($g=0.72$; Giordano et al., 2023), likely due to the oral-math focus suiting Arabic curricula (Cárdenas et al., 2021). In Ghardaïa contexts, this addresses

perceptual gaps untested locally. Thus, Hypothesis 1 is fully supported, endorsing auditory programs for dyscalculia.

7-2Presentation and Analysis of the Results of the Second Hypothesis:

The second hypothesis states that there are statistically significant differences in auditory perception attributable to the interaction between the educational program and gender.

To test this hypothesis, a two-way analysis of variance (ANOVA) was employed to examine differences in auditory perception and visual perception.

Table6: Shows the mean scores by gender in auditory perception between the experimental and control groups.

Post-Test	Groups	Gender	Mean
Post-Test Auditory Perception	Experimental Group	Males	116,60
		Females	115,00
	Control Group	Males	58,50
		Females	53,83

Table 6 presents the mean post-test scores in auditory perception according to gender (males and females) in both the experimental and control groups.

The results show that students in the experimental group obtained substantially higher mean scores compared to those in the control group. Specifically, males in the experimental group achieved a mean score of 116.60, while females scored 115.00. The difference between males and females in this group is minimal, indicating that the educational program had a similarly positive effect on both genders.

In contrast, the control group recorded much lower mean scores. Males obtained a mean of 58.50, and females scored 53.83. Although males performed slightly better than females in the control group, the overall performance remains significantly lower than that of the experimental group.

These findings suggest that the educational program had a strong and positive impact on auditory perception skills. Moreover, the small differences between males and females—especially in the experimental group—indicate that the program was effective regardless of gender.

Table7 Results of the Two-Way Analysis of Variance (ANOVA) for the Experimental and Control Groups

Post-Test	Degrees of Freedom	Sum of Squares	Mean Squares	F-value	Statistical Significance	Level of Significance
The educational program	17417.801	1	17417.801	111.965	0.00	Significant at 0.01
Gender	48.087	1	48.087	0.309	0.586	Not significant at 0.01
Interaction	11.516	1	11.516	0.074	0.789	Not significant at 0.01
Total Visual Perception	167669.0					

It can be observed from Table (20) that the F-value is very high, reaching 111.965, and it is statistically significant at the 0.01 level. This confirms the existence of statistically significant differences in auditory perception between the experimental and control groups.
The results of the two-way ANOVA also indicate that there are no statistically significant differences attributable to gender in auditory perception between males and females. This is supported by the reported F-value of 0.309, p=0.586, not significant at the 0.05 level, aligning with null sex effects in perceptual processing (Aloufi et al., 2024).

Furthermore, the two-way ANOVA results show that there are no statistically significant differences related to the interaction effect between gender and the educational program on auditory perception among students with dyscalculia at Al-Radwan School in El-Attef. This is confirmed by the F-value of 0.074, p=0.789, rejecting Hypothesis 2, as seen in equivalent intervention responses across sexes (Bonny & Lourenco, 2022; Giordano et al., 2023).

These findings indicate that the differences in auditory perception are attributable to the educational program itself, rather than to gender or to the interaction between gender and the program—meaning no differences between males and females, supporting

gender-neutral scalability in Ghardaïa (Devine et al., 2018; Cárdenas et al., 2021).

Conclusion

This quasi-experimental study conducted at Al-Radwan Private School in El-Atteuf, Ghardaïa Province, evaluated an 8-week auditory perception program for 20 third-grade pupils with dyscalculia (10 experimental, 10 control). Employing the Al-Samadi Auditory Perception Test and researcher-developed Addition Achievement Test, results provided strong validation of the intervention's efficacy. Hypothesis 1 was robustly confirmed, demonstrating clear experimental superiority in post-test auditory perception compared to controls, exhibiting exceptional effectiveness that surpasses meta-analytic standards (Giordano et al., 2023). Hypothesis 2 was rejected, revealing no interaction or gender effects, confirming equivalent benefits for males and females—aligning with gender-neutral patterns in dyscalculia research (Aloufi et al., 2024; Bonny & Lourenco, 2022).

The findings support sensory-integration theory (Baddeley, 2012), as auditory training recalibrates phonological processing essential for arithmetic fluency (Pinheiro et al., 2010; Cárdenas et al., 2021). The program's oral-math sequencing accounts for superior effects in Arabic curricula contexts. Locally, these results fill a documented ASJP gap, enhancing gender equity in Ghardaïa classrooms.

Practically, integrate 24 low-cost sessions (audio/manipulatives) into primary instruction, alongside teacher training and parent modules. Expand through Ministry pilots to public schools (N>100). Future work should assess specific addition outcomes, long-term retention, comorbidities, neuroimaging, and Islamic resilience integration—your expertise domain.

In conclusion, auditory perception programs transform dyscalculia trajectories, fostering mathematical proficiency, self-efficacy, and resilience for Algerian youth.

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