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Common Difficulties among Children with Down's Syndrome in Acquiring Basic Counting Skills

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Authors' contributions

This work was carried out in collaboration between all authors. All authors designed the study, wrote the protocol and supervised the work. Author GC carried out all laboratories work and performed the statistical analysis. Author GC managed the analyses of the study. Author GC wrote the first draft of the manuscript. Author SGS managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Through this quantitative approach we intent to investigate the existence of patterns in errors that children with Down's syndrome make while counting.
Study Design: The current study can be described as descriptive correlational, while we are also trying to extract data through quantitative analysis.
Place and Duration of Study: In the research, took part 15 Special Primary Schools in Attica-Greece. The study conducted between September 2013 and December 2013.
Methodology: The sample of the study included 40 students with Down's syndrome of moderate intellectual disability. All of them, attended in Special Primary Schools. Their mean chronological

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age was M = 10.07 (y;m). To include a child in the research, it was expedient that its mental age should range between 4;00 (y;m) and 7;01. As a research tool, it was used the Greek standardized version of Utrecht Early Numeracy Test. This psychometric criterion is called Utrecht Early Competence Test.

Results: The widespread failure of students with Down syndrome in activities related to enumeration, led us to speculate on the existence of typology in the errors of these students. Through this research, the hypothesis of the existence of patterns was confirmed and as a result the errors classified in 4 categories. The patterns of errors included recycling parts, skipping objects, double counting objects and a mixed pattern of skipping objects and double counting objects, which is coherent with previous research in the field. We also found that the variables of Correct answers in One to one subtopic are strongly correlated with Number String Production subtopic and Cardinality subtopic having rho=0.669 and rho=0.534 respectively. We should also mention that the Number String Production subtopic and Cardinality subtopic are correlated with coefficient 0.772. Finally, it is also clear, that gender does not affect the patterns of errors since it was not found to be statistically significant.

Conclusion: We focus on students' errors in order to understand not only their way of thinking, but also the way they discover new knowledge. The results are discussed in terms of their significance in curriculum design and designing of teaching scenarios.

Keywords: Down syndrome; utrecht early mathematical competence test; counting skills.

1. INTRODUCTION

Not until recently, many researchers studied academic attainments in children with Down's syndrome. The research related to numerical abilities in children with Down's syndrome is very limited, when literacy is the area in which researchers have paid more attention. Nye et al. [1] highlighted the important contribution of quantitative data in revealing typology of errors. This makes clear the need for qualitative research to be associated with counting errors of children with Down's syndrome. Many researchers claimed that children with Down's syndrome learn to count by memorization and as a result to this, they produce specific types of errors. Thereinafter, we quote the most important studies which assume that children with Down's syndrome acquire numbers by rote.

Moreover, Gelman [2] stated that there is a clear differentiation in types of errors that children with intellectual disability produce compared to typically developing children. The most common errors in enumeration in typically developing children is skipping-objects and double counting errors, whereas seems to produce an extra type of error. Their pattern of errors includes also recounting (multiple words-one point and point-no word errors). The strengthening of her claim that children with Down's syndrome learn to count by rote, results from the fact they are not able to detect or recognize counting errors. They also cannot correlate the cardinality with the last number word that they produce. By the same token, they are incapable of recognizing and self-correcting their counting errors and they constantly produce conflicting responses, such as letters or various words rather than number words. In addition to the above, Gelman was one of the first who claimed that children with intellectual disabilities do not have conceptual understanding of numbers. She stated clearly that, if the children are interrupted while enumeration, they will not be able to complete counting, they may have to start again or stop counting.

Finally, Cornwell [3] was also among those who suggested that children with Down's syndrome do not have conceptual understanding of number and they in fact learn to count by rote. His claim, which was similar to Gelman's reasoning, was reinforced by the fact that they cannot complete counting or start again correctly, if they are interrupted during enumeration.

As a conclusion Porter [4] was among those who tried to substantiate that children with Down's syndrome can have a conceptual understanding of numbers and appear basic understanding of cardinality. Through, an enumeration and an error detection assignment, she proved that some children were able to recognize errors which were made during enumeration, emphasizing the individuality in Down's syndrome. According to this research, children with Down's syndrome made three types of errors including object skipping, multiple words-one point and point-no word. Porter [4] revealed

that "children with Down syndrome who made one to one errors were more likely to miss numbers during their counting than to multiple count and most of their mistakes were point-no word and skipped-object errors".

In the current research, quantitative analysis of the data collected through interviews, we concluded to the same typology of errors. The above fact is encouraging and reinforces the findings of previous research [4].

2. AIM OF THE STUDY

The primary objective of this research is to investigate the counting errors. There is an attempt to discover patterns of errors and correlate them with previous research in the field. Though there is noticeable variation in numerical attainments in children with Down's syndrome [5,6], we should highlight the importance of the survey's findings not only for teachers, but also for parents. As Porter [4] mentions, "the more we can discover about the acquisition of these early skills, the better able we will be to develop appropriate learning environments for children with Down's syndrome".

3. METHODS

3.1 Research Design

Primarily, we contacted parents by epistle to share the nature of our research and to ask for their assistance. As they agreed that their children participate, were used Utrecht Early Numeracy Test to screen their mathematical competence; the descriptive study shares the results of those surveys.

3.2 Participants

The children in this study (N=40) were those with Down syndrome between seven and fourteen years old (M=10.07, SD=2.06) and enrolled in special school programs. The group comprised the entire number of children with Down syndrome in Attica's special primary education.

3.3 Research Tools: One to one Correspondence - Using number words - Structured counting

The obtaining of enumeration skills in children with Down syndrome was determined by the standardized psychometric criterion for early mathematical competence of Utrecht (Utrecht Early Mathematical Competence Test). For the purpose mention above we used the tasks of the third (one to one correspondence), the fifth (using number words) subtopic and the first 3 tasks of the sixth subtopic (structured counting). It is a tool that is both reliable and valid in terms of its content and conceptual structure.

4. DATA ANALYSIS

For the quantitative description of the variables involved in the statistical analysis, we present the descriptive statistics between all examined variables. Specifically, in Table 1, are depicted descriptive measures of the data such as the mean (M), the standard deviation (SD), maximum and minimum value, the skewness and kurtosis of the distribution. As we can directly mention, the students' attainments in One to one tasks is obviously better, than their attainments in Number String Production and Cardinality tasks. To be more specific, the mean of correct answers for One to one tasks is obviously better, than their performance in Number String Production and Cardinality tasks. More specifically, the average of correct answers for One to one tasks stands at M = 2.25, while the average both for Number String Production and Cardinality tasks decreases dramatically at M = 0.78 and M=0.65 respectively. It also worth mentioning, that the remarkable failure on counting skills, is the main factor which motivates us to discover patterns in their errors.

5. RESULTS

5.1 Correlation Analysis

For the illustration of the correlations between the variables examined, we used the correlation coefficient Spearman rho. The statistical significance of the correlations is controlled at a level of significance of *α=1%* and *α=5%.* For processing and statistical data analysis was used the software package for statistical data analysis IBM SPSS Statistics 20.

As we can see in Table 2, there is strong positive correlation between all variables. They found to be statistically significant at a significance level of *a=1%,* consistently with our previous research [7]. Correct answers in *One to one subtopic* are strongly correlated with *Number String Production subtopic* and *Cardinality subtopic* having rho=0.669 and rho=0.534 respectively. We should also mention that the *Number String*

Production subtopic and *Cardinality subtopic* are correlated with coefficient 0.772.

In our previous research, we found that gender is significantly correlated not only with mathematical competence, but also with numerical ability, measured by Academic Attainments Checklist – Sloper et al. [8]. Consequently, a reasonable question is whether the gender affects the variables of One to one correspondence, *Number String Production and Cardinality.* In order examine this hypothesis we used Mann-Whitney U Test. As we can easily discern in Table 3, gender is not statistically significant.

It should also be mentioned, that there is no correlation between Gender and Recycle parts (χ^2=.614, df=1) – Skipped Objects (χ^2=.005, df=1) – Double Counts (χ^2=1.153, df=1) – Combine Skip & Double (χ^2=.614, df=1) – Point no word (χ^2=.234, df=1).

5.2 Patterns of Responding

In Table 4, we can see the distribution of correct answers in One to one tasks. We can easily understand that only a small fraction of the population could not answer fluently, as only 5% of the sample could not give any correct answer. It is also important to mention, the outstanding performance of 3 children, which constitute the 7.5% and could correctly answer all the tasks.

In Table 5, is presented the frequency distribution of correct answers for the Number String Production tasks. While this subtopic consists of 5 tasks, only 15% of the sample could give 3 correct answers. None gave more than 3 correct answers and the majority of them, reaching a 60%, did not answer to any question correctly.

In Table 6, we can see the frequency distribution of correct answers for the *Cardinality* tasks. This subtopic consists of 3 tasks. At this point it is appropriate to mention that approximately all of the children, reaching 80%, could give only 1 or none correct answer.

In Table 7, we can find the distribution for the types of errors. Regarding the types of errors, 28 out of 40 students, comprising 70% of the sample, omitted words during enumeration (e.g.1, 3, 5, 6). All students mentioned above kept counting forwards but only 15 students out of the 28 made another type of error. They double count objects. 14 out of 40, comprising 35% recycled parts during enumeration (e.g. 1,3,4,5,3,4,5,6,7,8,9,7,8,10,20). We should also report that only 11 children pointed no word. Finally, from the statistical analysis there was no differentiation, between girls' and boys' errors.

6. DISCUSSION

The results confirm the hypothesis that there is typology in errors that the child with Down's syndrome make, while enumeration. According to Baroody & Wilkins, [9], "the systematic errors that children, with and without special educational needs make, constitute evidence of their active efforts to understand the world and they are an open window in the mind of the child". Furthermore, as Ginsburg [10] mention, "students' spontaneous but systematic errors also constitute clear evidence that children construct knowledge actively and not passively absorb".

Table 1. Descriptive Statistics between all examined variables

Variables	M	SD	Maximum	Minimum	Skewness	Kurtosis
Chronological age (months)	116,46	27,81	176,4	74,4	0,641	-0,777
Mental age	4,86	0,97	7,01	4	0,838	-0,604
One to one scores	2,25	1,43	5	0	0,424	-0,955
Number string production scores	0,78	1,12	3	0	1,161	-0,164
Cardinality scores	0,65	1,08	3	0	1,412	0,497

Table 2. Correlation coefficients (spearman rho) between the variables

Variables	1	2	3	4	5
One to one scores (1)	1	,669**	,534**	,076	,287
Number string production scores (2)		1	,772**	-,177	-,104
Cardinality (3)			1	,017	-,043
Chronological age (4)				1	,597**
Mental age (5)					1

*Note: *= p < 0.05, Note: **= p < 0.01*

Table 3. Results from Mann-Whitney U test

Null hypothesis	Test	Sig	Decision
The distribution of one to one scores is the same across categories of gender.	Independent samples Mann-Whitney U test	,899	Retain the null hypothesis
The distribution of number string production scores is the same across categories of gender.	Independent Samples Mann-Whitney U test	,504	Retain the null hypothesis
The distribution of cardinality scores is the same across categories of gender.	Independent samples Mann-Whitney U test	,478	Retain the null hypothesis

Asymptotic significances are displayed. The significance level is ,05.

Table 4. Frequency distribution for the one to one scores

One to one tasks		
	Frequency	Percent
0	2	5,0
1	15	37,5
2	6	15,0
3	8	20,0
4	6	15,0
5	3	7,5
Total	40	100,0

Table 5. Frequency distribution for the number string production scores

Number string production scores		
	Frequency	Percent
0	24	60,0
1	7	17,5
2	3	7,5
3	6	15,0
Total	40	100,0

One of our primary goals was to examine even if difficulty with producing the number string effected on tagging objects one – to – one. We found that students are more inclined to make errors such as recycling parts, skipping objects and point no word during enumeration than double counting objects, as Briars & Secada, [11] claimed, fact which is coherent with research findings [4] and previous research in typically developing preschool children.

Thus, according to Baroody & Wilkins, [9], "the failure of counting tasks may be related to the fact that many students can indeed learn by memorization the numerical string and have no particular problem with showing an object at a time, but substantially they face a leading problem with the coordination of these two skills".

Table 6. Frequency distribution for the cardinality scores

Cardinality scores		
	Frequency	Percent
0	27	67,5
1	5	12,5
2	3	7,5
3	5	12,5
Total	40	100,0

While in our previous research, we highlighted the significant effect of gender which shows that, at this level, girls have a better grasp of basic skills than boys [8] and there was no differentiation in the type of errors the two groups made. The hypothesis that girls are more inclined to a specific type of errors, while boys to another, was not retained. As Porter [4] reports, one possible explanation of this phenomenon is that students with Down's syndrome, both girls and boys, have not learnt sufficient number words, perhaps due to the effect of auditory memory on the acquisition of vocabulary [12]. Another, possible explanation may be connected with the fact that they have an additional difficulty in counting orally.

7. PRACTICAL IMPLICATIONS

As we have already mentioned in our previous research [9] "parents are likely to have a greater impact on their children's development than professionals or other adults because of the greater opportunities for providing support" [13]. So firstly, parents should use games in order to find opportunities to teach enumeration. A multi-sensory approach according to each child's age and educational needs is also suggested. The use of image and sound can help in this direction.

Table 7. Frequency distribution for the types errors

	Recycle parts		Skipped objects		Double count objects		Combine skip and double count		Point no word	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Yes	24	60,0	28	70,0	15	37,5	14	35,0	11	27,5
No	16	40,0	12	30,0	25	62,5	26	65,0	29	72,5
Total	40	100,0	40	100,0	40	100,0	40	100,0	40	100,0

In Fig. 1, we can see the Goose Game. This game could possibly be used to teach enumeration in a creative and enjoying way. They can also use the Box Game, which can be seen in Fig. 2. It is an interesting game, through which children can practice not only their enumeration skills, but also their ability to choose the bigger number among two numbers, that they are presented to them.

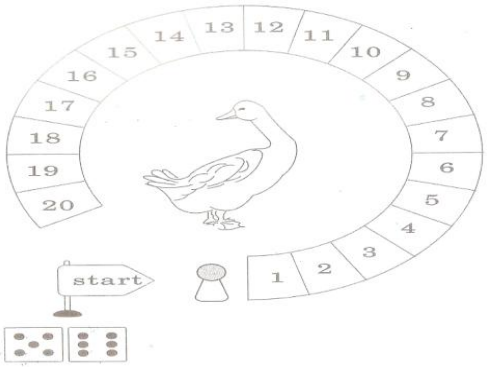

Fig 1. The Goose game (40th Task of utrecht early competence test)

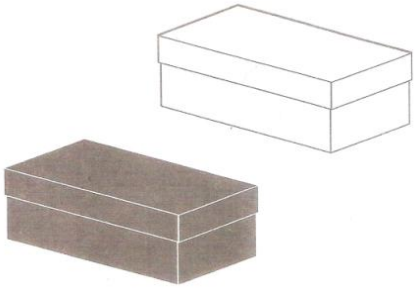

Fig. 2. The box game (36th Task of utrecht early competence Test)

8. CONCLUSION

As in previous research, we concluded that children with Down's syndrome face difficulties in enumeration and present patterns of errors. In order to provide not only specialists, but also parents with useful information for intervention we should shed light in the reason of this phenomenon. It is very possible that the answers, we seek relate to this children' special profile. Short-term memory in children with Down's syndrome is impaired. A possible factor, that should be examined, is Short-term memory's affect in counting ability.

8. STUDY LIMITATIONS

We should be cautious in interpreting the results found here because of the small sample studied. It is common knowledge that with such a population, it is often necessary to study small sample. It is also encouraging the fact that many of the findings are consistent with previous research such as Porter et al study.

CONSENT

All authors declare that 'written informed consent was obtained from the students and parents for publication of this descriptive study and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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