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COMPARISON OF STUDENTS WITH NON-VERBAL LEARNING DISABILITIES AND STUDENTS WITH ASPERGER SYNDROME IN SOLVING WORD ARITHMETIC PROBLEMS

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Abstract:
This study compares the performance of students with Non-Verbal Learning Disabilities (NVLD) and students with Asperger Syndrome (AS) in Solving Arithmetic Problems (SAP). The participants were 15 students with NVLD and 12 students with AS, who were asked to solve 15 word problems of various arithmetic operations. The results showed that both groups faced significant difficulties in SAP. Difficulties have appeared in all phases of the SAP. More intense difficulties appeared in the phase of forming the necessary coherent mental representation of the problem, which is the prerequisite for the activation of cognitive schemata and the choice of the appropriate arithmetic operation. The two groups showed more similarities than differences. Results are discussed in terms of the methodological choices for their instructional support.

Keywords: nonverbal learning difficulties, Asperger syndrome, mathematical word problem solving

1. Introduction

Non-Verbal Learning Disabilities (NVLD) constitute a subgroup of the heterogeneous category of Learning Disabilities (LD) (Mammarella & Cornoldi, 2014). Although the NVLD group has been known for several decades, recognition of students presenting it and their distinction from students belonging to other categories of special needs is still regarded internationally as an open issue (e.g. Fine, Musielak & Semrud - Clikeman, 2014). A group of special needs that is often confused with the NVLD group is Asperger Syndrome (SA), which is part of the pervasive developmental disorders (Klin, Volkmar, Sparrow, Cicchetti & Rourke, 1995; Semrud - Clikeman, Fine & Bledsoe, 2014).

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Confusion arises from the fact that the profiles of cognitive strengths and weaknesses of people with NVLD and people with AS have several common characteristics. Important common elements and differing characteristics of the two groups, pinpointed by the respective research (e.g. Hagberg, Billstedt, Nyden & Gillberg, 2014; Kegel, 2010; Klin et al, 1995; Pennington, 2009, Seung, 2007, Whitby & Mancil, 2009), are presented in Table 1.

Table 1: Similarities and differences between people with NVLD and people with AS

Similarities	**Differences**
- VIQ>PIQ	- Obsessed with routine (AS)
- Difficulties in pragmatics	- Stereotypical behaviors (AS)
- Difficulties in motor skills and coordination	- Unclear / conflicting findings on
- Visual-perceptual difficulties	the performance of people with AS
- Difficulties with novel material	in mathematics, visuospatial skills
- Problem solving difficulties	and reading comprehension
- Difficulties in Executive Functions	
- Difficulties in visuospatial skills	
- Difficulties in visual memory	
- Difficulties in semantics	
- Difficulties in social perception, judgment, interaction	
- Emotional difficulties	
- Appropriate auditory memory	
- Well-developed reading decoding	
- Appropriate spelling	
- Difficulties in information synthesis and process	
- Difficulties in reading comprehension	

The existence of similarities and differences between people with NVLD and people with AS is of particular importance when it comes to decisions on their education. More specifically, it is important to decide whether students from both groups of special needs can benefit from the same, similar or entirely different educational programs (Venneri, Cornoldi & Garuti, 2003). One way to adequately enlighten this issue is to compare the mistakes of students with NVLD and those with AS in a cognitive field in which both groups have weaknesses. Mathematics and especially word problem solving is such a field (Forrest, 2004).

2. Literature Review

Solving word arithmetic problems is a complex process that requires the effective use of a range of skills and processes, such as: reading decoding and comprehension, mathematical vocabulary, concepts, strategies, algorithms, arithmetic combinations, activation of cognitive schemata of the four arithmetic operations, the visuospatial organization of information, attention and memory (Agaliotis, 2011; Bae, 2013). These skills and processes are activated to varying degrees and play a different role in each of the steps of the problem solving process, depending on the cognitive requirements of

each step. In the present study, the following scheme of problem solving steps is used: *translation, integration, planning, implementation and control* (Agaliotis, 2011). The specific characteristics of each step are as follows:

The step (or phase) of translation is that in which the individual elements of the problem are transformed into cognitive representations. The accuracy of these representations is significantly influenced by pre-existing experience and knowledge of the individual. During the integration phase, all of the individual representations of the translation phase are combined into a coherent mental representation, including the dynamic relationships between the situations and the actions mentioned in the problem. In the planning phase, the student has to choose the appropriate actions on quantities and magnitudes and, then, to determine the arithmetic operations required to solve the problem. The implementation phase involves applying algorithms and finding results. Finally, the control phase includes the reflection on the reasonableness of the response (Agaliotis, 2011).

Research data show that students with NVLD fail or find it very difficult to solve math problems, due to difficulties with:

- recognition of the distinct structural elements of the problems (knowns, unknowns), and their interaction;
- managing novel material / new information (such as elements and information included in an unfamiliar problem);
- incomplete comprehension of cause - effect relationships;
- distinction between important and insignificant information of the problem;
- difficulty in interpreting the feedback they accept about their possible mistakes, as well as in the appropriate use of executive functions such as working memory, action planning and cognitive flexibility (Forrest, 2004; Rourke, 1995).

On the other hand, students with AS find it difficult to solve math problems, due to inadequacies in:

- the use of mathematical vocabulary;
- the organization and understanding of verbal information;
- the formulation of a mental problem representation;
- processing and memorizing complex information of problems requiring the use of various arithmetic operations;
- the execution of arithmetic operations;
- the implementation of planning strategies (Bae, 2013; Mayes and Calhoun, 2008; Minshew, Goldstein, Taylor & Siegel, 1994).

The search for studies comparing students with NVLD and students with AS in SAP, in databases such as ERIC and Google Scholar, with keywords such as “Non Verbal LD”, “Asperger Syndrome” and “Problem Solving”, which was run in December 2017, has not yielded exploitable results.

Based on all the above, the following research questions were formed:

- What is the level of performance of students with NVLD and students with AS in solving word arithmetic problems?

- What is the nature of the errors presented by students with NVLD and students with AS in solving word arithmetic problems?
- What are the similarities and differences between students with NVLD and students with AS per problem solving step (phase)?

3. Material and Methods

3.1 Participants

The participants were a total of 27 primary school pupils, in third, fourth and fifth grade of primary school, who lived in a large urban area in northern Greece. Participant information is shown in Table 2.1.

Table 2.1: Data on the composition of the two groups of participants

	Group				**Total**
	NVLD(N=15)		AS(N=12)		27
Age (SD)	9.27(±0.28)		9.67(±0.28)		
Gender (N)	Boys (6)	Girls (9)	Boys (11)	Girls(1)	

Students with NVLD were identified by researchers with the process, criteria and tools described below. Students with AS were identified by public agencies responsible for diagnosing special educational needs, but were included in the participants of this research after a confirmatory evaluation conducted by the present researchers.

3.2. Research procedures

Researchers have obtained permission to conduct the study from the Ministry of Education. All primary schools of a large city in northern Greece were briefed in writing for the purposes of the research and asked if they wanted to participate in it. About 87% of schools responded positively. There were about 6,200 students attending these schools. School teachers were asked to indicate students who were recognized by public agencies responsible for diagnosing special educational needs / disabilities, as persons with mild disabilities. A total of 1,136 students were identified. Students' parents were sent informative material about the purposes of the research and forms of consent on their children's participation in the next stages of the research. The signed consent forms were 1,077. Students whose parents had signed the consent form were examined by the researchers in order to identify those belonging to the NVLD group.

It should be emphasized that the NVLD diagnostic category is not included in the list of special educational needs and disabilities recognized by the Greek educational system (Law 3699/2008). For this reason, processes and tools for identifying students belonging to this category have not been developed in Greece. Therefore, the present researchers are the first Greek researchers who proposed and tested a process of identifying students with NVLD, based on criteria that have been already used by researchers in other countries (e.g. Mammarella & Cornoldi, 2014). More specifically, in order to be included in the NVLD group of the present study, a pupil should

necessarily meet the first of the following criteria and, in addition, at least two of the criteria 2-4, while the fifth criterion was optional:

1. Practical Intelligence Quotient (PIQ) < Verbal Intelligence Quotient (VIQ) with Total Intelligence Quotient (TIQ) ≥80;
2. Performance in a visual motor coordination test one standard deviation below the mean;
3. Poor mathematical performance, but relatively good reading performance
4. Visuospatial memory deficits;
5. Emotional and / or social deficits.

Exclusion criteria included a history of any syndrome (AS, Down Syndrome, etc.), neurological and / or sensory problems, epileptic syndromes, craniocerebral injury or other medical conditions (Mammarella & Cornoldi, 2014).

Three sessions of 20-40 minutes were necessary in order to administer all measurements to identify students with NVLD, and one session of 20-40 minutes for the administration of SAP test to each of the two groups. The administration and interpretation of the intelligence test was conducted by a clinical psychologist, while the rest of the tests were administered by the researchers.

The students with AS included in the participants of the present survey were diagnosed by Greek public agencies for diagnosing special educational needs and disabilities. However, in order to confirm the existence of AS, a questionnaire of 6 questions was used, following the criteria of Gillberg (Attwood, 2007). All the diagnoses of public agencies were confirmed.

Note that the 15 pupils with NVLD initially identified by the researchers participated in all stages of research. Conversely, for various reasons, only 12 students with AS finally took part in all stages of the research.

3.3 Research tools

The tools that were used for collecting the data of the present study, and the procedures for their application, are:

The Greek version of WISC-III (Georgas, Bezevegis, Paraskevopoulos & Giannitsas, 1997) was used to measure the Practical, Verbal and Total Intelligence Quotient. It is noted that during the survey period (2015-2016) there was no newer version of this psychometric tool standardized in Greek (Agaliotis, 2016). For the purposes of this research, each participant was examined in two verbal (Vocabulary and Information) and two practical (Block Design and Object Assembly) WISC sub-scales, which yielded scores that were subsequently used for calculating a total IQ score, as proposed by Sattler (2001).

The Grooved Pegboard Test (Klove, 1963) was used to control the visual-kinetic coordination. This test has been used in the identification of individuals with NVLD (e.g. Galway and Metsala, 2011) and their distinction from individuals with other Learning Difficulties (Durand, 2005). Investigation of the present researchers showed

that during the period of this research there was no Greek version of the Grooved Pegboard Test. Therefore, the norms of the original test were used.

The Screening Test of Arithmetic Ability (STAA) for primary students (Papaioannou, Sideridis, Mouzaki & Simos, 2011) is a standardized tool used for the assessment of the mathematical performance of primary school students. The correct solution of each arithmetic operation included in the test is awarded 1 point, whereas the incorrect solution is awarded 0 points. The internal consistency of the test has been found to be very satisfactory (Cronbach's α = .91).

Test of Reading Achievement (ToRA) (Panteliadou & Antoniou, 2007) is a standardized tool for assessing decoding of individual words and text fluency. Word decoding is tested through reading pseudo-words (24 in total), reading ordinary words (53 in total) and distinguishing real words among pseudo-words (36 in total). The sum of the three tests presents the student's performance on a percentile scale, depending on school grade and gender. To test text fluency, students are asked to read a text for one minute. The words read incorrectly are subtracted from the words read in total, and the result presents the child's performance on a percentile scale, depending on school grade and gender. Internal consistency of the tool has been found to be satisfactory (Cronbach's α = .84).

The Rey Complex Figure Test (RCFT) (Osterrieth, 1944) was used to evaluate the visuospatial memory. In this test examinees are asked to reproduce, with as much detail as possible, a complex image that is shown to them. Different modes of implementing the test have been developed: copying, immediate recall and delayed recall. Copying assesses the visuospatial ability, whereas the immediate and delayed recall evaluate the visuospatial memory (Lezak, 1995). In the present study, immediate recall was used, as the objective was to examine the visuospatial memory. Since the above scale is not standardized in Greece, and in accordance with Vlachos and Karapetsas (2003), the English version of the tool was used in the present study (Corwin & Bylsma, 1993), which provides a 36-point grading system, with 18 individual gradings (for each of the 18 parts of the scheme).

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997), which evaluates social and emotional difficulties and psychological adaptation in 3-16 year old students; the test was standardized in Greek by Bibou - Nakou, Stogiannididou, Kioseoglou, and Papageorgiou (2002), and was used in the present study to outline the profile of students with NVLD. There are questions about 25 properties, some positive and others negative, associated with: emotional issues, behavioral problems, hyperactivity / attention deficit, relationship problems with peers and prosocial behavior. The 25 questions are divided into 5 scales, each containing 5 questions and producing a separate score for each of the above categories. The questionnaire is answered by adults who know the child well, and who use a 3-point Likert scale to show the degree to which each property applies to the child (Garralda, Hates and Higginson, 2000; Goodman, Ford, Simmons, Gatward & Meltzer, 2000).

The Gillberg criteria (Attwood, 2007) for the AS were used to confirm the diagnoses for the participants who formed the AS group. In particular, the parents of these pupils responded to a questionnaire with 6 criteria, which were: serious difficulties in reciprocal social interaction, limited interests, imposition of routines and interests, speech and language problems, non-verbal communication problems, motor clumsiness. In order to confirm the diagnosis, all 6 criteria had to be met.

A sub-test of the "Psychometric-Differential Assessment of Children and Adolescents with Learning Disabilities" (Barbas, Vermeulen, Kioseoglou & Menexes, 2008) was used to explore the differences between the two groups in solving math problems, which was the main objective of this research. This test can be given to persons aged 7.06-15.05 years and consists of a total of three sub-tests, which are: vocabulary, calculations and problem solving. In the present study, the problem solving sub-test was used. In this sub-test, the participants are asked to solve as many of the 15 problems included in the test as possible. The problems are characterized by the fact that most of them do not have the standard wording of the problems of the school textbook; for their solution, various arithmetic operations are needed. An example of the test problems, which includes information that is irrelevant to the interactions requiring processing in order to solve the problem, is the following: *"Anna loves ice-cream. Sometimes she eats so much ice-cream that her belly hurts. Yesterday she ate one vanilla ice-cream, one strawberry ice-cream and one melon ice-cream. How many ice-creams did Anna eat yesterday?"* Another example of a problem included in the test is the following: *"Eleni is 8 years old and her birthday is in one week exactly. Today is April 2nd. What is the date of her birthday?"* Arithmetic data appear in the problems either in numerical or verbal form (e.g., 3, five). For each correct solution, the student gets one point, while the wrong answers are scored with (0). The sum of the correct answers is the initial score, which is converted into scaled score (M=10, SD=3). The test is interrupted after 5 consecutive incorrect answers. The tool has satisfactory internal consistency (Cronbach's α for the total population .80). Prior to administering the test, the teachers who taught students with AS were asked if these students had low grades in Language Arts, due to particular difficulties in reading. No such case was reposted. As far as students with NVLD are concerned, they were subjected to a reading decoding test in the context of their identification process, and it was established that their reading performance ranged on satisfactory levels.

It should be noted that in the context of the present study, the answers of the students were evaluated not only in terms of accuracy, but they were also analyzed in order to pinpoint qualitative differences in the answers of the two groups.

4. Results and Discussion

Since this research is the first systematic study of NVLD in Greece, it is worth mentioning the prevalence of this condition in the general student population from which the participants come. In the present study, then, the percentage of pupils with

NVLD in the general student population reached 0.24%. This percentage is within the range of 0.1% - 1%, which is the estimated frequency of NVLD in the general population worldwide (e.g. Roman, 1998; Thomson, 1996).

Concerning the math problems solving, the means, the standard deviations, the minimum and the maximum score of the performance of the two groups are shown in Table 3.

Table 3: Performance of participants in solving math problems

Group	NVLD	AS
Mean	7.36	6.25
Std. Deviation	0.929	2.094
Minimum	6	4
Maximum	9	10

It is obvious that both groups' performance was about 1 standard deviation below the mean of 10. There was no statistically significant difference between the two groups (Mann-Whitney U test - p-value=0.256>0.05).

In the NVLD group, correct answers were given up to the 5th problem, while in the AS group correct answers were given up to the 8th problem (out of a total of 15 problems). The incorrect answers were analyzed per math problem solving phase, and the results are presented below. It is noted that there was no participant who responded to all the problems correctly, while 1 pupil with NVLD and 1 pupil with AS responded to all problems incorrectly. In the following problem, both groups showed their worst performance: *"The 50 states of the USA cover a total of 9,364,925 square kilometers. From this area, the 203,013 square kilometers are lakes and rivers. How many square kilometers are land?"*. Finally, in most problems the most incorrect answers were given by the NVLD group.

4.1. Errors in Translation phase

In the first phase of the problem solving process (which is characterized by the effort of the solver to comprehend each individual component of the problem, by activating their pre-existing knowledge), the pupils with NVLD and the pupils with AS presented significant similarities. From the group of pupils with NVLD, 6 participants had a success rate of 37.5%-50% and 9 participants 51-75%. From the AS group, 6 participants had a success rate of 16.6%-50% and 6 participants 51-83.3%.

Approximately 40% of the participants from the group of students with NVLD and 45% of the participants with AS showed complete ignorance, incomplete knowledge or limited understanding of the specific mathematical significance of some individual words or phrases included in the problems, such as: "cover, land, square kilometers, pair of socks, cost, below zero, Celsius degrees, week." Other difficulties presented by participants from both groups referred to the understanding of fractions (1/20). Examples of specific errors presented by individual participants of both groups regarding the above words and phrases are: (a) The inability to understand the

information indicated by the word "cover" in the first sentence of the problem *"The 50 states of the USA cover a total of 9,364,925 square kilometers. From this area, the 203,013 square kilometers are lakes and rivers. How many square kilometers are land?"*; as well as the doubt about the content of the word "land" in the question of the problem, since for some students the word "land" turned out to mean "that which exists where the sea ends". (b) The incomplete comprehension of the concept of "pair" (Problem: *Panos washed 4 pairs of socks. When he pulled them out of the washing machine, one sock was missing. How many socks did Panos take out of the washing machine?* -Researcher's question: If we counted one by one all the socks that Panos put in the washing machine to wash them, how many we would find?" - Students Response: "Four")

Individual students from both groups presented idiosyncratic difficulties (e.g. a student with AS asked the researcher to read the problems to him, although he did not experience significant decoding difficulties). However, these difficulties do not change the general finding that the two groups present mainly similarities in the translation phase. It should be noted that no student from both groups responded to the translation phase in all of the problems, but there were problems in which no group participant made any mistakes.

4.2 Errors in Integration phase

In the second phase of the problem-solving process (which is characterized by the solver's attempt to determine the relationship between the givens and the unknown, combining the individual elements understood during the translation phase in a coherent representation), 5 participants from the group with NVLD had a success rate of 16.6%-50% and 10 participants 51-87.5%. From the group with AS, 6 children had a success rate of 0-50% and 6 children 51-87.5%.

The qualitative analysis of the two groups' errors shows that they have remarkable similarities, but also some differences. Specifically: Approximately 40% of the participants with NVLD and 45% of the participants with AS failed at this phase. They took into account only part of the data, at the same time ignoring some critical piece of information, such as (a) the need to compare sizes and not simply to define quantities, (b) the existence of a multiplicative relationship in the problem, and (c) the fact that the problem involves several individual pieces of information that are all necessary for the right solution, but it includes also unrelated or peripheral data. For example, in the problem *"Anna loves ice-cream. Sometimes she eats so much ice-cream that her belly hurts. Yesterday she ate one vanilla ice-cream, one strawberry ice-cream and one melon ice-cream. How many ice-creams did Anna eat yesterday?"* - some students replied that Anna ate "vanilla ice-cream and strawberry ice-cream". To the problem *"Ioanna took 3 mastic chewing gums from the neighborhood kiosk for 12 cents each and 3 more mastic chewing gums from the supermarket for 10 cents each. How much more money did Ioanna pay at the kiosk?"* - several participants said that Ioanna paid 12 cents at the kiosk and 10 cents at the supermarket altogether and, therefore, an operation with these two numbers will give the arithmetical solution to the problem. Ignoring pieces of the problem's

information was also noted in the case of students of both groups who took into account only data presented through arithmetic symbols, while ignoring the data expressed by number words. For example, when presenting the situation described in the problem with the ice-creams Anna ate, some students said that Anna ate one ice-cream (they even seemed surprised by the researchers' question "How many ice-creams did Anna finally eat?", and answered emphatically "One, the problem itself says it!" - while pointing at the number 1).

Participants from both groups have had difficulty in the determination of the whole and its parts. For example, in the problem, *"Ares had some small flags. He gave 2 of these to Markos. He was left with two for the celebration of the upcoming national day. How many small flags did he initially have?"* - some students explained that the flags that Ares had in the beginning were 2 (so they thought the question of the problem was meaningless). Similar errors appeared in the case of the problem *"The cat of Petros, Susan, had 5 kittens. Petros gave a red kitten to Andreas. He gave a white kitten to Sofia. He could not find other children for the rest of the kittens. How many kittens has Petros given so far?"* - some students from both groups, when asked to identify the problem's question, said that it was "how many kittens does Petros have now".

Also noteworthy is the difficulty presented by individual students from both categories of special needs of the present study, in terms of understanding the relationship between problem data containing words, which they had found difficult to understand in the translation phase. For example, in the problem with the USA, a typical student question was "Is “area” and “land” the same?"

Besides the similarities, there were some differences between participants from the two categories of special needs. One distinctive difference was the fact that only some students with AS, when asked to present the problem in their own words and identify knowns and unknowns, reported data that did not exist in the problems or did not make any sense. For example, in relation to the problem with the ice-creams Anna ate, a student with AS responded, *"I want her to have eaten 10 ice-creams, chocolate, peanut and other flavors."* Another student with AS, when asked what was the problem with Ioanna and the purchases made at the kiosk and the supermarket, replied "the kiosk". Another characteristic error of students with AS was the distortion of the numerical data of the problems (such as the fact that the cat gave birth to 12 kittens - instead of 5) and the answer to the question "where does it say that?" - "I made it up". At any rate, such responses were given only by a small number of students with AS.

It should be noted that no student from both groups succeeded in the integration phase for all the problems, but there were problems in which there were no errors from the participants of the groups.

Summarizing the similarities and differences of pupils with NVLD and pupils with AS at the stage of integration, it can be mentioned that the two groups showed difficulty in compiling comprehensive and coherent images of the situations referred in the problems, with typical errors: (a) ignoring data, especially that expressed in number words; (b) difficulty in understanding relationships between givens and unknowns,

especially in reference to elements not recognized in the translation phase and (c) the inability to determine the quantities and sizes involved in the problem, especially when they were linked with a whole-part relationship. The differences between the two groups were mainly found in the fact that only students with AS reported as problem components arbitrary data, which had actually no relation to the problems.

4.3 Errors in Planning phase

In the third stage of the problem solving process (in which the solver passes from the perception formulated about the situation to which the problem refers, to the activation of the available cognitive schemata of the arithmetic operations and the selection of the operations considered necessary for the solution of the specific problem), the participants of the two groups showed similarities and differences, as they did in the stage of integration. In terms of success rates, participants in the group with NVLD presented rates from 0-44.45%, while participants in the group with AS presented rates from 0-46.1%.

The qualitative analysis of the errors in this solution phase revealed errors that were obviously due to errors in previous phases, but there were also errors related to the specific processes of the Planning phase. Specifically:

Some students of both groups chose and executed a correct operation, but did not continue their effort to finally solve the problem. For example, in the problem with Ioanna and the purchases made at the kiosk and the supermarket, some students from both groups implemented the multiplication 3*12 (which is the right operation to find the amount spent by Ioanna at the kiosk). Some others chose the subtraction 12-10 (which is correct for finding the price difference of a mastic as sold in the kiosk and the supermarket). However, in both cases the students did not proceed to further operations as required by the problem.

Another mistake presented by some students of both groups is that they chose the opposite of the required operation, although they used the correct numbers. Examples of such an error is the case of the addition 12+10 in the problem with Ioanna and the purchases made at the kiosk and the supermarket, and the addition of 9,364,925+203,013 in the problem with the USA land.

A third error category that occurred in the planning phase is the choice to use problem numbers (whether they appear in the form of arithmetical symbols or number words) to implement an operation that is meaningless or not justified based on the situation described in the problem. Examples of such errors is the subtraction “5-3” in the kitten problem (5 is the initial number and 3 the remaining kittens, while the question is how many kittens were given away, and requires the addition of 1+1), as well as the subtraction “7-2” in the birthday problem, which is supposed to be a week after April 2nd.

Finally, another error category in the planning phase is the one that was presented only by participants of the group with AS, who had introduced arbitrary data in the problem situation described in the integration phase. These students chose some

operations that correspond to the arbitrary data, or simply stated a result without choosing an operation. For example, following the (false) statement that "Anna ate vanilla, strawberry, melon and chocolate ice-cream", which was stated during the integration phase, the 1+1+1+1 addition was implemented.

To sum up, the similarities between students with NVLD and students with AS in the planning phase include (a) correct but incomplete attempts, (b) opposite operations to those necessary and (c) meaningless operations, usually between numbers not related to the problem. The differences between the two groups refer to arbitrary and unrelated operations proposed by students with AS, following similar proposals in the integration phase.

4.4 Errors in Implementation stage

In the fourth problem-solving stage (in which the solver uses their knowledge on algorithms and arithmetic combinations to find numerical results), the participants of both groups showed both differences and similarities. It should be noted that only a small number of participants (about 15% of each group) reached this stage without error even in one problem, while the others made several mistakes in previous solving stages.

In particular, students with NVLD made mistakes in subtracting zero from another number (9-0=0), as well as mistakes in transferring a number from the problem to the arithmetic operation (instead of using 203.013, student wrote 203).

On the other hand, students with AS have made unexpected arithmetic combination errors (7+2=11 - despite the fact that previously they had executed correctly other operations), as well as errors in subtracting large numbers from smaller ones (203.013-9.364.925=9.161.910).

To sum up, the errors of the students of both groups in the phase of finding the arithmetical answers to the problems are similar, in the sense that they refer to the comprehension and application of principles and properties of the operations (e.g., commutative property, zero principle), mainly in the subtraction. However, mistakes show diversity in terms of declarative elements of the execution of operations (such as arithmetic combinations and the transfer of numbers from the problem to the operations).

4.5. Errors in Control phase

In the fifth stage of problem solving, in which the solver controls the reasonableness of the result reached and considers whether there are actions to be revised, the students of the two groups, without exception, stated either that they consider their answers reasonable or that they do not know if there is any other action that would yield better results.

4.6. Discussion

The present research aimed at identifying similarities and differences between pupils with NVLD and pupils with AS in the solution of word arithmetic problems. For this reason, 15 pupils with NVLD and 12 pupils with AS were examined with a test involving a total of 15 problems. The results showed that both groups scored lower than the mean of the test, and that they have made mistakes at all steps of the problem-solving process. In terms of errors types, participants from both groups showed (a) complete ignorance or limited understanding of the particular mathematical significance of certain individual words or phrases, (b) difficulties in forming comprehensive and coherent picture of the situations depicted in the problems, (c) incomplete or incorrect operation choices to solve the problems, (d) errors in the execution of operations, and (e) lack of reviewing the results. Overall, the two groups showed more similarities than differences. Specifically:

The performance of the participants in the Translation phase can be described as deficient, with several instances of incomplete or incorrect understanding of individual words (and the phrases that contained them). This finding can be considered as consistent with descriptions of the cognitive characteristics of both disability groups, which suggest that these pupils usually have difficulties with semantics and pragmatics (e.g. Seung, 2007). The difficulties encountered in terms of words may be due to weaknesses in factual knowledge. Such weaknesses are mentioned in the catalogues with characteristics of the two groups (e.g. Mitchell, 2006). Consequently, the findings of this research are in agreement with what is known about the two groups of special needs. The difficulties that appeared at the Translation phase have created preconditions for mistakes in the later phases, although specific errors have occurred in these phases too.

At the phase of Integration, the participants' errors from both groups were extensive and serious. The finding that, when attempting to build a comprehensive understanding of the situation to which the problem refers, students of both groups did not take into account part of the information included in the problems, may be attributed to the identified difficulty of these students in compiling various information and integrating them into a coherent framework of interrelated actions (e.g. Telzrow & Bonar, 2002; Whitby & Mancil, 2009). In this context, the difficulty of these students in determining cause-effect relationships plays a significant role, as this relationship is pivotal in understanding relationships between givens and unknowns (Mitchell, 2006). This difficulty is more pronounced when pupils of both groups of special needs are asked to manage complex and unfamiliar situations (as are probably the problems used in this research for several of the participants). This happens because these individuals use conventional responses and stereotypical behaviors (routines) to a large extent, which makes it difficult to them to meet the requirements of novel situations (e.g. Burger, 2004; Semrud-Clikeman, Walkowiak, Wilkinson, & Christopher, 2010). Another possible explanation about the difficulty of participants from both groups to take into account all the information included in the problems may be found in various identified

difficulties with the concentration and use of attention that are reported as elements of the cognitive profile of the two groups (e.g. Greenham, Stelmack & van der Vlugt, 2003; Kaland, Smith & Mortensen, 2008).

In reference to the differences between the two groups at the phase of Integration (which refer mainly to the fact that only some students with AS introduced elements irrelevant to those contained in the problems, when asked to describe the problem situation in their own words), these may perhaps be attributed to the reading profile of the participants with AS, which seems to resemble that of "imaginative readers" reported by Williamson, Carnahan and Jacobs (2012). According to these researchers, "imaginative readers" with AS, when asked to give the meaning of unknown texts, tend to produce a different story, using only some elements of the text, which usually relate to their personal experiences and preferences.

The difficulties of the pupils of the two groups in the Integration phase may explain part of the difficulties encountered in the Planning phase. It is characteristic that in several cases the choice of arithmetic operation during the Planning phase was in full correspondence with their incomplete or incorrect descriptions during the Integration phase. This finding seems to confirm the thesis that incomplete or incorrect Integration makes it difficult or impossible to choose the right operation for solving the problem, because the appropriate cognitive schemata cannot be activated (Agaliotis, 2011). In other words, as students construct an incomplete or distorted representation of the situation to which the problem refers, they find it difficult or impossible to perceive similarities of this situation with the situations that they have memorized as examples of situations in which each one of the four arithmetic operations is used. The difficulty of participants in this research in activating cognitive schemata, that facilitate the selection of appropriate arithmetic operations, is in agreement with research data that has shown that the ability of individuals with NVLD and individuals with AS to form cognitive patterns appears to be incomplete, especially in the management of complex semantic structures (Burger, 2004; Kamio & Toichi, 2007). In the attempt to interpret the difficulties of the participants of the two groups at the Planning phase, it is certainly worth mentioning the possibility that the cognitive schemata of the operations have never been developed in these populations. In the present study, there has been no attempt to distinguish cases where the cognitive schema is incomplete, dysfunctional or non-existent and therefore no aspect can be clearly supported. The issue certainly deserves more research.

Regarding the Implementation phase, it was ascertained that both pupils with NVLD and pupils with AS had difficulty using the principles and properties of the operations (such as the role of zeros in subtraction or the commutative property). These difficulties may be related to the problems of these people in the formation of concepts (Minshew, Meyer & Goldstein, 2002; Spreen, 2011). Several mechanistic mistakes of the participants with NVLD, such as the incorrect transfer of numbers from the problem in the operation, may be associated with difficulties of the individuals of this group in visuospatial organization and psycho-motor coordination (e.g. Harnadek & Rourke,

1994). Mistakes in arithmetic combinations of pupils with AS that were found in the present research, are not in tune with findings from relevant research (e.g. Sansoti, Powell-Smith, & Cowan, 2010), but they may be attributable to the increased anxiety often experienced by individuals in this group (e.g. Attwood, 2007).

Finally, regarding the difficulties experienced by pupils of both groups in controlling the reasonableness of the answers they gave, they may perhaps be linked to deficits of the two groups in the executive functions (e.g. Semrud-Clikeman, Walkowiak, Wilkinson, Butcher, 2010; Spreen, 2011). Of course, another hypothesis that can be stated concerning the lack of control is inadequate teaching, which was not investigated in this study.

5. Recommendations

The present research has provided data that could perhaps contribute to the specification of ways to enhance the ability of pupils with NVLD and pupils with AS to solve arithmetic problems. For example, the findings of the present study highlight the need for systematic teaching students of the two categories how to deal with each individual problem solving phase, with particular emphasis on the phase of Integration. At this phase, extensive and systematic activities (comparisons, analyses and syntheses) are required in order to enable students to develop a comprehensive understanding of the problem situation. Another important objective of the supportive programs for the students of the two groups in problem solving could be the strengthening of their cognitive schemata of the four arithmetic operations. In all these teaching actions, the learning preferences of pupils with NVLD and pupils with AS should be certainly taken into account.

Future research on this issue could focus on studying the possible impact of the way the problems are presented on the ability of students to identify the right solution. Specialized presentation through extensive verbal descriptions or pictorial representations may yield different results. Another important research goal may be the development of cognitive schemata of the arithmetic operations.

6. Conclusions

Both participants with NVLD and AS have encountered significant difficulties in solving problems with one or more operations and have shown that they face significant obstacles in managing the requirements of all the problem solving phases, though not to the same extent. The majority of students from both groups of special needs were unable to construct a complete and coherent mental representation of the situation to which each problem referred, so they could not identify the initial conditions and actions that caused the various changes and, therefore, they could not choose all or the appropriate operations to solve the problems. Most difficulties have arisen at the Integration phase, although, due to the research design, it is not easily

discernible whether these difficulties were specific difficulties of this phase or direct and indirect results of problems in the Translation phase. However, it seemed that pupils of both groups that succeeded in the Translation phase may not necessarily be able to construct a functional mental representation of the problem.

Difficulties in Integration seemed to be parallel to particular difficulties in planning the solution of the problem. It is clear that further research is needed to determine whether the difficulties in Planning are a direct result of the difficulties in Integration or are independent and specific to this phase. The difficulties of the students in operations also require deeper study, because only a limited number of participants in the present study proceeded to this phase. Finally, the fact that the participants collectively did not take any action regarding the Control of the result is an issue that needs to be investigated as to whether it is characteristic of the pupils with NVLD and the pupils with AS or is it a more general characteristic of the Greek pupils of Primary School, as a possible result of inadequate teaching.

Regarding the similarities and differences in problem solving between pupils with NVLD and those with AS, what seems to emerge from this research is that the two groups are mostly similar. The most distinctive difference is that students with AS tend to incorporate arbitrary elements into the mental representation of problems. This fact certainly needs deeper study.

6.1 Limitations of this research

The present research has some limitations that require caution in exploiting the findings and generalizing its conclusions. One limitation arises from the small number of participants. Outlining a detailed profile of strengths and weaknesses of the two groups in solving problems requires data analysis of more participants. Of course, it should be noted that especially students with NVLD are not easy to find because of their extremely low number in the general population. A second limitation of the study arises from the difference of the two groups with respect to gender participation. Possible differences in the ability to solve problems between boys and girls may affect the current research. Finally, another important limitation is the one that refers to the fact that students with AS were not subjected to the test used for the identification of students with NVLD to confirm that they do not belong to this group (NVLD), but were included in the research based on the recognition by the state disability diagnostic agencies. Considering the difficulty of differential diagnosis between the two groups, the possibility of a categorization error cannot be ruled out.

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