

Memory in children with attention deficit hyperactivity disorder (ADHD)

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Resumen: Memory of children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and normal children of the same age group has been examined. Sixty-six boys with a normal level of intelligence were divided into four groups: boys with ADHD aged 7-9 (N=11), boys with ADHD aged 9-11 (N=11), normal boys aged 7-9 (N=22) and normal boys aged 9-11 (N=22). Six memory tests were administered: *numbers* and *phrases*, *pictures* and *patterns*, *objects* and *movements*. Time recall in the 1st and 2nd tests was recorded. No significant difference was found between the individual ADHD and control subjects regardless of age, nor between the age sub-groups. In the *numbers* and *phrases* tests, better scores were obtained by the controls, whereas in the *pictures*, *patterns*, *objects* and *movements* tests the boys with ADHD achieved higher scores. With regard to time recall, a significant difference was recorded to the disadvantage of the ADHD children, which raises a question as to the most appropriate teaching methods for their education. **Key words:** ADHD, memory, time recall, attention, Non- Verbal Memory.

Memoria en niños con trastorno por déficit de atención con hiperactividad (TDA-H)

Resumen: Se ha examinado la memoria de niños con trastorno por déficit de atención con hiperactividad (TDA-H) y la de niños normales del mismo grupo de edades. Se dividió a 66 niños con cociente intelectual normal en 4 grupos: niños con TDA-H con edades de 7 a 9 años (N= 11); niños con TDA-H con edades de 9 a 11 años (N= 11); niños normales con edades de 7 a 9 años (N=22); niños normales con edades de 9 a 11 años (N= 22). Se administraron seis tests de memoria: *números y frases*, *formas y dibujos*, *objetos y movimientos*. Se registró el tiempo de reacción en el primer y segundo test. La investigación muestra que no hay una diferencia estadísticamente significativa entre niños con TDA-H y los niños control,

respecto a la edad intra y entre los subgrupos de edades. En los tests de *números y frases*, hubo un mayor porcentaje de éxito entre los sujetos de control, mientras que en los de *dibujos, formas, objetos y movimientos*, los niños con TDA-H obtuvieron mejores resultados. Esto da una idea de sus particularidades a la hora de asimilar estímulos no-verbales. En cuanto al tiempo de reacción, se registró una diferencia estadísticamente relevante en detrimento de los niños con TDA-H, que lleva a plantearnos cuáles son los métodos más apropiados para su educación. **Palabras clave:** TDA-H, memoria, tiempo de reacción, atención, memoria no-verbal.

The incidence of Attention Deficit Disorder has been found to be six times higher in boys than in girls (Sharp et al, 1997). However, in random samples the above ratio was found to be 3.1:1, higher in boys (Szatmari et al, 1989). In recent years, the frequency of school age boys with ADHD ranged between 7% in the United States. (Wolraich et al, 1996), 10.9% in Germany (Baumgaertel et al, 1995), and 10% in Greece (Kakouros & Maniadaki, in press). These studies supported the selection of male as opposed to female subjects in our study.

In the first studies of cases of school-aged children with ADHD in Greece (Haritou - Fatourou, 1977) symptoms of motor restlessness, low self-esteem and difficulties in adjusting to the school group were detected. Research conducted in Athens on children from 6 - 8 years old, showed that the parents of 52% of the boys and 45% of the girls detected symptoms of hyperactivity in their children (Papatheophilou, Bada, Micheloyannakis, Makaronis, and Pantelakis, 1981). Later, also in Greece, research indicated evidence of problems of personality, and a more general emotional immaturity, in hyperactive children (Ierodiakonou, 1988). At that time, clinical studies of cases in Greece emphasized that a cause of ADHD syndrome is the existence of biological- genetical factors and disorganized family environment (Bezevegis, 1989; Papadopoulos, 1998; Karavatos, 1999).

More recent research conducted in Greece is consistent with international findings that children with ADHD are impulsive, disobedient, demanding and easily exhibit anger when disappointed (Kakouros & Maniathaki, 1998). Their frequent referral to Greek Medical Educational Centres is due to the fact that they do not complete their school activities, easily abandon every attempt they begin, are impulsive, make unnecessary actions and noise, get angry easily and in general, give their teachers a difficult time. (Kakouros, Maniathaki, Lalioti, 1999). Because of those behaviour, educators and parents express negative reinforcement and punishment and, as a result, children with ADHD are not motivated to try and control their behaviour;

even though their intelligence is normal, it is accompanied by low self-esteem.

The above behaviour does not cause concern to most parents in Greece, who usually take some form of action only when learning disabilities are exhibited by their children (Kakouros, & Maniathaki, 2000). Research conducted outside of Greece (Minde, Lewin, Weiss, Lavigneur, Douglas, and Sykes, 1971; Weiss, & Hechtman, 1986; 1993) showed that 15 - 20% of school-aged children with ADHD had significant difficulty in retaining words, sentences and/or letters (auditory memory), in decoding sounds (auditory discrimination) and even in copying shapes (visual-motor memory and perception) in sensory and short-term memory. In the last decade, Barkley (1990; 1995) has also detected a problem in the development of short-term memory of children with ADHD, and also in their linguistic internalization, which attributes to their inadequate ability for self-control. The same researcher has ascertained that they have difficulty in retaining different types of stimuli and non-synoptic ways of presenting these stimuli in short-term memory.

Children with ADHD have difficulties with internal, verbal enactment of things (Funk & Ruppert, 1984), the deficient nature of their abilities to abide by rules, co-operate and follow instructions (Barkley, 1990), their difficulty in self-regulation and deficiencies exhibited in their level of arousal, especially when the stimuli are related to directed learning (Douglas, 1972; Parry & Douglas, 1976; Kakouros et. al., 1996; Filipek, 1999).

In this article conducted at the Paedopsychiatric Hospital of Attica in Greece from 1998 to part of 2001, the following research hypotheses were put forward :

Children with ADHD will manifest

- a. Reduced, quantitative recall of stimuli after five minutes.
- b. Confusion of stimuli of pre-informed and predetermined series recall, which would be accompanied either by reduced, quantitative recall or by integrated recall.
- c. Shorter recall speed of the required input (increased reaction time) in respect to the duration of final answer in the first and second tests (number rehearsal test and phrase rehearsal test respectively).

In order to test the above hypotheses, six memory tests of verbal and non-verbal stimuli were administered, which sometimes activated the cerebral hemispheres one by one and other times simultaneously. The tests were applied in order to be simulated, as conditions, into the functioning of the Greek primary educational system.

Method

Participants

Sixty-six boys of primary school age, 22 with ADHD and 44 normal boys took part in the study. The ADHD subjects were chosen to meet DSM – IV criteria, subtype 314.01 Attention Deficit Disorder/Hyperactivity, Combined Type, (APA, 1994; Barkley, 1995), 11 boys with ADHD ages 7 - 9 and another 11 with ADHD ages 9 - 11 were examined at the Paedopsychiatric Clinic of Attica Hospital. The boys of the control group were selected per a ratio of 1:2 (1 ADHD to 2 normal) and attended the same classes at the same school during the same school year and had the same teachers as the subjects with ADHD. For the selection of the normal subjects, visits were made to the same 22 schools where the children with ADHD attended, during the same period of time that the latter were examined. The cross-cultural, non-verbal Raven Coloured Progressive Matrices Test (edition 1986) was administered to test the intelligence quotient of all subjects, normal and ADHD. This was done at the beginning of each interview, before the memory tests were administered. In addition, before examining the normal subjects, teachers and directors were given a check-list of criteria, which included the following requirements:

- a) Subjects should not have been diagnosed with Hyperactivity Disorder nor should they exhibit Hyperactivity Attention deficits.
- b) Subjects should not have been diagnosed who are mentally retarded and should exhibit expected perception in learning processes.
- c) Subjects should not be characterised by learning disability.
- d) Subjects should not necessarily be pupils with high academic achievement.
- e) Subjects should not have been diagnosed with organic damage, dysfunction or somatic disability.
- f) Subjects should be willing to participate in the study.

The diagnoses for ADHD were made at the A' and D' Paedopsychiatric Clinic of Attica Hospital. Subjects' intelligence was tested using the Hellenic WISC-III (Georgas et al, 1998), a Greek standardization of the Wechsler Intelligence Scale for Children Test (WISC-III, (Wechsler, 1987). The diagnosis of Hyperactivity Disorder was done with the use of scales (Barkley, 1988). The following tools were administered: The Child Behavior Checklist (CBCL), the Teacher Report Form TRF questionnaire, the DuPaul Questionnaires for Parents (DuPaul, 1991, DuPaul 1998) and DuPaul for Teachers (DuPaul, 1997), the Conners - 28 Questionnaire for Teachers (Conners, 1990). The CBCL scale and the TRF and Conners-28

questionnaires have been standardized for Greek samples (Roussou et al, 1999).

Material

Number Recall: A part of the 12th scale of the Hellenic WISC-III was applied using the condition of number series repetition up to two groups of four (digit span) in sequence. The last group of four was repeated up to three times until correct recall was achieved (condition of recall before instructions). It was then made clear that recall was required only once, after five minutes. This was repeated up to three times after the instructions were given (condition of recall after instructions). During the conditions of recall before and after instructions, the examiner interrupted the test only if the subject failed to recall correctly three consecutive times. Following this, a timed five-minute non-assessed verbal interference was given, initiated by saying "start" (Hellenic WISC-III, scale 6, Arithmetic problems 12 - 18). After five-minutes, the subjects had to recall the last set of four numbers in serial processing.

Phrase Repetition: The second tool to be administered was Part of questions 8 and 11 of the Binet - Simon test (Binet & Simon, 1905), standardized by Zazzo, Gilly & Vebra-Rad as "New Metric Scale of Intelligence" based on the original "Nouvelle Echelle Metrique De La Intelligence", and translated by Vamvoukas & Papageorgiou. Phrases of two to fourteen syllables, with a gradual increase of quantity were used (Conditions of recall both before and after instructions). Interference Exercise or verbal analysis consisted of eight words (Hellenic WISC-III, scale 8, vocabulary, questions 1 - 8). Serial recall of the last series of phrases (14 syllables) after exactly five minutes was recorded.

Picture Memory and Shape Memory: Third and fourth test (semantic and meaningless material). Parts of scales 5 and 6 of the Athina Test - Difficulties in Learning, standardized at the University of Athens (Paraskevopoulos et al, 1996). Serial Recall, from the first set of three up to and including the third set of four symbols, with non-verbal element (conditions both before and after instructions). Interfering Exercises for Picture Memory, symbol material from the Encoding Scale Level B' (Hellenic WISC-III), and for Shape Memory, symbols Level B' from the same test.

Object Memory: Four specific objects, the same each time, (pencil holder, telephone, book, and chair) were placed during the second break in fixed positions, based on a simple, specific space diagram. This constitutes a variation of a partial scale of the test RBMT (Wilson et al, 1989; Knight & Godfrey, 1995). Subject's "skillful behaviour" was tested as well as the motor behaviour of the "open skills" of the ADHD (Newell, 1991). They were asked to reposition the objects, in series (1st, 2nd, 3rd, 4th) into their initial positions, after these had each been moved approximately 20cm to the right. Only the condition after instructions was applied; the condition before instructions and that of increasing stimuli recall were not applied (Interfering Exercise, Scale 14 of the Athina Test, (Lateralization Test) with non-verbal element).

Motor Memory: A variation of the Corsi Test (Vallar and Papagno, 1995) was applied, examining the range of visual-spatial memory. During the second three-minute break, five silver balls of exact same size and shape (A, B, C, D, E) were placed in a specific, unchanging position in the area (on teacher's desk). The examiner touched the balls - applying the condition of increasing stimuli recall - while simultaneously verbally numbering them. The subjects repeated both verbally and with movement every range of serial movement made by the examiner. (B/1, A-B/1,2, B-A-C/1,2,3 and B-C-A-E/1,2,3,4). Interfering Exercise, Scale 13 of the Athina Test, (Perception of Right-Left), with verbal instructions of movement for the body and the area.

Procedure

The ADHD subjects were examined individually at the Attika Hospital and the controls individually at their schools. Each subject was examined for approximately 60 minutes, and each session began with the Raven Coloured Progressive Matrices Test (edition 1986), followed by the three pairs of memory tests and two three-minute breaks immediately after the second and fourth tests respectively. During the second break the examiner placed the material for the 5th and 6th tests in the examination area. The series of tests administered were numbers-phrases, symbols - shapes, objects - movement. The effect of the stimulant drugs administered daily to children with ADHD, (for example Ritalin and Dexedrine) last from 3 up to 7 hours. These drugs bring about improvement in the areas of sustained attention and impulse control. (Kuperman et al, 1996).

In the present study only 4 of the 22 boys with ADHD took Ritalin on a daily basis. They underwent voluntarily memory tests on Monday of each week, after having stopped taking the drug the previous weekend, following the instructions of the child psychiatrist.

It should be noted that for these particular subjects, Ritalin was to be interrupted during the weekends, but taken systematically during school days (Monday to Friday). It was suggested that the other eighteen boys with ADHD take Ritalin, but as their parents were wary of the effect and side effects of the drug they refused to allow it.

Memory was tested exactly five minutes after the stimuli were presented. The following basic hypothesis was formulated: reduced quantitative recall of stimuli after five minutes; subjects' confusion regarding series recall; and slower recall speed during the final answer (increased recall time). In order to test the above hypothesis as systematically and objectively as possible, six memory tests were administered using a variety of stimuli, some which activated the cerebral hemispheres one at a time, while others caused activation of both hemispheres simultaneously. Following Laursen and Invik, sensory and short-term memory were both studied. (Laursen, 1991, Invik, 1991). Other tests were carried out with variations in digit span numbers, words, syllables, shapes, objects and movement based on studies by Petersen, and Vallar and Papagno. (Petersen, 1991, Vallar & Papagno, 1995). The tests of the present study were applied in order to be used in the primary level of education in Greece. Given that ADHD is mainly manifested in the developmental stage of childhood ages 6 - 12 (Halpelin et al, 1995), the present study was directed at a sample group of subjects of this age.

The particular order of the administration of four (4) memory elements was chosen based on research conducted on selective attention (Deutsch & Deutsch, 1963) as well as on the recall ability index (7 ± 2) on serial processing of the 6 - 12 year old age group (Miller, 1956).

The following conditions were observed in testing:

- a) Presentation and recall of stimuli in a particular order.
- b) The possibility to repeat the four stimuli up to three times in the particular order.
- c) Four stimuli for final recall.
- d) Five-minute interval delay recall with interfering exercise, not evaluated.
- e) Material similar to that of input to be used in the interference exercise
- f) Speed of presentation of the stimuli was increased or delayed during the five-minute delay interval depending on the speed of the individual subject.

g) Recording of reaction time (Test 1 and 2). Reaction time was considered as the interval immediately following the five-minute interference exercise until the completion of the final answer (Rabbit, 1981).

In order to distinguish between the function of attention and that of memory, the condition of recall before instructions was enforced. In order to record sustained attention, The last set of four stimuli was repeated, up to three times by the subject, until the correct recall so that the sustained attention could be recorded. Interference material similar to that of the required input was given during the five-minute delay intervals. Stimulation of the same cerebral area was continued throughout the duration of each test, with the intention that the interference would be strong and continual. (Reeves & Wedding, 1994).

Results

All statistical analyses were carried out using SPSS for Windows (version 10.0.1). No significant difference was noted between the age sub-groups of the two groups in the intelligent quotient measured by the Raven Coloured Progressive Matrices Test (Table 1). The associations between categorical variables such as gender, age group, or the children's answers in each one of the six tests were analysed using Pearson's chi-square test or Fisher's Exact Test where appropriate.

| Variable | Controls | Cases | p |
|----------------------------------|------------------|------------------|-------|
| Raven scores (7-11 years old) | 30.89 \pm 3.85 | 29.55 \pm 3.63 | 0.179 |
| Raven scores (7-9 years old) | 27.91 \pm 2.74 | 26.36 \pm 1.69 | 0.098 |
| Raven scores (9-11 years old) | 33.86 \pm 2.08 | 32.73 \pm 1.62 | 0.123 |

Table 1. Raven scores of subjects in the two study groups (for each age group separately): means, standard deviations, and p-values for analysis of variance

To show the strength of the association, p-values are shown in the test. Comparisons of mean response times done in the 1st and 2nd tests between cases and controls and age groups were made by Two-Way-Analysis of Variance (ANOVA). It is noted that all subsequent statistical analyses of response times are based on log-transformed values. Differences were considered significant when p was 0.05. In the Number Memory test, a difference was found in favour of the controls (which was consistent with

the hypothesis) of 18.1% (63.6% and 45.5% for control and experimental groups respectively), while in the second test (Phrase Memory) there was no statistically significant difference (4.5%) in favour of the same group 31.8% for control group and 27.3% for experimental group where $p=0.705$). (See Table 2).

| Variable | Control (n=44) | Experimental (n=22) | p |
|----------|-------------------|------------------------|-------|
| Test 1 | 63.6 | 45.5 | 0.159 |
| Test 2 | 31.8 | 27.3 | 0.705 |
| Test 3 | 97.7 | 95.5 | 1.000 |
| Test 4 | 86.4 | 90.9 | 0.709 |
| Test 5 | 77.3 | 68.2 | 0.426 |
| Test 6 | 93.2 | 90.9 | 1.000 |

Table 2. Percentages of success in six tests of subjects in the two study groups: percentages, p-value for Chi-square Test (or Fisher's Exact Test were appropriate).

The percentage success rate in the 2nd test for both groups was low (less than 50%). In the 3rd and 4th tests (Table 2), it was noted that in both Tests 3 and 4 there was high performance by both groups (97.7% and 95.5% for control and experimental groups respectively for Test 3; 86.4% and 90.9% for control and experimental groups respectively in Test 4). The pair of tests 3 and 4 totalled the highest performance in comparison to the other tests, in both the two groups under examination as well as the two age groups. In the last pair of tests there seems to be a dominance (9%) in favour of the controls in the 5th test (77.3% and 68.2% for both control and experimental group respectively, $p=0.426$), while in the 6th test this difference decreased (+3%) in favour of the same group (93.2% and 90.9% for controls and cases respectively, $p=1.000$).

A significant increase in performance was noted in the cases (irrespective of age) after the 1st pair of tests. There was a statistically significant difference ($p < 0.001$) in the success rate percentage (36.4%) in the first pair of tests (tests 1 and 2) in comparison to the success rate percentages in the other two pairs (93.2% and 79.55% average percentage success rates in the 3rd - 4th and 5th - 6th tests respectively). Performance levels similar to those of the 2nd test were recorded in the 5th test (Object Memory).

There were success rate percentages of 86.4% and 100.00% ($p=0.534$) in the 7 - 9 year old age group (Table 3) and 68.2% and 36.4% ($p=0.081$) in the 9 - 11 year old age group, for controls and cases respectively (Table 4). The

mentioned difference in the 9 - 11 year old age group is statistically worth noting.

| Variable | Controls (n=22) | Experimental (n=11) | P |
|----------|--------------------|------------------------|-------|
| Test 1 | 59.1 | 45.5 | 0.458 |
| Test 2 | 27.3 | 45.5 | 0.437 |
| Test 3 | 100.0 | 100.0 | - * |
| Test 4 | 95.5 | 90.9 | 1.000 |
| Test 5 | 86.4 | 100.0 | 0.534 |
| Test 6 | 95.5 | 90.9 | 1.000 |

* This variable is constant. Chi-Square Test cannot be performed.

Table 3. Percentages of success in six tests of subjects in the two study groups of 7-9 age group: percentages, p-value for Chi-square Test (or Fisher's Exact Test were appropriate).

A statistically significant difference was recorded in the response time in the Number and Phrase test, to the disadvantage of the ADHD group ($p=0.007$ and $p=0.003$ respectively). More precisely, the response time in the 1st test was 7.68 seconds (standard deviation (s.d) = 4.02) and 10.86 seconds (s.d. = 5.05) for controls and cases respectively, while in the 2nd test the corresponding response time for both groups was 9.09 sec (s.d. = 4.01) for controls and 12,36 sec (s.d. = 4.06) for the cases (Table 5).

| Variable | Controls (n=22) | Cases (n=11) | p |
|----------|--------------------|--------------|-------|
| Test 1 | 68.2 | 45.5 | 0.208 |
| Test 2 | 36.4 | 9.1 | 0.097 |
| Test 3 | 95.5 | 90.9 | 1.000 |
| Test 4 | 77.3 | 90.9 | 0.637 |
| Test 5 | 68.2 | 36.4 | 0.081 |
| Test 6 | 90.9 | 90.9 | 1.000 |

Table 4. Percentages of success in six tests of subjects in the two study groups of 9-11 age group: percentages, p-value for Chi-square Test (or Fisher's Exact Test were appropriate).

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| Variable | Controls (n = 44) | Cases (n = 22) | p |
|------------------------------------|----------------------|-------------------|-------|
| Average Time of Response at Test 1 | 7.68 ± 4.02 | 10.86 ± 5.05 | 0.007 |
| Average Time of Response at Test 2 | 9.09 ± 4.01 | 12.36 ± 4.06 | 0.003 |

Table 5. *Average Time of Response at Test 1 and Test 2 respectively, of subjects in the two study groups: means, standard deviations, and p-values for analysis of variance*

Discussion

This study supports the view that school-aged boys with ADHD have particular, self-terminating strategies. (Denkla, 1995). They activated memory processes with stimuli that seems to be directed to the right cerebral hemisphere, and stimuli which correspond to parallel, synthetic and non verbal processes, more efficiently than the controls after five minutes. (Zaidel, 1988, Bogen, 1990). To be more specific, in the number and phrase rehearsal tests, the controls exhibited a significantly higher percentage of correct answers compared to those with ADHD, but in the picture, shape, item and motor tests, both groups exhibited a very high success rate, with the ADHD children showing a slight advantage. The only statistically significant difference between the two groups - a difference in favour of the controls - was recorded in reaction time. This difference was observed in the age group (7 –11 years) but not between sub groups.

In regard to reaction time, the results supported the view that school-aged boys with ADHD assimilate through a broader perceptive passage and, as a result, there is a delay in the memory process of recall of the required input. (Barkley, 1995). Futhermore, right from the beginning, the hypothesis of reaction time was the strongest of all those put forward, as those affected by ADHD were already at a disadvantage for two reasons :

a) They have difficulty with working memory and organization of their behaviour with regard to time (Barkley et al., 1997, Dooling-Liftin, 1997), and

b) they delay in filtering and choosing stimuli that seems to be directed to the left cerebral hemisphere (Lou et al., 1989; Quinn, 1995).

Even though the hypotheses of the present research concerning stimuli directed to the left cerebral hemisphere were not verified, they encompass not only a problematic message, but also an optimistic message for hyperactive children and their families, as there are indications that creative people (with artistic, resourceful and creative tendencies and interpretations

of cognitive stimuli and dominance of the right hemisphere), can achieve high levels of performance at school when they receive educational stimuli directed to their right hemisphere. (Edwards, 1979, Springer & Deutsch, 1989).

Suggestions for the educational system

The present research supports the view that children with ADHD have particular self-terminating strategies. They activate more effectively the after-five-minute-intervals memory related procedures with stimuli aimed at the right hemisphere and correspond in parallel, synthetic, intuitive processes. Nonetheless, the confirmation of the hypothesis for the reaction time, while indicating the inability to assimilate recalling - learning strategies of the left hemisphere, reminds us of the inertia on the part of the primary education level in Greece in programs which include the combination of both verbal and intuitive thinking. If these indications are established as strong and effective in further research, then the Greek educational system might possibly need to partially modify the ways in which the learning of memory material is applied in primary schools, and to create specialized programs (incorporating methodology directed to ADHD) which will activate both the left and right cerebral hemispheres with verbal, visual, motor, visual-motor, auditory and kinesthetic stimuli. (Chelune et al, 1986, Liberakis, 1997, Kosmopoulos, 1990).

It is a fact that methods and strategies (with dominance of the right hemisphere, as is the case for most ADHD), have been put forward for learning in children who have difficulty in stereotype learning of the written word, time evaluation and adhering to predetermined programs of assimilating information (Vitale, 1982, Katsiou-Zafrana, 1988, Savaki, 1996). However, even though visual aids are used in Primary Schools in Greece today, there still has not been any systematic effort made to use verbal and non-verbal educational material. As a result, the shared and equal contribution of both hemispheres in the teaching process is not achieved. (Flouris, 1988).

It was asserted that ADHD children are able to obtain high achievement scores under conditions of controlled teaching, as long as the educational system comprehensively modifies the way it presents and assesses the learning and memory materials offered to them.

With the intent of minimising educational inequality, the contemporary school community of Greece ought to develop specialised, integrated programs with methodologies aimed at both left and right cerebral

hemispheres including verbal, visual, motor, and audio-kinetic stimuli. In answer to these proposed changes in the primary educational system, part of the material used (inserted within a broader educational program, for ADHD children) and conditions specified in the present research study could be implemented.

The present research study asserted the necessity for further and detailed inquiry on the after five-minute recall memory conditions for ADHD children in the contemporary processes of learning and comprehension, to be assimilated in controlled school education.

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