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ORIGINAL ARTICLE

Verbal fluency in adults diagnosed with attention-deficit hyperactivity disorder (ADHD) in childhood

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Abstract It has been increasingly believed that attention-deficit hyperactivity disorder (ADHD) is a disorder with lifelong course associated with cognitive difficulties including among others, language production, verbal learning, and verbal fluency. However, research is limited to children and adolescents, and very few researchers have examined the impact of ADHD in adulthood on the cognitive domain. The aim of the present study is to examine the performance of adults, diagnosed with ADHD in childhood, on semantic and phonemic verbal fluency tasks. It is hypothesized that adults with ADHD will perform worse on both tasks than matched controls. Sixty university students (30 diagnosed with ADHD in childhood and 30 matched controls) of mean age 20.5 participated in the study. They all completed two verbal fluency tasks. The ADHD group had statistically significant lower scores than the non-ADHD group on the phonemic, but not the semantic task. The study provides some evidence that ADHD in childhood has a negative impact on adults' phonemic verbal fluency. This finding could be probably explained by the fact that phonemic fluency is considered more cognitively demanding and impacting more on the frontal lobe functions, known to be impaired in ADHD, than semantic fluency.

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Introduction

It has been increasingly documented by longitudinal research that attention-deficit hyperactivity disorder (ADHD) is a disorder with a lifelong course with its symptoms persisting across the life span (Shaffer 1994; Weiss and Hechtman 1993; Wender 1995; Wilens et al. 2002). The notion that ADHD is a childhood disorder that is typically outgrown by adolescence and always by adulthood has declined.

Several longitudinal investigations that followed children with ADHD into young adulthood have found that over 50 % of children diagnosed with ADHD in childhood continue to evidence symptoms of the disorder into adulthood, especially with respect to inattention and impulsivity (Barkley et al. 1990; Weiss and Hechtman 1993). Adults are able to employ coping or compensatory strategies such as self-management or medication in response to the problems they face but still continue to be handicapped by the disorder (Wender 1995).

Problems in the cognitive domain and academic underachievement evidenced in adolescents with ADHD continue to be possible outcomes for adults with ADHD. It has been reported that almost a third of adults previously diagnosed with ADHD drop out of high school and only 5 % of adults with ADHD manage to complete a university degree program (Barkley et al. 1990). In addition, ADHD in adulthood can cause more serious problems in the adults' lives apart from simple cognitive and academic difficulties as it is often manifested in vocational difficulties, such as lost jobs, frequent job changes, instability or

failure in important intimate relationships, and communication problems (Nadeau 1995; Weiss and Hechtman 1993).

Due to the continued maturation of the prefrontal cortex, the period of development from adolescence to young adulthood is a period of massive changes in the consolidation of certain cognitive control processes (Engelhardt et al. 2009). In parallel, it has been unclear whether the clinical manifestation of ADHD from adolescence into adulthood is the same or changes with development, in particular due to the normative decline in activity level, namely hyperactivity, during this period. Research (Walker et al. 2000) on ADHD in adults has found that one of the most prominent features of the neuropsychological function of adults with ADHD is inattention, suggesting that inattention is a key feature in adulthood ADHD, whereas response disinhibition is more associated with childhood ADHD. Such a progression in the type of the core symptoms of the disorder from childhood to adulthood may reflect the influence of maturational processes, particularly the development of the frontal lobes. Children with ADHD display impulsivity in both everyday life and on formal neuropsychological testing, while adults on the other hand are more able to inhibit their behavior in structured situations such as that of formal testing (Walker et al. 2000).

There are a number of reported cognitive impairments in adults with ADHD, including problems in language production (Engelhardt et al. 2009), mathematical skills (Biederman et al. 1993), working memory span, and psychomotor speed (Walker et al. 2000). In addition, adults with ADHD display slow information processing and much slower reaction times especially as the complexity of the task increases (Johnson et al. 2001), suggesting that performance decrements in adults are more likely to be seen with tests involving greater cognitive demands (Hervey 2004). Hervey (2004) p. 496 indicates that "the point at which adults with ADHD appear to operate at maximum cognitive capacity may be reached, on average, sooner or more easily than for adults without ADHD."

It has been shown that the brains of individuals with ADHD do not show the normal frontal asymmetry and exhibit a smaller right frontal width, resulting in symmetrical frontal lobes (Hynd et al. 1990).

Impairments in frontal lobes can be summarized as (a) frontal lobe dysfunction (b) delayed frontal maturation and (c) subcortical-frontal motor subsystems dysfunction. The frontal lobes are considered the area of the brain that controls the executive functions. In addition, behavioral disinhibition, inattention, and restlessness have also been associated with impairments in the frontal lobes (Grodzinsky and Diamond 1992).

Welsh and Pennington (1988, cited in Boonstra et al. 2005 p. 1098) defined executive functioning as "the ability to maintain an appropriate problem-solving set for attainment of a future goal." Following this definition, they indicated five domains of executive functioning: (a) fluency (the ability to generate different solutions for a problem), (b) working memory (the ability to keep information online while performing), (c) planning (the ability to plan the steps needed to reach a solution for a problem), (d) inhibition (the ability to inhibit or withhold one's actions), and (e) set shifting (the ability to shift to another action or problem-solving set when necessary).

A cognitive function highly correlated with executive functioning and attention capacity, which is often used to evaluate cognitive functioning in ADHD, is the fluency of speech or verbal fluency. This function is usually defined as the number of words produced usually within a restricted category and over a limited period of time (usually 60 s) (Lezak 1995).

The verbal fluency task was first introduced as a means of evaluating the overall productivity in brain damaged subjects (Szatkowska et al. 2000). Nowadays, it is regarded as a frontal lobe test since patients with frontal localization of damage are especially impaired in that task (Lezak 1995), and it is considered one of the four most prominent and reliable measures that differentiate adults with ADHD from healthy controls (the other three are: Stroop tasks, auditory-verbal list learning and continuous performance tests) (Woods et al. 2002). Two major categories of verbal fluency tasks can be distinguished, namely (a) *semantic fluency* task, in which words are elicited according to a semantic criterion (items belonging to a specific semantic category, e.g. animals, fruit) and (b) *phonemic fluency* task, in which words are elicited according to a phonological criterion (words beginning with a given initial letter, e.g. F, A) (Szatkowska et al. 2000).

Although both semantic and phonemic fluency require an access to lexical memory and retrieval of lexical items following the instruction given to the individual, it is possible to distinguish between search strategies according to the semantic or phonemic nature of the task. In the phonemic fluency task, one has to suppress the ordinary way of retrieving words from memory according to their meaning (Szatkowska et al. 2000). Such a task forces the individual to use a search strategy through lexical representations based on alphabetical order. In contrast, the semantic fluency task requires first an exploration of the conceptual knowledge and then a search strategy according to semantic category.

Priming studies have shown that language is represented semantically (Hurks et al. 2004), so when asked to generate words according to a category, this matches with the way in which language is stored. On the other hand, an initial letter fluency task is different, in that language is not organized alphabetically; thus, this type of task is relatively

more difficult to most individuals and likely to require more executive function than a semantic fluency task (Riva et al. 2000). Semantic fluency is dependent on intact semantic memory stores and effective search processes. In contrast, phonemic fluency is not so much dependent on memory stores as it is on effective initiation and shifting skills (Kosmidis et al. 2004). Semantic fluency tests (e.g. animals) have been shown to be easier than letter-based tests (phonemic tests, e.g. F, A), and the differences in performance are explained on the basis of the different hierarchical organizations of the two categories (letters vs animals), since retrieval by letters requires the exploration of more subsets of categories than the retrieval of the names of animals (Riva et al. 2000). In addition, it has been suggested that the ability to organize and retrieve words phonemically develops slowly in children and is probably related to their spelling skills, whereas the ability to produce words in different semantic categories develops much earlier (Riva et al. 2000).

It has been documented that there are certain cognitive strategies used to complete verbal fluency tasks successfully (Troyer 2000). The usual process is for an individual to search mentally for subcategories (semantic or phonemic, depending on the nature of the task) and, once identified, produce words within this subcategory. The process of organizing words into semantically or phonemically related subcategories is referred to as *clustering*. Once a subcategory is exhausted, it is most efficient to quickly move to another subcategory or cluster, a tactic referred to as *switching*. Each of the strategies used to maximize word production is mediated by separate brain mechanisms and regions. Clustering words that are related to a subgroup is dependent on processes such as verbal memory and word storage. Switching on the other hand is dependent on the ability to engage in strategic search processes, such as initiation, cognitive flexibility, and mental shifting. Research has indicated that performance on phonemic fluency tasks is closely related to switching, but not to clustering, while performance on semantic fluency tasks seems to be influenced by both switching and clustering. In addition, it has been shown that switching is closely related to frontal lobe functioning, while clustering seems to be associated with temporal lobe functioning (Troyer et al. 1997).

Studies of ADHD and verbal fluency have provided inconclusive results. In children with ADHD, some studies revealed unimpaired phonemic fluency (Fischer et al. 1990; Reader et al. 1994) and/or semantic verbal fluency (Barkley et al. 1992; Weyandt and Willis 1994), while other studies reported impaired phonemic (Grodzinsky and Diamond 1992; Pineda et al. 1998), and/or semantic verbal fluency (Pineda et al. 1998) and low verbal intelligence (Andreou et al. 2005, 2003).

Fewer studies have examined the association of ADHD and verbal fluency in adults. While Barkley et al. (1996) and Johnson et al. (2001) found no differences between adults with ADHD and healthy controls in verbal fluency tasks, the findings of a variety of studies indicate gross disturbances in adults with ADHD in phonemic verbal fluency (Dinn et al. 2001; Tucha et al. 2005; Walker et al. 2000) and/or semantic verbal fluency (Tucha et al. 2005; Walker et al. 2000) and verbal memory and learning (Lovejoy et al. 1999). The heterogeneity of findings among the studies which examined the association of both children and adult ADHD with verbal fluency could probably be explained on the basis of a number of methodological differences between the studies, such as differences in age range, reading age, level of maturity, and assessment criteria.

Given the documented impaired executive functioning of individuals with ADHD and the fact that verbal fluency is a cognitive function highly correlated with executive functioning, it is hypothesized that adults with ADHD will perform more poorly on verbal fluency tasks than adults without ADHD. More specifically, the hypotheses are as follows:

a. Young adults diagnosed with ADHD in childhood will obtain lower scores on a *semantic verbal fluency* task than young adults who never received a diagnosis of ADHD.
b. Young adults diagnosed with ADHD in childhood will obtain lower scores on a *phonemic verbal fluency* task than young adults who never received a diagnosis of ADHD.

Methods

Participants

Sixty young adults, namely university students (mean years of age 20.5, SD = 1.5; mean years of education 14.6, SD = 1.2), selected from a large cohort of 410 students, according to the criteria mentioned below, in the Faculties of Human Sciences in a university in Greece, participated in the study. Thirty of them (21 males and 9 females) had received a diagnosis of ADHD in childhood, and 30 were controls without a diagnosis of ADHD in childhood, who were matched for native language, the history of diseases, and medications taken. Twenty-six out of 30 participants with ADHD fell into the combined type of ADHD, and there were only 4 who fell into the hyperactive impulsive type. Their mean year of diagnosis was 6.2 years of age, SD = 0.9.

Students of both groups must have met the following criteria: (a) entered the Greek university through the

national Greek system of exams (which is important for ensuring they have not entered university after special exams for Greek students living abroad, which may not make them equal in terms of native language exposure), (b) reported Greek as their native language, (c) were free from medications known to affect the central nervous system, and (d) had no history of neurological or psychiatric disease.

Students who were included in the ADHD group must have also met the following criteria: (a) had received an ADHD diagnosis in childhood, according to DSM-IV criteria and (b) obtained a high score (mean 2.51 out of 3 in the ADHD questionnaire (adapted from Conners' Hyperactivity Index, 1998, cited in De Quiros and Kinsbourne 2001, "Appendix"). On the other hand, students who were included in the control group must have obtained a low score (mean 1.25 out of 3) in the ADHD questionnaire mentioned above.

Procedures

Email messages were sent to all students, via registration records, of a university in Greece who are currently enrolled in the Faculties of Human Sciences, asking them to contact us, personally or by email, if they would like to participate in a brief verbal test and complete a brief questionnaire in relation to a research study.

All those who contacted us and met the criteria described above in the *Participants* section, for the ADHD or the control group, were given or sent consent forms, and they were asked to return them signed in a hard copy if they agreed to take part in the research project. All respondents who returned a signed consent form were recruited to the project.

Then, they completed a non-diagnostic *ADHD questionnaire* (adapted from Conners Hyperactivity Index, 1998, cited in De Quiros and Kinsbourne 2001), following which a target of 30 students from each group who met the criteria for their group were randomly selected. All participants completed the ADHD questionnaire ("Appendix"), both those who reported they were diagnosed with ADHD in childhood and those who did not, in order to reduce the possibility of putting adults with ADHD symptoms in the control group and being sure that those diagnosed with ADHD in childhood continue showing symptoms of ADHD in young adulthood. All students who had received a diagnosis of ADHD in childhood still showed symptoms of ADHD according to the questionnaire. However, some of them were excluded because they did not fulfill one or more of the other criteria of inclusion in the ADHD group.

The ADHD questionnaire given is composed of ten questions which are rated on a 1–3-point scale according to whether each behavior is "not at all present," "just a little," or "pretty much." There was statistical significance in the mean scores obtained by adults with ADHD and controls (2.51 (out of 3), SD = 0.29 vs 1.25 (out of 3), SD = 0.24, $p = .000$), which was one of the criteria for inclusion in either of the two groups of the study. In other words, adults with ADHD answered more questions of the ADHD questionnaire with "pretty much" and controls with "not at all present."

Materials

Two verbal fluency tests were administered: one *semantic* and one *phonemic* (Kosmidis et al. 2004). The selection of the particular tests was done on the basis that there are normative data for them stratified by age and level of education in the Greek adult population (Kosmidis et al. 2004).

Differences in verbal fluency scores among various languages have been reported, and they have been attributed either to differences in the length of the words belonging to the categories examined (e.g. animals) among various languages (Kosmidis et al. 2004) or to culture-specific characteristics (Kosmidis et al. 2004). In addition, the significant role that age and education play in word production has been suggested by previous research (Kosmidis et al. 2004). Therefore, it was considered important to use verbal fluency tests for which culture- and language-specific norms were developed for the Greek population for the entire age range and all educational levels.

Both tests were completed in one session. On the *semantic* test, participants were asked to produce orally as many different words as possible belonging to each of the following three semantic categories: animals, fruit, and objects. The time limit was 60 s.

On the *phonemic* test, participants were asked to produce orally as many different words as possible beginning with each of the following Greek letters: X (chi), Σ (sigma), and A (alpha). The letters are selected based on the ratio of words in the Greek language starting with these letters relative to the total words in a Greek dictionary, which corresponds to the ratio of words in the English language beginning with the letters F, A, and S relative to the total number of words in an English dictionary. The time limit for this test was also 60 s.

The semantic test was administered before the phonemic and categories, and letters were administered in the above-mentioned order which was the same for all participants.

Participants were instructed to begin generating words as soon as the category or letter was announced. They were also instructed to avoid repetitions, variations of the same

word, and proper nouns. In addition, they were given examples of what was considered as a variation of a word, repetition, or proper noun. No guidelines were given as to how they were to organize their word search and production, and their answers were noted down by the lead researcher.

In *scoring test performance,* errors were considered: (a) any identical or variations of a previously given word (e.g. play-playing, teacher-teaching), (b) proper nouns (e.g. John, Greece), and (c) words irrelevant to the designated category or letter (e.g. a vegetable instead of a fruit, a word beginning with a letter other than the one designated). The last two types of errors (b and c) did not count in the total number of words generated, while from the first type of error (a), only one of the two words counted in the total number. For example, if the designated category was "fruit" and the participant gave a word belonging to the category of "vegetable" (e.g. eggplant), this word did not count in the total number of words for this category. If the designated category was the letter Σ (S) and the participant produced the word «Στέφανος» (Stefanos), which is a proper noun in Greek, this word did not count in the total number of the words generated for this category. For the same category, if he produced the words "stavros" and "stavrono" (cross and crossing), only one of the two counted in the total number.

Statistical analysis

Paired samples *t* tests were performed in order to detect possible statistically significant ($p < 0.05$) differences between young adults diagnosed with ADHD in childhood and adults with no diagnosis of ADHD in childhood on the scores obtained for each verbal fluency task as well as on the errors made per task. The data were analyzed with the SPSS statistical program.

Results

Paired sample *t* tests revealed statistically significant ($p < 0.05$) differences between adults with ADHD and controls on the scores obtained for the phonemic verbal fluency task (23.03 vs 39.66) but not on those obtained for the semantic (54.36 vs 58.56).

Mean scores obtained by adults with ADHD and controls on both tasks are presented in Table 1.

The analysis of the errors did not reveal any statistically significant ($p < 0.05$) differences between the adults diagnosed with ADHD in childhood and those without a diagnosis in both tasks: semantic: ADHD: 6.08 versus controls: 6.03 ($p = 0.060$, $t = 1.958$), phonemic: ADHD: 4.76 versus controls: 3.90 ($p = 0.090$, $t = 1.726$).

Discussion

The present study showed that adults diagnosed with ADHD in childhood still have problems with their verbal fluency skills compared to adults with no ADHD diagnosis in childhood. However, our hypotheses were not both confirmed in that adults with ADHD did not obtain lower scores in the semantic task than those without ADHD, but only in the phonemic task, the scores obtained by adults with ADHD were statistically significantly lower than matched controls without ADHD.

Given the fact that verbal fluency is one of the five domains of executive functioning, according to Pennington and Ozonoff (1996), which is mediated by frontal lobes known to be impaired in ADHD, it was expected that adults with ADHD would give statistically significantly fewer answers on both verbal fluency tasks. However, this was not the case with the *semantic verbal fluency* task. Results did not support the prediction that adults with ADHD would differ in the number of answers given for the semantic verbal fluency task in comparison to adults without. Although they produced fewer words than matched controls for the categories given in the semantic task, this difference did not reach statistical significance.

There are very few studies (Barkley et al. 1996; Johnson et al. 2001) which found no differences between adults with ADHD and healthy controls on a semantic verbal fluency task, and the current study searches the issue further and provides additional new information on the semantic performance of adults with ADHD.

Johnson et al. (2001) provide an explanation for their findings. They claim that their sample consisted of higher functioning adults with ADHD since their education attainment (education years) was comparable to their normal sample, a thing that does not usually happen in more representative samples of adults with ADHD. Therefore, they supported the idea that higher functioning adults with the disorder may be better able to perform normally on simple tests of executive function. In addition, education appeared to be the most influential demographic factor and a higher level of education was associated with increased total word production in the study by Kosmidis et al. (2004), which provided normative data for semantic and phonemic verbal fluency tasks in the Greek adult population.

Table 1 Mean scores obtained for semantic and phonemic verbal fluency tasks by ADHD and non-ADHD adults

	ADHD	Non-ADHD	*p* value	*t* value
Semantic task	54.36 ± 5.59	58.56 ± 10.46	0.067	−1.905
Phonemic task	23.0 ± 38.67	39.66 ± 9.17	0.000*	−7.749

* Indicates statistical significance

The claim made by Johnson et al. (2001) and the fact that in the study by Kosmidis et al. (2004) education was the most influential factor could provide an explanation for the findings of the present study as well. The mean years of education were the same (14.6, SD = 1.2) for both adults with ADHD and controls in this study. The adults diagnosed with ADHD in childhood in this sample are already university students which means they did not drop out of high school as some of their equivalents (according to Barkley et al. 1990, a third of adults previously diagnosed with ADHD drop out of high school), and therefore, they are not accompanied by a low verbal IQ, that has also been associated with ADHD (Fischer et al. 1990). Furthermore, the adults diagnosed with ADHD in childhood in this sample had no history of psychiatric diagnosis, that is no comorbidity with psychiatric diseases, which could make their performance on the semantic verbal fluency task worse, since adults with ADHD and comorbid psychiatric diagnoses have been shown to perform more poorly on neuropsychological tests than those with pure ADHD (Walker et al. 2000). Therefore, adults with ADHD in this study are high functioning adults, with a high level of education and no comorbid psychiatric diseases, who managed to reach higher education, which is not usually the case with individuals with the disorder. This is probably the reason they scored equally high with controls in such a simple verbal fluency activity, the semantic verbal fluency task.

A semantic task is considered an easy verbal fluency task, in that language is represented semantically (Hurks et al. 2004), so when ADHD adults were asked to generate words according to a category, this matched the way in which language is stored. The different hierarchical organizations of the two tasks (semantic vs phonemic) require searching of fewer subsets of categories during the retrieval of semantic categories in comparison to the retrieval of letter-based categories and that is possibly another explanation for the non-statistically significant results between adults with ADHD and controls in this semantic task. Moreover, since the ability to organize and retrieve words semantically develops much earlier than the ability to produce words phonemically, possibly young adults with ADHD of this sample have developed it to an extent comparable to that of young adults without ADHD.

In addition, as mentioned in the "Introduction" section, there are certain strategies, namely switching and clustering, used to maximize word production which are mediated by separate brain mechanisms and regions. Performance on a semantic verbal fluency task is closely associated to both switching and clustering. However, it is not the case that both strategies are mediated only by frontal lobe functioning which is found to be impaired in ADHD. Switching is closely related to frontal lobe functioning but clustering is mainly based on temporal lobe functioning which is known to be intact in ADHD (Troyer et al. 1997). Therefore, it is hypothesized that the absence of differences in the semantic verbal fluency task between adults with ADHD and adults without could be due to the fact that this task is also based on the intact temporal lobe functioning which possibly compensates for impairments in frontal lobe functioning.

Moreover, studies (e.g. Tucha et al. 2005) which analyzed clustering and switching strategies, showed that individuals with ADHD switched less frequently on verbal fluency tasks than individuals without ADHD and that the two groups did not differ significantly concerning mean cluster size. Tucha et al. (2005) suggested impairment of switching but not of clustering in adults with ADHD which also provides an explanation for the absence of statistically significant differences between the two groups in the semantic task which relies not only on switching but also on clustering strategies.

It has been shown that individuals with ADHD produce an increased number of rule violations and/or repetitions in verbal fluency tasks (Tucha et al. 2005). However, this is not the case in our study. Adults diagnosed with ADHD in childhood in our sample did not produce statistically significant more errors than controls. Thus, we could accept the claim made by Jenkins et al. (1998, cited in Tucha et al. 2005) concerning the absence of differences in the errors made by adults with ADHD and controls that "the patients' disturbances on fluency tasks may probably be the result of reduced productivity rather than deficient processing." However, since the time limit (60 s) of the task was restricted, if extra time was given, this could enhance the possibility of finding differences between the groups.

The second hypothesis of this study is confirmed in that adults diagnosed with ADHD in childhood gave fewer correct answers than adults without an ADHD diagnosis in childhood in the *phonemic verbal fluency* task. These results are in line with most research findings which indicate gross disturbances in adults with ADHD in phonemic verbal fluency (Dinn et al. 2001; Tucha et al. 2005; Walker et al. 2000).

In a phonemic verbal fluency task, one has to suppress the ordinary way of retrieving words from memory according to their meaning (Szatkowska et al. 2000). Language in not organized alphabetically and the ability to organize and retrieve words phonemically develops more slowly than the ability to retrieve words from different semantic categories (Riva et al. 2000). Phonemic fluency tasks (letter based) have been shown to be more difficult than semantic fluency tasks since retrieval by letters requires the exploration of more subsets of categories than the retrieval of the names of animals or fruit for example (Riva et al. 2000). Moreover, a task with given letters of

the alphabet provides less structure to the individual conducting the word search than when given semantic categories, which restrict the range of potential words (Kosmidis et al. 2004). Therefore, a phonemic verbal fluency task is likely to require more executive function than a semantic verbal fluency task, as mentioned elsewhere.

In addition, phonemic fluency depends less on memory stores and more on effective initiation and shifting skills (Kosmidis et al. 2004), thus forcing an individual to use a search strategy based mainly on lexical representations, a process which involves increased complexity and great cognitive demands. The point at which adults with ADHD appear to operate at maximum cognitive capacity may be reached, on average, sooner or more easily than adults without (Hervey 2004). Thus, in a demanding task such as the phonemic verbal fluency task, adults with ADHD display performance decrements because its increased complexity puts greater cognitive demands on them.

The restricted time limit (60 s) of this difficult task may also account for the poor performance of adults with ADHD and for the absence of statistically significant differences between the groups in the number of errors analyzed. It has been suggested (Hurks et al. 2004) that individuals with ADHD are able to achieve on a similar level of performance as those without, if they are given sufficient time to do a task. Thus, if extra time was given to them to complete the task, the difference between adults with ADHD and those without ADHD might not have reached statistically significant levels, while the opposite might have happened with their errors.

As mentioned elsewhere, the cognitive strategies used to complete both semantic and phonemic verbal fluency tasks successfully are clustering and switching. However, their role is not equally important in the two verbal fluency tasks. Both clustering and switching appear to play an important role in semantic fluency, whereas switching appears to be more important than clustering in phonemic fluency (Kosmidis et al. 2004). In addition, each of the strategies is mediated by separate brain mechanisms. Clustering words depends on verbal memory and word storage, processes mediated by both temporal and frontal functioning while switching depends on initiation, cognitive flexibility and mental shifting which are strategic search processes solely mediated by frontal lobe functioning (Troyer et al. 1997). The fact that phonemic verbal fluency depends on switching which is closely associated to frontal lobe functioning, which has been shown to be impaired in ADHD (Johnson et al. 2001), could provide an explanation for the poor performance of adults with ADHD on this task.

In conclusion, the findings of this study suggest phonemic verbal fluency deficits on the part of adults diagnosed with ADHD in childhood giving further support to the notion that ADHD is a disorder with lifelong course. These findings have practical implications for ADHD adults since they stress the need to provide them with compensation strategies–techniques and especially those who attend university since only 5 % of young adults with ADHD who manage to enter university finally obtain a university degree (Barkley et al. 1990). Techniques for how to manage time, how to study, and how to plan and organize are frequently recommended (Teeter 1998). The phonemic verbal fluency deficits found in individuals with ADHD in this study seem to support the idea that university students with ADHD should use strategies that strengthen their study skills. Since phonemic verbal fluency is dependent on initiation skills and is related to spelling skills as noted elsewhere, they should use active study techniques when reading from text, for example, read headings before reading chapter, skim chapters to see what comes next, make up questions using chapter headings, practice answering these questions and recite answers aloud (Teeter 1998, p. 308–9). In addition, since phonemic verbal fluency deficits are related to the effectiveness of controlled processing which is attention demanding, university students with ADHD need to strengthen their organizational planning and time management skills by developing strategies such as asking for extra time for writing assignments, taking notes while studying, highlighting or color coding important information, using folders to organize class notes, starting each day with a list of what needs to be done or using a daily planner to write down all important tasks for the day (Teeter 1998, p. 308–9).

Despite the fact that the results of the present study strengthen the notion that the symptoms of ADHD persist across the life span, they must be interpreted in light of some limitations. First of all, the current study used a sample of university students which limits the generalizability of the findings to other adults with ADHD. Individuals with ADHD who have reached the university level are high functioning adults and may not be representative of the average population of adults with ADHD. In addition, the two groups were not matched for intelligence which, as stated elsewhere, might play a main confounding factor in fluency performance, and their cognitive strategies were not analyzed, a fact which would provide additional explanation for the poor performance of adults diagnosed with ADHD in childhood in verbal fluency tasks. Other restrictions of the study include the relatively small sample size and the overrepresentation of males. Although males are more likely to manifest ADHD than females, and it is suggested that there may be some gender-linked mechanism involved in the expression of the disorder (Barkley 1998), the absence of gender-matched comparison of individuals with ADHD limits the conclusions that can be drawn, as noted earlier.

Further limitations of the study which concern the sample are that it is consisted only of community recruited not clinically referred adults, who had a diagnosis for ADHD in childhood and were not examined for other known cognitive deficits in ADHD such as psychomotor slowing. In addition, all the adults with ADHD in this study belonged to the combined subtype; therefore, the findings cannot be generalized to the other ADHD subtypes.

Therefore, more research is needed in the field of ADHD in adulthood with larger samples of people who have a diagnosis of ADHD as adults, with both sexes and more subtypes of ADHD represented.

Appendix: Non-diagnostic ADHD questionnaire

Indicate the degree you feel the following symptoms for more than six months: 1 = not at all present; 2 = just a little; 3 = pretty much.

a. restless or overactive
b. excitable, impulsive
c. disturb other people
d. fail to finish things you start; short attention span
e. constantly fidgeting
f. inattentive, easily distracted
g. demands must be met immediately; easily frustrated
h. cry often and easily
i. mood changes quickly and drastically
j. temper outbursts, explosive and unpredictable behavior

(Adapted from *Conners Hyperctivity Index,* 1998, cited in De Quiros and Kinsbourne 2001.)

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