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Article

Greek Norms for the D-KEFS Verbal and Design Fluency Subtests in Adult Population between 20-49 Years Old

Marianna Tsatali [1,2,*], Andromachi Konstantinou [2], Fotini Surdu [2] and Despina Moraitou [1,3,*]

[1] Laboratory of Psychology, Department of Cognition, Brain and Behavior, School of Psychology, Aristotle University of Thessaloniki (AUTh), Greece
[2] Department of Psychology, School of Humanities and Social Sciences, University of Western Macedonia, Kozani, Greece
[3] Lab of Neurodegenerative Diseases, Center for Interdisciplinary Research and Innovation, Aristotle University of Thessaloniki, Hellas (CIRI - AUTh)
* Correspondence: mtsatali@yahoo.gr

Abstract: Background: Delis-Kaplan Executive Function System (D-KEFS) is a neuropsychological tool used in clinical practice to measure executive function in clinical and non-clinical populations, in individuals aged 8-89 years, and consists of nine subtests that can be administered either as a single system or separately. Aims: In the present study, were established norms for the Verbal Fluency Test as well as the Design Fluency Test of the D-KEFS in a Greek population aged 20 to 49 years, since there is no previous study conducted in Greece for these age clusters. Methods: The study sample consisted of 100 healthy adults (44.4% male and 55.6% female), aged 20 to 49 years (M=32.81 SD=11.04) with education from 12 to 18 years (M=14.73, SD= .91). First, Spearman and Pearson tests explored the associations of gender, age and education with D-KEFS subtests' performance. Afterwards, we calculated normative data using raw scores and transformed to percentile scores. Results: The present study is the first attempt to calculate norms for the two fluency subtests of the D-KEFS in Greek adult population stratified by age and educational level. Conclusion: Future research will promote the use of D-KEFS, in order to introduce a widely used tool which measures all basic executive functions subtypes for Greek adult population. Given that the majority of neuropsychological tools are adapted for older adult population, the current study aims at filling the gap in neuropsychological assessment of young adults as well as those who have co existing neurological or psychiatric disorders.

Keywords: D-KEFS; design fluency; executive functions; normative data; verbal fluency

1. Introduction

Basic Characteristics of the Delis-Kaplan Executive Function System (D-KEFS)

Executive functions refer to a range of higher cognitive processes associated with frontal lobe function [1] affecting behaviors which have frontal lobe as their neural substrate, such as impulsivity, emotional control, and lack of organization. Research on the aforementioned abilities in healthy children and adults has shown that they differ by age [2]. In particular, it seems that in preschool children these abilities work as a single model, in elementary school children working memory works independently of the other two abilities, while in adults it has been found that working memory, inhibition and shifting work separately and independently [2].

Delis – Kaplan Executive Function System (D-KEFS) [3] is a neuropsychological test measuring a multiple set of executive functions consisted of a series of nine subtests designed to assess upper levels of executive functions administered in people aged from 8 to 89 [4]. According to the literature [5,6], D-KEFS is assumed to be one of the first tests used to measure verbal and nonverbal executive

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functions in children, adolescents and adults. In more details, D-KEFS includes some of the most appropriate, available and well used tests which assess executive functions, and therefore, it is quite important to create norms and calculate their psychometric properties to detect people with neurological, neurodevelopmental and psychiatric conditions in healthy population [6,7]. Since D-KEFS assesses executive functions, researchers and clinicians can use a complete set of subtests which provide a holistic evaluation of frontal lobe's integrity and function, and therefore calculate whether executive functions' deficits impact daily living of adults', who live with various neurological or psychiatric conditions.

D-KEFS consists of nine tests that can be used as an integrated system to map higher and lower executive functions and cognitive processes, while its results can be used to indicate the integrity of the frontal lobes, as well as to determine how deficits in higher order thinking may affect a person's functioning [6,8]. According to the literature, D-KEFS has been used in both clinical and non-clinical populations to assess executive functions for various purposes [9]. In particular, it can predict executive dysfunctions in various clinical populations such as, in cases of traumatic brain injury, frontal lobe dysfunction, psychiatric disorders, neurodegenerative, learning and neurodevelopmental diseases, in both adults and children [9–17]. In addition, it has been also used for the prediction of neurodevelopmental disorders, because according to the study of Ridley et al. (2011) [13] who investigated the characteristics of the autistic phenotype in a typical population, D-KEFS can predict these characteristics in a clinical and even in non-clinical population. Additionally, Wodka et al. (2008) [18] examined executive dysfunctions using the D-KEFS in children with Attention Deficit Hyperactivity Disorder (ADHD), while McLean et al. (2014) [19] investigated the likelihood of Autism Spectrum Disorder in adults and first-degree relatives of individuals on the spectrum. Additionally, studies [9,20] have found that D-KEFS sub tests can predict executive dysfunction in people with psychiatric disorders, but not along with psychotic symptoms. Depressive and anxiety disorders are also closely related to executive functions, but only in severe symptomatology [21]. Moreover, the fact that in the last five years the executive function of young adult athletes has been systematically investigated [22,23], seems that the D-KEFS is assumed to be a widely used tool measuring executive function in adult clinical and nonclinical population, and therefore normative data studies should be conducted to expand its use in research as well as clinical practice.

Finally, D-KEFS consists a new era in the measurement of executive functions, because new processing demands are required to achieve a good performance, in comparison to the traditional relevant tests used in clinical population, and therefore, the possibility to detect subtle executive functions' deficits is increased [24]. Since several D-KEFS tasks can be assumed as games, hence, they are appealing in children and adults. Moreover, subtests do not provide "wrong" evaluation after their response, which is encouraging for participants, especially children, who are getting easily frustrated with repeated negative feedback [24].

Description of the D-KEFS Tests

D-KEFS consists of nine tests (a) Trail Making Test (TMT), (b) Verbal Fluency Test (VFT), (c) Design Fluency Test (DFT), (d) Color–Word Interference Test (CWIT), (e) Tower Test, (f) Twenty Questions Test, (g) Word Context Test, (h) Sorting Test and (i) Proverb Test. According to the test's authors, several versions of the tests are frequently used in the field of neuropsychology (McFarland, 2019) either individually or in groups [25]. Through the D-KEFS tests the following executive functions are measured indicatively: (1) spatial planning, (2) phonemic and semantic processing, (3) inductive reasoning, (4) problem solving, (5) verbal fluency, (6) design fluency, (7) cognitive flexibility, (8) inhibition, and (9) verbal deductive reasoning [25]. The D-KEFS subtests can either be administered as a group or each subtest can be used individually for each domain it represents [8,26].

The nine tests of D-KEFS are either relatively new, or standardizations from other established clinical or experimental tests by previous researchers [27]. For example, the VFT is a modification of Controlled Oral Word Association Test in 1976. Each D-KEFS test gives primary as well as optional scores, which provide qualitative information about participants' cognitive performance [28]. To

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sum, it is worth emphasizing that the D-KEFS is the first set of executive function tests, weighted in a large and representative national sample, designed exclusively to assess executive functions, including cognitive flexibility, inhibition, problem solving, planning ability, impulse control, conceptualization, abstract thinking, and creativity [4].

In the current study, two out of nine D-KEFS tests, in specific Verbal Fluency Test (VFT) and Design Fluency Test (DFT) were adapted in Greek adult population, because average to above average scores on fluency tasks demonstrate deficits in fundamental executive functions', fluency in generating visual patterns and language performance. Measures of design and verbal fluency constitute a significant component of neuropsychological evaluation, both in clinical and in research settings [14]. Particularly, verbal fluency constitutes two different tasks, the phonological which involves the production of words beginning with a particular letter or sound (such as the letter "F" "A" or "S"), as well as the semantic, which is associated with producing words which belong to a specific category (such as animals and boys' names). Design fluency, also known as nonverbal fluency, consists of three trials through which participants must generate as many novel drawings as possible during one minute by connecting dots using a pattern of five dot matrices without repeating previous drawings; e.g connecting filled dots connecting empty dots throughout a set of filled dots which work as distractors and switching between filled and empty dots. It is noteworthy that according to functional neuroimaging and studies involving brain- damaged patients, verbal fluency tasks are widely used to evaluate functionality of the prefrontal regions of the left hemisphere in studies involving functional neuroimaging [29] and brain-damaged patients [30]. On the other side, design fluency tasks are used to detect right and left frontal lesions [31].

Demographics' Effects - the Role of Age and Education

Despite the discrepancy across studies, educational level and mainly age seem to significantly affect participants' performance in all D-KEFS tests. However, the findings across studies regarding the participants' performance in verbal fluency tasks are mixed. Vogel et al. (2019) [32] mention that a person's vocabulary performance peaks at 40s or later in life, whereas healthy older individuals were found to typically produce more words in tests measuring categorical fluency compared to those measuring phonemic fluency. Moreover, Strauss et al. (2006) [33] mention that performance in verbal fluency tasks is better in young individuals, whereas it progressively declines as age increases [34]. Nevertheless, Jebahi et al. (2020) [35] found that young age is positively related to the number of words produced, mainly in categorical rather than phonemic fluency, but it is worth mentioning that this study recruited Lebanese speaking adults and therefore, maybe cross cultural differences explain the controversy across studies. Educational level also appears to be positively related to verbal fluency tasks, because the higher the education level, the better the performance on the semantic and phonemic fluency tasks [34]. It is worth mentioning that in the research of Kosmidis et al. (2004) [36] conducted in Greek population, using a variant of the test in a Greek population, found that younger age in conjunction with a higher level of education was positively related to the production of more words, fewer repetitions and more alternations.

Moving to DFT, Zhao et al. (2020) [37] mentioned that scores in the inhibition condition and percentage of correct drawings were highly correlated with age. As regards education, Wecker et al. (2005) [38] and García-Escobar et al. (2021; 2024) [39,40] found that education did not appear to affect DFT scores among healthy adults in America and Spain, respectively, in the age range of 20–50 years. In particular, the latter studies identified a positive correlation between educational level and performance in this test only in adults over 50 years old [39]. Finally, according to the study of Wecker et al. (2005) [38] age negatively affects verbal and non-verbal cognitive switching in Verbal and Design Fluency Tests.

To sum, according to the developers of the D-KEFS [3], age constitute the predominant factor affecting performance across all D-KEFS tests, however, education has a great impact on VFT because vocabulary is highly dependent on education and cognitive reserve. Although age is significant across all tests, the amount of variance explained by age varies across tests, ranging from 3.0% for the Trail Making Test to 8.7% for the Design Fluency Test, according to the study of Wecker et al. (2005)

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[38]. At this point, it is worth adding that the typical population often shows high scores on D-KEFS tests, however, the frequency of high scores increases proportionally with the number of tests administered [41].

Study's Aim

According to the literature, few studies were found in Greece using D-KEFS in clinical and non-clinical population which compare the performance of different groups of older adults with cognitive impairment, cross sectionally and longitudinally, via the use of raw scores [42,45] indicatively. On the other hand, Kosmidis et al. (2004) [36] created norms for the VFT in adult population, although they used a simpler version of verbal fluency test rather than the D-KEFS VFT, which has more conditions.

Moreover, it is worth noting that there is also a limited availability of norms for the specific tests of the D-KEFS in other linguistic and cultural contexts, as the majority use other versions of them [46–48]. In particular, the research of García-Escobar et al. (2021) [39] is of great interest, as the only one that includes the D-KEFS design fluency test, aiming to produce norms based on age, education and gender in a typical adult population, divided into two age groups (< 50 and ≥ 50 years old).

Therefore, the D-KEFS VFT and DFT have not been extensively used in Greek adult population in research as well as in clinical practice, and till now there are no previous studies calculating norms for this population. The present study aims to calculate norms in a typical Greek population based on age (20-29 years, 30-39 years, 40-49 years), to measure basic executive functions, but also to introduce this tool in clinical practice for the general population.

2. Materials and Methods

Participants

One hundred (100) healthy adults, aged from 20 to 49 years old (44.4% male and 55.6% female), participated in this study voluntarily, anonymously, after giving their written consent. The mean age was 32.81 years with mean education (as years of schooling) 14.73 years. To collect the sample, a data sample from the wider area of North and Central Greece was used; especially, participants were university students from the University of Western Macedonia and Aristotle University of Thessaloniki, as well as other adults from the same area, who were recruited from towns, villages and islands of this area representatively.

All participants met the inclusion criteria: age from 20 to 49 years and Greek as their native language. Exclusion criteria were the following; presence of previous addictive disorder, psychosis and major depression, concurrent history of neurologic disease known to affect cognitive functioning, auditory functioning no sufficient to understanding normal conversational speech, and visual acuity non-normal or non-corrected to anticipate visual stimuli.

Description of the D-KEFS Tests

Verbal Fluency Test (VTF)

VFT measures initiation, auditory attention, speed of processing verbal and vocabulary knowledge spelling ability, as well as retrieval of lexical items, Both phonemic and categorical fluency assess language functions such as vocabulary and naming, response speed, organization, retrieval strategies etc. [49,50]. Additionally, according to Diamond (2013) [51] verbal fluency tasks are assumed as useful tools for assessing cognitive flexibility. The ability to recall requires executive control, because participants must have access to their mental vocabulary, concentration and avoid word repetitions [50]. Concerning the switching categories' fluency, the speed of retrieval from the semantic vocabulary as well as cognitive flexibility in switching between two semantic categories are measured.

D-KEFS VFT includes three conditions: phonological fluency (the production of words starting from a specific letter of the alphabet) which requires initiation, simultaneous processing, speed of

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processing, vocabulary knowledge, spelling, attention and retrieval of phonemically similar lexical items, categorical fluency (the production of words included from specific categories; animals and boys' names) which requires vocabulary knowledge, rapid retrieval of lexical items, retrieval of multiple words from a high-frequency semantic category, semantic memory, naming, and the switching categories fluency (the production of words through the switching of different categories as well as the number of correct switches; fruits and furniture) which measures cognitive flexibility, retrieval from semantic knowledge, switching and shifting. According to D-KEFS authors, other than neurostructural factors, for example anxiety, pain, mood, medications and/or inconsistent effort may produce atypical patterns of performance across all D-KEFS tests.

In each subtest the participant was given one minute to produce as many words as possible per each condition. For the Greek version of the D-KEFS, the letters in the phonological condition are the same as in the original version; Άλφα (A), Φι (Φ) and Σίγμα (Σ) for A, F, and S respectively. In the semantic fluency condition, the examinee is asked to name as many words as he/she could from a specific conceptual category, regardless of the letter with which the word begins. The semantic categories of this condition are 'animals' and 'boys' names'. In the category switching fluency condition the examinee is asked to produce words from different categories, alternately. The categories are "fruit" and "furniture". For all conditions, the instruction is given not to repeat the same words, not to use grammatical variants of words (unless it changed the meaning of the word) and not to mention proper names, while the time to complete all conditions is 60 seconds.

As regards the semantic condition, words representing broader characteristics of a sub- category (e.g., for animals, the word "carnivore") are considered incorrect. In the last condition, the words belonging to the category "fruit" and "furniture" are considered correct, as well as the correct number of substitutions made by the examinee, while repetitions and superimposed meanings of the same words are marked as errors. Finally, lexicon characteristics of the sample, such as reading style or letter processing speed, which may affect participant's performance in visual-mental tracing and verbal search in verbal fluency, are not be taken into account. The variables attributable to the VFT are the following; Letter Fluency: Total Correct; Category Fluency: Total Correct; Category Switching: Total Correct: Category Switching: Total Switching Accuracy).

Design Fluency Test (DFT)

DFT evaluates basic visual attention, planning, initiation motor speed, visual perceptual skills, constructional skills, processing, non-verbal creativity and cognitive flexibility primary in research as well as clinical settings. Additionally, it assesses a participant's ability to generate geometric patterns, and therefore is thought to measure executive functions. DFT was originally developed by Jones-Gotman and Milner (1977) [52] as the nonverbal counterpart of verbal fluency [33,53], and is based on the coordination of multiple executive functions in the initiation, visuospatial and constructional domains, including fluid productivity, monitoring and planning [54], problem solving, motor speed and creativity in drawing new patterns. Additionally, the scoring system provides qualitative as well as quantitative information such as the number of novel designs, complexity of designs, variations in designs, and concrete, frankly perseverative, and scribbled responses. Additionally, although Delis and colleagues (2001) [3] argued that graphomotor speed and visual scanning were significantly correlated with participants' performance in the first two DFT conditions, in the study by Suchy et al. (2010) [14] graphomotor skills had minimal impact on performance, accounting for less than 5% of the variance. The only exception was found in individuals with significant graphomotor deficits.

According to the instructions, examinees are asked to connect dots using continuous four-line patterns, and therefore draw as many different drawings as possible in one minute, avoiding repetition of previous drawings and connecting four lines in a series of dot arrays. In more specific, DFT includes three conditions; in the first condition (Filled Dots), the participant is given a sheet including stimulus boxes all of them containing five filled dots, so that the examinee can use any of the dots to draw designs. In the second condition (Empty Dots), the stimulus boxes include five filled dots and five empty dots, whereas the participant must connect only empty dots while filled dots

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function as visual distractors. Conditions 1 and 2 are quite similar because participants must focus on one type of dots (filled or empty) in order to produce designs, therefore, they require visual attention, motor speed to nonverbal creativity, simultaneous processing, initiation in problem solving, productivity and monitoring. The third condition (Dot Switching condition) represents a new clinical task, which is identical with the Empty Dots layout, but the examinee must alternate between filled and empty dots in each box. The term "switching" refers to the flexible transition from one set of rules to another in response to changing environmental contingencies [55]. It measures nonverbal creativity and cognitive shifting skills.

Due to the fact that each pattern requires only four lines, the pattern production rate in the D-KEFS DFT appears significantly reduced relative to the production rate of other versions of the same test, and is further reduced in the switching condition [57]. Good performance in DFT conditions requires from the participants to shift their attention between response production and response monitoring [58]. In particular, these two prerequisites of the test are associated with conflicting demands, because when the participant shifts the attention from producing drawings to monitor his/her progress the possibilities to sacrifice production speed are increasing [58]. To sum, the first condition could be considered as the "pure" flow process [33], the second requires the ability to suspend inhibition and control, and the third involves ability to switch. The variables attributable to the DFT are the following; Design Fluency Test (Filled Dots: Total Correct; Empty Dots Only: Total Correct; Switching: Total Correct).

Ethics

Before the start of data collection, consent was obtained from the Ethics Committee of the University of Western Macedonia, in order to approve the processing of the participants' personal data. Demographic information, such as age, gender, and education, was collected, adhering to the law of the European Union since 28 May 2018, which allows the use of sensitive personal data for research purposes. Participants were told and consented to that, upon a written request, their data could be removed from the online database. The study was aligned with the principles outlined in the Helsinki Declaration (World Medical Association, 1997).

Procedure

First, a pilot study was conducted to evaluate the two tests of the D-KEFS, which have been administered to 15 participants, most of whom were students of the Psychology department of the University of Macedonia. Before their inclusion to the study, participants read the information sheet, which stipulated that the researchers could use their data for research purposes. Additionally, they were told that they would be able to withdraw from the study whenever they wanted without facing any consequences or having to give any explanation. Before the completion of the consent form, the participants were told that their records would be coded and anonymized for future research purposes.

After signing consent to participate in the research, a short, structured interview followed to collect demographic information, including the participant's gender, age, and education level. These data were accompanied by a code, which included the initial letters of the participant's name in combination with the number of the series of administration (e.g. PM54), to preserve anonymity, but also to facilitate the identification process of the participants in the statistical database. D-KEFS tests' administration was conducted in a quiet environment at the University premises, mainly during morning hours, to perform better without external interference.

The neuropsychological assessment lasted about half an hour maximum and involved a face-to-face assessment. In specific, the instruction sheet of each condition was presented in front of the participants, before each test's administration. Especially for the VFT a smart phone was used to record participants' responses and then the answers were transcribed in the corresponding reference booklet. The D-KEFS tests were counterbalanced across participants.

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Statistical Analyses

At first, Kolmogorov–Smirnov test for normality have been conducted to check whether the dependent variables were normally distributed. Therefore parametric tests were further employed. Moreover, Pearson correlations were computed for continuous variables such as age and education, and Chi Square test was conducted to examine whether there was any relationship between gender with the two D-KEFS tests.

Despite that D-KEFS tests' raw scores are otherwise converted to scaled scores having a mean of 10 as well as a standard deviation of 3, in the current analyses we provide only raw scores to identify participants' performance. Inferential cut off scores were also calculated to select the score under which the possibility for an individual to belong to the normal population was below 10% and therefore would be assumed as low performance.

Finally, after calculating raw scores, they have been transformed into scaled scores, to compare Greek norms with the American norms, D-KEFS provides primary and optional variables; in specific, primary measures give scores reflecting overall performance, and therefore provide global scores, whereas optional scores give a more detailed assessment of executive functions to allow researchers and clinicians have a more comprehensive knowledge about examinees' performance. An alpha value of .05 (two-tailed) was used. The statistical analyses were performed using the SPSS software v 27 (IBM Corp. Released 2020. IBM SPSS Statistics for Macintosh, Version 27.0. Armonk, NY: IBM Corp).

3. Results

Demographic distribution is shown in Table 1.

Table 1. Demographic distribution of the sample.

	Age groups			Total
	Age group 20-29	Age group 30-39	Age group 40-49	
Years of education				
10-12	-	15	15	30
13-16	11	12	12	35
16+	12	12	11	35

In order to extract the Greek norms, all participants were divided into three age classes, a typical separation in normative data studies (age range 20–29; 30–39, and 40–49 years), and three educational classes (Secondary school graduates (10-12 years), Diploma degree or Bachelor degree (13-16 years) and Master Degree to Doctorate studies (16< years) in line with the USA classification [4]. Pearson test showed that the total number of correct words in the phonological fluency ($p < .01$), semantic fluency ($p < .01$), category Switching ($p = .004$) and category switching- switching accuracy ($p = .004$) was significantly related to education. The higher score indicates the production of more correct words, thus higher performance. Due to the absence of participants in the age group of 20-29, with education level less than 10-12 years, the following category was not included in the relative tables.

VFT norms were not stratified by age and gender, because no differences were observed between men and women, as well as between the three age classes regarding VFT performance. On the contrary, DFT performance was strongly dependent on age, according to Pearson test, and therefore, different age-related norms have been extracted in its three conditions: Filled Dots ($p < .05$), Empty Dots ($p < .05$), and Switching ($p < .01$). The higher score indicates the production of more correct designs, thus higher performance.

Norms were established using percentiles scores (Tables 2–5). Specifically, we calculated the raw mean scores, per age and education for DFT and VFT respectively (as well as for both age and education in the case of VFT), and their mean and standard deviation. Afterwards, we converted the raw scores into percentile scores. Inferential cut off scores were then calculated to extract those under

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the lowest 10%, assumed to be low performance [59]. Scores above the 95% of the population were regarded as superior performance.

Table 2. Norms for the VFT in Conditions 1 to 3b stratified by education in age-class 20-29.

Age range 20-29 years (Age-Class 1)								
Educational classes								
	13-16 years of education (Education-Class 2)				16+ years of education (Education-Class 3)			
%ile	Cond.1	Cond.2	Cond.3α	Cond.3b	Cond.1	Cond.2	Cond.3α	Cond.3b
95	65.35	66.55	20.35	18.35	-	-	-	-
90	59.70	55.10	19.00	17.00	-	-	-	-
75	49.75	48.75	16.75	15.00	50.00	52.25	18.75	17.75
50	43.50	42.00	14.00	12.00	48.00	48.50	16.50	15.50
25	34.00	40.00	12.00	9.00	42.50	44.75	13.00	11.50
10	26.50	33.30	10.30	7.30	29.00	41.00	10.00	7.00
Mean	42.97	44.06	14.50	12.19	45.33	48.16	16.00	14.67
S.D.	11.33	9.00	3.00	3.49	8.11	4.35	3.74	4.41

Notes. Mean= Mean score, S.D.= Standard deviation. Condition1=Phonological fluency, Condition2=Category fluency, Condition3a=Category Switching, Condition3b=Category Switching Total Switching Accuracy.

Table 3. Norms for the VFT in Conditions 1 to 3b stratified by education in age class 30-39.

Age range 30-39 years (Age-Class 2)												
Educational classes												
	1-12 years (Education-Class 1)				13-16 years (Education-Class 2)				16+ years (Education-Class 3)			
%ile	Cond.1	Cond.2	Cond.3a	Συνθ.3b	Cond.1	Cond.2	Cond.3a	Cond.3b	Cond.1	Cond.2	Cond.3a	Cond.3b
95	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	52.20	58.00	18.40	18.40	72.40	61.20	19.20	18.20
75	40.00	36.50	17.00		50.00	55.00	15.00	17.00	60.00	53.00	17.00	15.00
50	38.00	35.00	16.00	15.00	44.00	42.00	14.00	11.00	52.00	47.00	15.00	14.00
25	36.00	34.00	12.00	11.00	36.00	39.00	13.00	11.00	48.00	44.00	14.50	13.00
10	36.00	34.00	12.00	11.00	29.80	36.80	12.00	9.70	39.40	41.40	13.00	12.40
Mean	38.67	35.66	15.00	15.00	42.60	45.40	14.20	12.93	53.62	49.00	15.69	14.46
S.D.	2.30	2.08	2.64	4.00	7.98	8.20	2.07	3.19	10.35	6.49	1.97	1.89
95	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	52.20	58.00	18.40	18.40	72.40	61.20	19.20	18.20
75	40.00	36.50	17.00		50.00	55.00	15.00	17.00	60.00	53.00	17.00	15.00
50	38.00	35.00	16.00	15.00	44.00	42.00	14.00	11.00	52.00	47.00	15.00	14.00
25	36.00	34.00	12.00	11.00	36.00	39.00	13.00	11.00	48.00	44.00	14.50	13.00
10	36.00	34.00	12.00	11.00	29.80	36.80	12.00	9.70	39.40	41.40	13.00	12.40
Mean	38.67	35.66	15.00	15.00	42.60	45.40	14.20	12.93	53.62	49.00	15.69	14.46
S.D.	2.30	2.08	2.64	4.00	7.98	8.20	2.07	3.19	10.35	6.49	1.97	1.89

Notes. Mean= Mean score, S.D.= Standard deviation. Condition1=Phonological fluency, Condition2=Category fluency, Condition3a=Category Switching, Condition3b=Category Switching Total Switching Accuracy.

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Table 4. Norms for the VFT in Conditions 1 to 3b stratified by education in age-class 40-49.

	Age range 40-49 years (Age-Class 3)											
	Educational Classes											
	1-12 years (Education-Class 1)				13-16 years (Education-Class 2)				16+ years (Education-Class 3)			
%ile	Cond.1	Cond.2	Cond.3a	Cond.3b	Cond.1	Cond.2	Cond.3a	Cond.3b	Cond.1	Cond.2	Cond.3a	Cond.3b
95	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	55.20	52.00	18.00	17.00	-	-	-	-
75	46.50	46.00	15.50	13.50	51.50	48.00	17.00	16.00	62.00	59.75	19.75	18.50
50	36.00	43.00	13.00	10.00	43.00	44.00	16.00	15.00	50.50	51.50	15.50	14.00
25	33.50	36.00	10.00	7.00	34.00	37.00	13.50	11.00	49.25	44.75	14.00	11.50
10	32.00	32.00	9.00	6.00	30.00	31.80	12.40	9.80	41.00	39.00	12.00	9.00
Mean	40.22	42.00	12.89	10.22	43.00	42.76	15.54	14.08	53.50	53.00	16.38	14.50
S.D.	8.62	7.14	2.84	3.34	9.26	6.88	1.98	2.66	8.50	10.90	3.33	3.66

Notes. Mean= Mean score, S.D.= Standard deviation. Condition1=Phonological fluency, Condition2=Category fluency, Condition3a=Category Switching, Condition3b=Category Switching Total Switching Accuracy.

Table 5. Norms for the DFT in Conditions 1 to 3 stratified by age.

							Age range		
	20-29 years (Age-Class 1)			30-39 years (Age-Class 2)			40-49 years (Age-Class 3)		
%ile	DFT1	DFT2	DFT3	DFT1	DFT2	DFT3	DFT1	DFT2	DFT3
95	20.00	18.00	13.00	21.35	19.90	15.00	18.00	19.70	13.00
90	16.90	17.00	13.00	19.70	17.90	13.90	16.90	16.90	12.00
75	15.00	15.00	12.00	15.00	15.00	12.00	15.00	15.00	11.00
50	13.00	12.50	10.00	12.00	13.00	10.00	13.50	12.50	9.00
25	10.00	11.00	9.00	10.00	12.00	9.00	10.00	10.00	7.00
10	10.00	10.00	8.00	10.00	9.10	8.00	8.00	8.10	6.00
Mean	13.00	13.00	10.15	13.27	13.57	10.50	12.57	12.77	9.00
S.D.	3.00	3.00	2.00	3.53	2.94	2.35	3.29	3.40	2.31
95	20.00	18.00	13.00	21.35	19.90	15.00	18.00	19.70	13.00
90	16.90	17.00	13.00	19.70	17.90	13.90	16.90	16.90	12.00
75	15.00	15.00	12.00	15.00	15.00	12.00	15.00	15.00	11.00
50	13.00	12.50	10.00	12.00	13.00	10.00	13.50	12.50	9.00
25	10.00	11.00	9.00	10.00	12.00	9.00	10.00	10.00	7.00
10	10.00	10.00	8.00	10.00	9.10	8.00	8.00	8.10	6.00
Mean	13.00	13.00	10.15	13.27	13.57	10.50	12.57	12.77	9.00
S.D.	3.00	3.00	2.00	3.53	2.94	2.35	3.29	3.40	2.31

4. Discussion

In the current paper, norms have been established for two D-KEFS tests; VFT and DFT, in Greek adult population for further use in research as well as for clinical use/purposes. This endeavor is crucial due to lack of relevant studies in this population. Additionally, given the importance of using standardized data that could help determine impaired performance of Greek adults with psychiatric and neurological diseases, extracting normative data for widely used tests measuring executive functions can help clinical neuropsychologists better differentiate impaired from normal performance in adult population. Despite that DFT has not been previously adapted in Greek adult population and therefore this is the normative data study, however the verbal fluency task is available for people between 18-79 years old in the study of Kosmidis et al. (2004) [36]. However, in their study, they calculated norms for people with 1-9 years of education, in comparison to our study which did not extracted normative data for this educational range due to lack of participants 20 years

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after the first study conducted in Greek population. Additionally, Kosmidis et al. (2004) [36] used a version of a verbal fluency test which does not include switching, and therefore, this is the main gap which the current study aims to fill. Despite that they adapted in Greek the initial verbal fluency task using the letters Chi (X), Sigma (S), Alpha (A) rather that F, A, S which are typically used in the English version. Actually according to the F, A, S test, letters have been initially chosen, because A has wide use as an initial letter, S has moderate use and F has little, but not very little, use in English language [60]. Since there are not official data concerning the actual equivalence between the above letters' frequency with specific Greeks, in the current study we used links speciliazed to the Greek letters frequency to identify letters with similar frequency [61] with the initial English letters. Hence, Greek letters Chi (X) and Fi (F) do not differ by means of frequency in Greek alphabet with those in English alphabet, despite that till now there are no official data which directly correspond to the English letters' frequency with the Greeks. Therefore, no changes have been made in the D-KEFS VFT as regards letters selection.

Regarding the VFT, the results showed that higher educational level was positively related to word production, but no statistically significant correlation was found with age. Similar studies [32,36,62–66], using different verbal fluency test's versions, showed the same results highlighting the significant impact of educational level on participants' performance. Nevertheless, some studies reported that younger people perform higher in all test's conditions [32,36,62,63], while others reported that age affects performance in some VFT conditions [64,65]. However, in the current research, results showed that age does not affect word production in either semantic or phonological fluency, and therefore no statistically significant differences were found between the three age groups. Of course, we do not know if there will be revealed such differences when more age-classes will be added to the Greek sample. At the theoretical level, Elgamal et al. (2011) [67] reported that age is not considered an important factor in phonological fluency performance because older adults can produce more words and possibly perform better in the condition. However, due to reduced processing speed and working memory impairment, they do not perform as well and therefore their performance offsets with that of younger individuals [67]. Our results are also in line with previous studies [68,69], which showed that a higher level of education is solely responsible to produce more words among people of the same age. Moreover, similar studies that has recently been carried out in Greece [70,71], found that education contributed more to the VFT performance, as compared to age, and especially in the research of Alexiadou (2021) [70], age affected only semantic fluency. The following conclusion is particularly important, if we consider that their research was carried out in a Greek population and their results coincide quite well with the findings of the current study. In this case, it is necessary in future research to take into account other factors, such as processing speed per age group, as well as cultural factors and cognitive reserve, which can justify age differences observed in the results across different studies (64; 71). In conclusion, the results regarding VFT, and especially for the education factor, coincide with the results of research both abroad and in Greece [36,63,65,70,71]. However, all these studies used different versions of the test [64]. Furthermore, although the Greek literature offers some data on the VFT, heterogeneity was found in the instructions and the conditions applied [36,70,74]. Therefore, the comparison of the results does not show homogeneity in terms of the linguistic and verbal features used, although they coincide significantly (64; 65; 70; 71]. In any case, we decided to present data related to age-classes and education-classes too, having in the mind that when our sample will be completed they may be revealed useful.

Regarding gender, no differences in both fluency tests' performance were found between men and women. The following conclusion agrees with similar studies (32; 65; 72]. However, some research has observed that gender affected performance in some conditions, but not overall across the entire D-KEFS test [63,66]. In most studies, the heterogeneity of results by means of gender is not reported as a significant indication, as these differences may be due to cultural, linguistic, geographical differences as well as unweighted factors, and therefore they are not generalizable [64,73]. In specific, educational background between men and women is often observed to be non-homogeneous in data samples [73].

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Regarding DFT, results showed that age influences participants' performance mainly in the Cond, in terms of both the number of correct and incorrect drawings as well as their repetitions. This result is consistent with the findings of Sanders & Schmitter-Edgecombe (2012) [74], according to which age was found to negatively affect the performance of a healthy sample in the Cond. 3 of the test, comparing scores between young adults (18–33 years) and older adults (60-94 ετών). In the present study, we found a negative correlation of age as exact years of life with the production of correct drawings. Additionally, the study by Wecker et al. (2005) [38] as well as Zhao et al. (2020) [37] identified age as the only predictor of the reduction in the number of correct designs in the Cond. 3, accounting for 17.6% at the 0.01 α level, in a healthy American adult population [38]. Moreover, recent findings by García-Escobar et al. (2021) [39], found negative correlation between age and the total number of correct drawings, but only for adults over 50 years old. In detail, age was positively related with wrong drawings in the Cond. 3 ($r = .214$, $n = 100$, $p < .005$) as well as with decreased sum score of the design accuracy ($r = .228$, $n = 100$, $p < .005$). In fact, it is worth underlining that the 40-50 age group scored twice the number of incorrect plans in the Cond. 3 compared to younger age groups. On the contrary, the study of Woods et al. (2016) who used a digital version of DFT found that the number of unique drawings produced over 90 seconds by participants between 18 to 82 years was significantly correlated with age, education, and daily computer-use. However, our results are not totally comparable with this study, because they used a design fluency test other than D-KEFS DFT, whereas their data sample included participants in a larger age range. Furthermore, in our study a pencil and paper version of DFT was administered. Additionally, in the digital version of the design fluency test used in the study of Woods et al. (2016) [57] each pattern disappears after being drawn (Woods et al., 2016). As a result, participants need to remember previous patterns to avoid repetitions, which increases the difficulty levels in relation to memory capacity.

In conclusion, the current study is the first attempt to evaluate executive functions, measured by verbal and design fluency tests in Greek adult population, since it is regarded as integral part of neuropsychological testing, whereas there are limited data for these age groups. Therefore, the adaptation of the D-KEFS VFT and DFT is crucial for their use in neuropsychological evaluation and the subsequent treatment of people who have neurological and also psychiatric conditions, when needed. Finally, having more accurate data regarding performance of the Greek older adult population on these two fluency tests, a researcher as well as a clinician can better differentiate impaired from non-impaired performance, and determine in a more efficient way the functional level of Greek adults on each condition. To conclude, the findings of the current study (in combination with other data) could contribute to the diagnosis and help the clinician setting tailored treatment goals and developing structured cognitive rehabilitation programs. Hence, the current study can be regarded as a significant addition to the relevant literature and therefore can be used in both research and clinical practice.

5. Conclusions

To conclude, our findings highlight the significance of adapting neuropsychological tests to measure executive functions in Greek adults, because till now there are limited data in this field. Through the current study, we aim at providing researchers as well as clinicians with useful and valid ways to detect executive dysfunction and also evaluate therapeutic interventions implemented in their patients.

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