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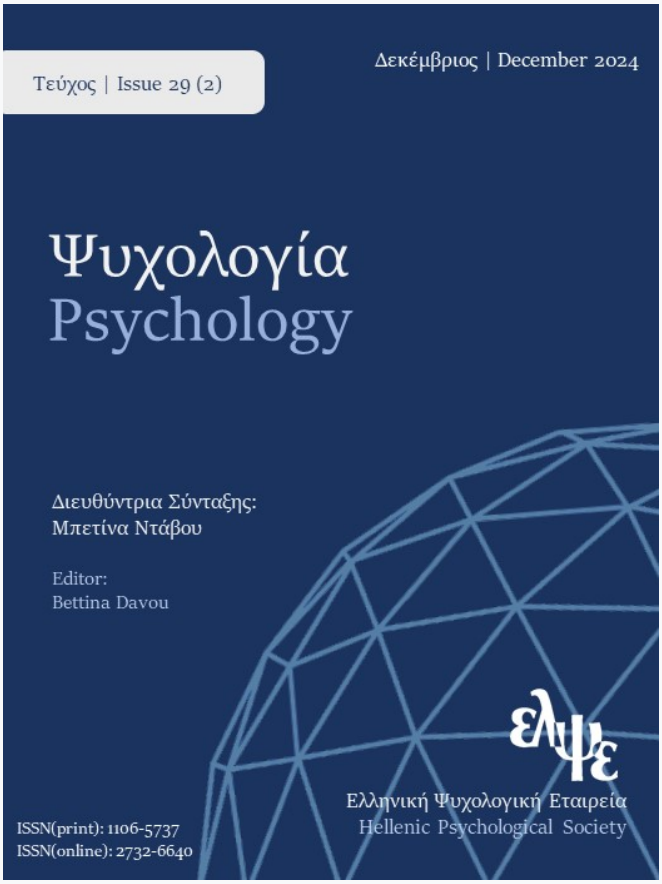

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ΕΜΠΕΙΡΙΚΗ ΕΡΓΑΣΙΑ | RESEARCH PAPER

The Effects of Age, Sex and Education on HVLT-R Performance Across the Lifespan: Data from the NEUROAGE Cohort

Flora NIKOLAOU[1,2], Michalis P. MICHAELIDES[1] ,' Juliana PROKOPIOU[2], George METAXAS[2], Fofi CONSTANTINIDOU[1,2]

1 Department of Psychology,University of Cyprus
2 Center for Applied Neuroscience, University of Cyprus

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CORRESPONDENCE

Flora Nikolaou
Center for Applied Neuroscience
Univeristy of Cyprus
Kallipoleos 75, New Wing
Nicosia 1678
nikolaou.flora@ucy.ac.cy

ABSTRACT

The study investigates the impact of age, education, and sex on memory within a diverse cohort of participants spanning the adult lifespan, utilizing the G-HVLT-R. A total of 1,055 Greek Cypriot individuals, both males and females aged 18 to 80, were recruited from the NEUROAGE longitudinal project. Participants underwent a comprehensive battery of neuropsychological tests, including the G-HVLT-R for assessing total learning and delayed recall, alongside the Logical Memory test measuring delayed recall performance in story recall. Significant performance disparities emerged between Forms 1 and 2 and Forms 1 and 3 of the G-HVLT-R. Regression analyses revealed age as the predominant predictor, with the highest coefficients, followed by education and sex. Notably, the G-HVLT-R demonstrated robust concurrent validity, evidenced by high correlation coefficients with Logical Memory delayed recall tasks. The findings underscore age as the primary determinant of performance, while also emphasizing the influence of education and sex across the lifespan. Consequently, establishing norms that account for demographic characteristics is imperative for refining the precision of neuropsychological assessment, particularly among those with lower education levels and in older age groups. This information enhances accurate clinical assessment across diverse populations and aids in identifying individuals necessitating specific treatment interventions.

Introduction

Verbal episodic memory is a key aspect of neuropsychological assessment. Memory problems manifested in difficulties in acquiring, retaining and/or retrieving new information, represent the main aspect of neurocognitive decline associated with healthy/pathological aging, neuropsychiatric and neurological conditions. Verbal learning through the implementation of supraspan lists and delayed recall tasks is being used widely in clinical and research literature (Constantinidou et al., 2016; Giogkaraki et al., 2013).

Hopkins Verbal Learning Test Revised (HVLT-R)

The Hopkins Verbal Learning Test (HVLT; Brandt, 1991), is a memory, word-list learning test which aims primarily to assess working memory and episodic memory in individuals with a variety of brain conditions. It contains a target list of 12 items representing three different semantic categories with four words per category. The target list is orally presented three different times and each time the examinee is instructed to recall as many

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items as possible. The test concludes with a yes/no recognition task consisting of 24 words, 12 words from the target list, 6 words semantically related to the target list, and 6 unrelated words (Brandt, 1991). The HVLT is easy to administer and quick in comparison to more extensive list-learning test batteries and well-tolerated by many types of individuals, including individuals with moderate dementia and moderate to severe traumatic brain injury (TBI; Brandt, 1991).

One of the contributions of the HVLT is the ability to conduct repeated assessments due to the availability of six different forms thus minimizing practice effects. Therefore, the HVLT is well suited to assess the effects of interventions or monitor disease progression in remitting or neurodegenerative diseases (Benedict et al., 1993). The revised version of the HVLT, (HVLT-R; Benedict et al., 1998; Brandt & Benedict, 2001), includes a delayed recall trial (20-25 minutes duration) and a forced choice recognition, thus improving the clinical utility of the test.

The HVLT has many promising psychometric characteristics. One of them is the interform reliability between the 6 different forms of the test across the learning trials, free recall, and recognition task (Benedict et al., 1998; Benedict & Zgaljardic, 1998). Interform reliability was supported by two different studies indicating that the 6 forms of the HVLT-R are equivalent for the recall trials, but there are slight differences in the delayed recognition trial.

The HVLT has good construct validity and more specifically convergent and discriminant validity (Lacritz & Cullum, 1998; Shapiro et al., 1999). Shapiro and colleagues (1999) correlated the HVLT-R total recall, delayed recall and retention with comparable measures derived from the Logical Memory and Visual Reproductions subtests of the WMS-R in an elderly sample of 302 participants. The total recall, delayed recall and retention scores on the HVLT-R were highly correlated with the immediate, delayed recall and total scores of the Logical Memory subtest respectively.

The Effect of Demographic Characteristics on Memory Performance: The Role of Sex and Education

There is general agreement that performance on key aspects of verbal learning, such as immediate, delayed recall and recognition tasks is influenced by demographic factors such as age, education years, and sex (Giogkaraki et al., 2013; Constantinidou et al., 2016; Constantinidou et al., 2014; Lara et al.,2021 Salthouse, 2009; Vakil et al., 1997). Williams and Kamper (2010) reported that active memory processes associated with encoding, storing, and retrieval of information become less effective with normal aging. Those age-related changes can be observed in working memory tasks that require high demands on mental manipulation of information (i.e., the information exceeds the normal span of five to nine items) or during delayed recall (Bopp & Verhaeghen, 2005; Constantinidou, 1998).

In addition to age, education is positively associated with performance on supraspan verbal learning tasks (Constantinidou & Baker, 2002; Vakil & Blachstein, 1997). The study by Lara et al. (2021) showed that both age and education influence test performance on tests of episodic memory. Also, Giogkaraki et al. (2013) concluded that years of education and cognitive engagement can moderate the consequences of aging through the cognitive reserve processes. Specifically, as Giogkaraki et al (2013) found, cognitive reserve moderated the effects of age on verbal episodic memory but did not obliterate its effects.

The exact predictive contribution of age and education has also been under investigation. Brandt and Benedict (2001) examined HVLT-R performance in a sample of 1,179 individuals with no neurological or psychiatric disorders with a wide age and education range. Age had the biggest effect on every variable of HVLT-R, accounting for 19% of the variance on total recall whereas education and sex accounted for 5% and 1.7% respectively.

Friedman et al. (2002) reported that age, gender, and education accounted for moderate amounts of variance in HVLT-R performance in a sample of African American individuals between 60-84 years. More recently, Duff

(2016) investigated the effects of age, education, and gender on HVLT-R in 290 individuals over the age of 65. Regression analysis showed that age has a significant effect on all HVLT-R scores, whereas gender and education contributed to seven of nine HVLT-R indices (not including Recognition Hits and Recognition Discrimination Index). Additionally, the study of Ryan et al (2021) aimed to establish normative performance data for the HVLT-R in community-dwelling older individuals, considering ethno-racial group, age, gender, and education. Results revealed demographic variations in HVLT-R performance, with gender, age, and education influencing total recall, and delayed recall. This comprehensive ethno-racial, age, gender, and education-stratified normative study provides valuable reference standards for assessing cognition in community-dwelling older individuals in Australia and the U.S.

The Present Study

The assessment of verbal learning and verbal episodic memory are at the core of neuropsychological assessment. While tests like the HVLT-R can provide important information on memory processes, socioeconomic and cultural factors should be taken into consideration when developing local norms (Duff, 2016; Lara et al.,2021) to avoid erroneous test results and misdiagnoses (Friedman et al., 2002; Nyberg & Pudas, 2019). The purpose of the present study was threefold. Firs, we investigated the interform equivalence of the first three forms of the G-HVLT-R. Second, we examined the effects of sex, age and education in a large Greek-speaking cohort in Cyprus. It was hypothesized that age, sex, and education will have impact on memory and specifically on working memory tasks like the G-HVLT-R. Finally, we examined the concurrent validity of the G-HVLT-R while with other established memory measures (e.g., paragraph recall tasks).

Method

Participants

The Neurocognitive Study for the Aging (NEUROAGE) was established in 2009 as the first longitudinal project on cognitive aging in Cyprus (clinicaltrials.gov Identifier: NCT01481246). NEUROAGE aims to explore modifiable and unmodifiable factors that affect cognitive and psychological health in Greek Cypriot adults. Participants are assessed at baseline and are followed up every 2 years.

One thousand two hundred and seventy-four Greek Cypriot males and females were recruited from the NEUROAGE project who completed baseline evaluations. The final sample consisted of 1055 individuals. Nineteen individuals had missing demographic data and 200 they not meet the inclusion criteria; thus, they were excluded from the analyses. The inclusion criteria for all participants were the following: a) native Greek speakers b) good general cognitive health with Mini-Mental State Examination (MMSE) score of 24 or higher. In the final sample, 418 (39.6%) were males and 637 (60.4%) were females. The mean age was 63.26 (SD=16.62, Age Range=18-80) and the mean years of education was 10.87 (SD=4.67). Regarding age, 424 were younger than 65 years old and the 631 were 65 years old or older. Figure 1 is the STROBE diagram.

Measures

Participants were administered a battery of neurocognitive and psychological tests, translated and adapted into Greek and previously used in other research studies (Chadjikyprianou et al., 2021; Constantinidou et al., 2014; Giogkaraki et al., 2013) to assess aspects of cognitive and psychological functioning. The following tests were part of this battery.

General Cognitive Screening. Mini Mental State Examination (MMSE; Greek version by Fountoulakis et al., 2000). The Mini-Mental State Examination (MMSE) consists of 11 questions commonly used by physicians and other health care professionals to detect cognitive impairment.

Memory Tests. The Greek version of the Hopkins Verbal Learning Test-Revised (G-HVLT-R; Benedict et al., 1998; adapted in Greek by Constantinidou upon permission from the publisher); total score (sum of the three learning trials) and delayed recall score. Each participant, drawn from the initial healthy sample, was assigned to one of the three HVLT forms using a randomization procedure. This method was implemented to ensure an unbiased distribution of participants across the various test forms, thereby minimizing the potential for systematic biases or confounding variables associated with specific forms. Random assignment enhances the internal validity of our study, allowing for a more robust examination of the cognitive outcomes associated with each HVLT form. This rigorous approach contributes to the reliability and generalizability of our findings, reinforcing the validity of our comparisons and conclusions drawn from the administered test forms.

The Greek version development of Forms 1, 2, 3, and 4 of the HVLT adhered to the publisher's requirements and was pre-agreed with Psychological Assessment Resources (PAR). Specifically, a forward translation of items and instructions was followed by a blind backward translation, which received approval from the publisher. It is noteworthy that, upon careful examination of the translated items in each form, it was determined that certain items needed to be substituted for the following reasons: a) absence or semantic unfamiliarity of the item in the Greek-Cypriot context (e.g., the bird "robin," the drink "bourbon," the coin "dime"), b) direct translation resulting in more than one word (e.g., the tool "wrench"). These substitutions maintain the semantic category of the initial item and the level of familiarity. The overall number of target item substitutions per list was minimal (1 item for Form 1, 3 items for Form 2, 2 items for Form 4) and received approval from the publisher.

Greek version of the Logical Memory adapted from the Wechsler Memory Scale-Revised (Wechsler, 2008); Immediate and delayed recall of a short story material consisting of 25 items/pieces of information (Constantinidou & Ioannou, 2008). During the Logical Memory tasks, the examiner reads a story and immediately afterwards asks the individual to recall details from the story. The process is repeated with a second story. Delayed recall for each of the two stories is administered 30 minutes later.

Procedure

The study recruited Greek Cypriot volunteers from community settings in compliance with the Helsinki Declaration and following approval by the National Bioethics Committee (ΕΕΒΚ/ΕΠ/2008/26). Participants were approached through various channels, including social media platforms such as Facebook, word of mouth, and campaigns conducted through radio, television, and other media as part of the Neuroage project. Potential participants were informed about the nature of the study, emphasizing that it is a longitudinal study with follow-ups every two years. They were provided with clear instructions on what the study entailed and what their participation would involve. After each assessment, participants received a report detailing their results along with suggestions for maintaining or improving their cognitive and mental health. The approximate duration of the neuropsychological assessment was two hours. Participants were given the option to take breaks during the assessment or to split the assessment into two separate sessions for their convenience. They were contacted biennially to confirm their willingness to continue participating in the study.

Results

Statistical Analyses

The data was analyzed in SPSS Version 29.0 (SPSS Inc.,Chicago, IL, USA). First, exploratory data analysis was conducted to examine distributions of scores for the G-HVLT-R and to identify cases with missing or inconsistent demographic data (see Figure 1). Descriptive statistics were performed to identify means and standard deviations for age and years of education for the participants assigned to each of the three forms (see Table 1.). As can be seen on Table 1, there are differences in the mean age and years of education, especially with the group that received form 3 which involves younger individuals compared to the other two groups. Therefore, to ensure comparability between the three groups and control for potential confounding factors, we proceeded with a matching process including only individuals above 40 years of age. For each participant who received Form 2, we identified matched cases who received Forms 1 and 3 based on age and education. More specifically, we matched participants who were of the same age, allowing a maximum difference of one year, and had the same level of education, allowing a maximum difference of one year of formal education (see Table 2). After the matching process, no statistically significant differences (p >.05) in age and education were observed among the three different groups. Then, Multivariate Analysis of Variance (ANOVA) was performed with the G-HVLT-Form used as an independent variable and total score and delayed recall as dependent variables. Afterwards, Multivariate Analysis of Covariance (MANCOVA) with age and education years as covariates was performed to assess the inter-form equivalence between the 3 forms on the total score and on the delayed recall score. Correlation analysis was performed between the two HVLT scores (total score and delayed recall score) and the demographic variables. Hierarchical regression was performed where we entered each demographic variable sequentially, beginning with the one with the highest Pearson r and then adding the second highest and the third highest. The HVLT-total score and delayed recall were entered into the regression models as dependent variables. Lastly, correlation analysis was performed between the two G-HVLT-R scores (total score and delayed recall score) and the Logical Memory immediate and delayed recall.

Figure 1. *STROBE flow diagram*

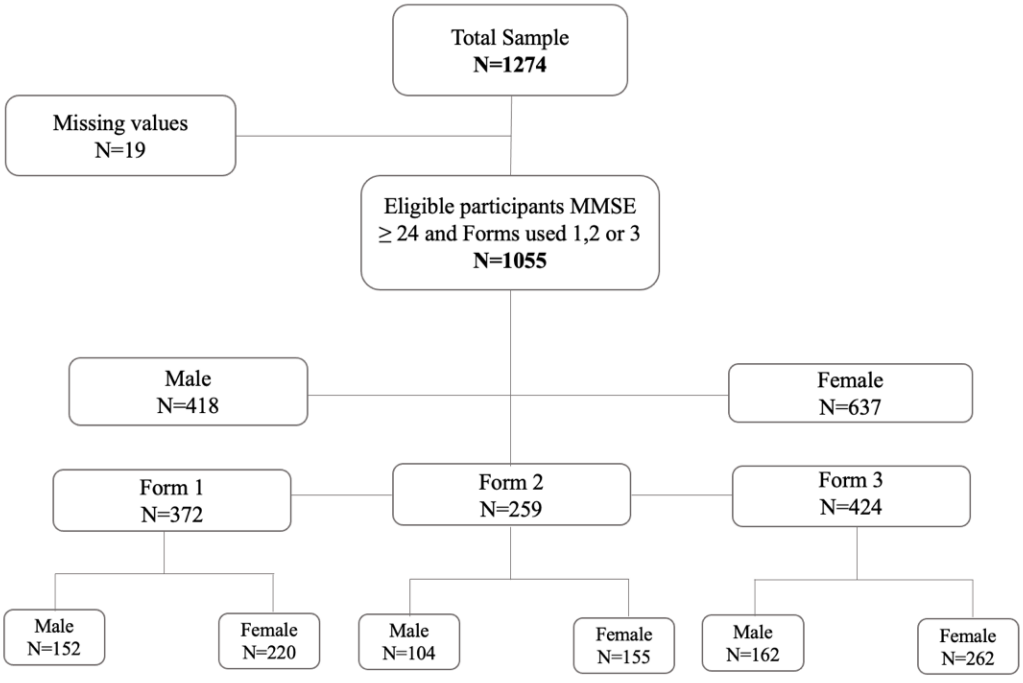

Table 1. *Descriptives of Demographic Characteristics Based on the G-HVLT-R Test Form Administered*

	Form 1			Form 2			Form 3		
	N(%)	***M***	***(SD)***	***N(%)***	***M***	***(SD)***	***N(%)***	***M***	***(SD)***
Sex									
Males	152 (40.9)			104 (40.2)			162 (38.2)		
Females	220 (59.1)			155 (59.8)			262 (61.8)		
Total	372			259			424		
Age		71.7	4.3		67.8	10		53	19.9
Education years		9	7.7		11.9	4.7		11.8	4.4

Table 2. *Descriptives of Demographic Characteristics in Three Different Groups were Administered the Three Different Forms after Excluding Individuals <40 Years of Age and Perform Match Case Control*

	Form 1			Form 2			Form 3		
	N(%)	***M***	***(SD)***	***N(%)***	***M***	***(SD)***	***N(%)***	***M***	***(SD)***
Sex									
Males	78 (41.9)			79 (36.7)			61 (38.1)		
Females	108 (58.1)			136 (63.3)			99 (61.9)		
Total	186			215			160		
Age		69.8	6.9		68.7	8.6		67.6	9.0
Education years		10.5	4.2		11.1	4.3		10.5	4.3

Inter-form equivalence

Inter-form equivalence was tested with MANOVA first. The MANOVA analysis results revealed a statistically significant effect of Form Wilk's Lamda=.964, F (4,1112)=5.14, p<.001, partial eta square=.018, on both the total score (F(2, 55) =7.93, p < .001, η^2_p = .028) and delayed recall (F(2, 55) = 9.15, p < .001, η^2_p= .032). Specifically, significant mean differences were observed when utilizing form 1 compared to the other two forms. This indicates that the choice of test form had a discernible impact on participants' overall performance and delayed recall scores. Afterwards, MANCOVA was performed to investigate inter-form equivalence, with age and education as covariates. MANCOVA resulted in a statistically significant effect on Form, Wilk's Lamda=.973, F (4,1108) =3.86, p<.01, partial eta square=.014. Age and education had statistically significant main effects, Wilk's Lamda=.817, F (2,554) =62.09, p<.001, partial eta square=.183 and Wilk's Lamda=.959, F (2,554) =11.79, p<.001, partial eta square=.041 on HVLT performance. More specifically, the analysis of Between-Subjects Effects revealed a statistically significant difference for both total score (p=.005) and delayed recall trial (p=.001). Pairwise comparisons showed that there were statistically significant differences between forms 1 and 2 (p<.05) for the total score, and 1 and 3 (p<.01) for both HVLT outcomes; there was no statistically significant difference between forms and 2 and 3 (p>.05) when controlling for age and education. Form 3 yielded the highest performance, while Form 1 exhibited the lowest performance.

Demographic variables and test performance

We conducted correlation analyses to explore the associations between the dependent variables, namely total score and delayed recall, and demographic variables including sex, age, and years of education. The outcomes of these correlation analyses are presented in Table 3. The most prominent relationship identified was the significant negative correlation between age and the dependent variables. This suggests that as individuals age, performance on the HVLT tends to decline. Additionally, there were moderate positive correlations observed for years of education, indicating that formal education is associated with improved performance on the HVLT. Furthermore, sex exhibited weak correlations, with females displaying a slightly superior performance compared to males.

Table 3. *Correlation analyses between dependent variables and sociodemographic characteristics*

	Sex	**Education Years**	**Age**	**Total Score**
Education Years	-.072*			
Age	-.110**	-.464**		
Total Score	.134**	.458**	-.621**	
Delayed Recall	.149**	.433**	-.599**	.835**

*Note.*Correlation is significant at the .05 level **Correlation is significant at the 0.001 level

Hierarchical multiple regression analyses were performed to explore the effects of demographic variables and the effect of form on the dependent variables (total score and delayed recall). Histograms and normal P–P plots indicated normally distributed residuals for the two dependent variables. A plot of the regression standardized residual against the standardized predicted value produced a random array of dots evenly dispersed around zero, showing that the assumption of homoscedasticity and linearity was met. Finally, the predictor variables did not show multicollinearity (all VIFs < 2), and the Durbin–Watson test statistic indicated that the assumption of independent errors was met. Table 4 displays the regression results, indicating the extent to which the form and individual's demographics such us age, education, and sex can explain the total score and and Table 4 for the delayed recall score on G-HVLT-R. More than 40% of the variance is explained, and all three predictors are significant in both models, with age having the strongest negative coefficient. The same procedure was repeated by excluding individuals assigned to Form 1 (which appeared to be more challenging), and the results of the analyses remained unchanged. Additionally, we conducted the same procedure by excluding Form 3 individuals, which appeared to be the easiest, and the results remained consistent.

Table 4. *Regression Analysis of Demographic Characteristics on G-HVLT-R Total Score and Delayed Recall*

	Total Score						
	Unstandardized B	***SE***	**Standardized B**	***t***	***p***	**Unique Variance**	**Total Variance**
Age	-.24	.009	-.62	-25.68	0	38.70%	
Education	.29	.037	.21	8.1	<.001	3.60%	43.10%
Sex	1.24	.31	.09	3.9	<.001	.80%	

	Delayed Recall						
	Unstandardized B	***SE***	**Standardized B**	***t***	***p***	**Unique Variance**	**Total Variance**
Age	-.12	.005	-.59	-24.21	<.001	35.90%	
Education	.14	.02	.20	7.3	<.001	3.10%	40.10%
Sex	.76	.17	.11	4.55	<.001	1.10%	

Concurrent validity

Correlation analysis was conducted to explore the association between G-HVLT-R and story recall performance. The results of this analysis are presented in Table 5 and show strong concurrent validity of the HVLT scores with the two delayed recall scores from the Logical Memory Stories.

Table 5. *Correlation analyses between performance on G-HVLT-R and delayed recall of Logical Memory Stories*

	HVLT Total Score	**HVLT Delayed Recall**	**Delayed Recall-Story 1**
HVLT Delayed Recall	**.84		
Delayed Recall-Story 1	**.70	**.71	
Delayed Recall-Story 2	**.70	**.70	**.80

**Note. **Correlation is significant at the .01 level*

Discussion

The Neurocognitive Study for the Aging is the first longitudinal project on cognitive aging in Cyprus. The project offers a unique opportunity to study different factors, including demographic and biological, factors contributing to brain health. Participants in the current study were neurologically typical community dwellers living in Cyprus, a small Mediterranean country with unique geopolitical, social- cultural, and genetic characteristics. The present study investigated the effects of sex, education, and age on different scores of G-HVTL-R. This study is the first since the Brandt and Benedict (2001) study, examining demographic factors that affect memory performance across the adult lifespan (18-73+) and with a wide range of educational experiences ranging from 1–22 years.

One of the benefits of the HVLT-R over other commonly used verbal learning tests is the ability to conduct repeated assessments by administering different test forms. In the present study, performance differences were identified among Forms 1, 2, and 3, with better performance on form 3. Precisely, Form 1 appeared more difficult than the other two. After conducting additional analyses (match case-control), the differences between the forms persisted. The observed discrepancy in difficulty levels among the three forms, with Form 1 appearing more challenging than Forms 2 and 3, prompts us to consider several potential explanations. First, it is plausible that Form 1 comprised words with a higher degree of complexity due to less familiar vocabulary to Greek-Cypriot participants. This variation in vocabulary intricacy may have contributed to the perceived difficulty. In light of these considerations, further analysis and exploration will be conducted in subsequent studies to pinpoint the specific factors contributing to the perceived variations in difficulty and to enhance the clarity of our findings.

In general, the various forms of the HVLT have research and clinical utility as they allow for repeated testing. The multiple forms reduce the effects of practice often observed with the same form. The present results provide support to the need for normative data for each of the G-HVLT-R test forms since the three forms have different difficulty levels for healthy participants. In the present study, we conducted additional analyses, incorporating

matching procedures and covariates, to mitigate potential confounding variables that could influence performance in each form, including factors like age and education. This rigorous approach enhances the validity of our findings by addressing and controlling for potential sources of variability, ensuring a more accurate assessment of the impact of different HVLT forms on cognitive performance.

The results of the hierarchical regression analysis underscore the influence of age, education, and sex on verbal learning and delayed recall performance as measured by the G-HVLT-R. Specifically, age emerged as the most robust predictor across total and delayed recall scores of the G-HVLT-R. Increased age was associated with decreased memory performance, confirming the expected link between age and memory on verbal learning. Additionally, education played a significant role in predicting verbal learning performance. Individuals with fewer years of education may have faced difficulties in acquiring and retaining a larger pool of words across the three learning trials, ultimately impacting their memory recall.

Furthermore, our study underscores the predictive value of sex in test performance, although its impact was found to be less pronounced than the other two characteristics. Specifically, females exhibited better performance on the HVLT compared to males. This suggests that while sex does play a role in G-HVLT-R performance, its contribution is not as substantial as that of age and education. Overall, these findings provide valuable insights into the interaction of age, education, and sex in influencing working and episodic memory as measured by verbal learning and delayed recall outcomes on the G-HVLT-R.

There is a growing debate on the exact contribution of education and sex to cognitive aging, particularly in memory. Our findings align with those of Brandt and Benedict (2001), who, in a similar design, also reported that age was the strongest predictor of HVLT performance, followed by education and sex. In contrast, Vanderploeg and colleagues (2000) found that age and gender had a significant effect on HVLT-R performance, whereas education did not. This discrepancy in findings might be attributed to methodological differences. Vanderploeg and colleagues (2000) examined only participants over 65 years of age, and most individuals were considered well-educated, unlike the considerable variability in age and education characterizing the NEUROAGE sample. Of particular interest is the fact that while education affects performance at baseline in the present cohort, longitudinal analyses within the same cohort suggest that years of education do not influence the patterns of cognitive change, as measured by memory tests in the same cohort (Chadjikyrpianou et al., 2021).

The current study contributes to the growing field of cross-cultural neuropsychology, aiming to adapt and validate neuropsychological tests across different languages and cultures. In line with our findings, Friedman and colleagues (2002) reported that age, education, and sex had a moderate to large effect on HVLT-R performance in African American participants. Similarly, Hester, Kinsella, Ong, and Turner (2004) found that age and education influenced HVLT-R performance in an Australian older age sample, but sex did not. Consequently, our study adds to this body of literature with a large sample of individuals (N=1055) across a wide age and education span.

The Greek version of the HVLT-R demonstrated good concurrent validity. Both the total score and delayed recall scores from G-HVLT-R were highly correlated with Greek version of the immediate and delayed story recall from the Wechsler Memory Scale-Revised). Our findings with the Greek cohort are consistent with English-speaking participants, indicating that HVLT-R performance scores are highly comparable with scores from Logical Memory Tests (A and B) (Shapiro et al., 1999). The strong association between the two memory tests suggests that to some extent, these two tests assess similar but not the exact same mechanisms of verbal episodic memory.

Conclusion

Our findings confirmed that while age is the strongest predictor of verbal learning and episodic memory performance, education and sex are also significant predictors of test performance. The Greek Cypriot cohort

performed similarly to the original US-based sample, but with a few differences (Brandt and Benedict, 2001; Friedman et al., 2002; Vanderploeg et al., 2000). The HVLT-R English manual suggests that since education and sex accounted for too little variance, it was unnecessary to develop separate norm corrections for these demographic variables. Our findings support the need for different norms for age, education, and sex, especially for those with lower education and for older age groups. Also, while our findings suggest that the contribution of sex to G-HVLT-R performance is not as substantial as age and education, we acknowledge the importance of considering all relevant factors for a comprehensive interpretation of results. Even though the impact of sex may be relatively weaker, its inclusion in normative data can contribute to a more precise understanding of individual performance variations. Thus, the present findings support the need for future studies with larger sample sizes to generate accurate normative data for age, education, and sex. The provision of different groups according to demographics ensures test sensitivity for individuals with very mild symptoms and reduces false positives by improving test specificity (Duff, 2016, Vakil, 2012. The high prevalence of cognitive deficits in the context not only of a growing elderly population but for individuals with many other conditions that implicate cognitive deficits highlights the need for demographically appropriate norms for neuropsychological instruments.

The current study significantly advances the field of cross-cultural neuropsychology by investigating the intricate dynamics of age, education, and sex on memory performance within a Greek Cypriot cohort across the adult lifespan. The study's unique focus on a Greek Cypriot population enriches the cross-cultural perspective by exploring how cultural and linguistic aspects may interact with demographic factors in shaping memory outcomes in this Eastern Mediterranean Island cohort. This exploration not only adds valuable insights to the field of cross-cultural neuropsychology but also contributes to a more comprehensive understanding of how memory functions across diverse cultural contexts. Establishing norms that account for these demographic characteristics is not only essential for accurate neuropsychological assessments but also advances cross-cultural knowledge, making the study a noteworthy addition to the growing body of cross-cultural neuropsychological research.

Implications, limitations, and future research

The present study is the first investigation following Brandt and Benedict's (2001) research to explore the impact of demographic characteristics on HVLT-R performance across the adult lifespan, encompassing a wide range of education, ranging from 1 to 22 years. Additionally, we compared performance on the three forms of G-HVLT-R to determine form equivalency and examined the tool's concurrent validity. Our findings indicate that the G-HVLT-R is a valid tool that can be implemented in the assessment of verbal episodic memory. Forms 2 & 3 exhibit similar difficulty and could be implemented when anticipating repeated assessments in short time intervals. Our results underscore the importance of validating tests in different languages/cultures, taking into consideration significant demographic variables such as age, education, and sex. One limitation of the present study is the cross-sectional nature of the findings, which may have contributed to response variability. Participants in the present study are members of the Neuroage project, a longitudinal study on aging. Recruitment takes place at various social centers and in the community, recruiting volunteers from different socio-economic backgrounds. While great care is given to reducing sampling bias, the possibility of sampling bias associated with participant motivation cannot be excluded. Previous studies in Greek samples have indicated that individuals willing to participate in neuropsychological examinations may exhibit heightened motivation and curiosity, potentially influencing the generalizability of findings to the broader population (Chadjikyprianou et al.,2021). Finally, representation of the younger cohort to forms 1 & 2 was limited.

Future research should investigate the equivalency of additional forms of the test. While the current study focused on healthy individuals, future studies should expand to include individuals with lower MMSE scores to capture the full spectrum of memory abilities and discriminate between healthy and pathological performance

on this test. Furthermore, the results of the study, in addition to guiding neuropsychological assessment for disease detection, can also inform clinical intervention efforts aiming to improve cognitive performance in healthy aging. For instance, research with the Categorization Program (CP), an intensive neurocognitive rehabilitation program, indicates significant improvement after a ten-week treatment period in healthy older adults experiencing neurocognitive changes associated with the normal aging process (Constantinidou, 2019). Future studies may explore whether these benefits counteract the effects of low education on memory functioning and the impact of older age, as measured by the HVLT-R.

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Conflict of Interest

The authors have no commercial or financial relationships that could be construed as a potential conflict of interest.

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Data Availability Statement

The datasets generated and/or analyzed during the current study are not publicly available, but certain data could be made available from the corresponding author upon reasonable request.

Ethics Statement

The studies involving human participants were reviewed and approved by National Bioethics Committee (ΕΕΒΚ/ΕΠ/2008/26). The patients/participants provided their written informed consent to participate in this study.

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ΕΜΠΕΙΡΙΚΗ ΕΡΓΑΣΙΑ | RESEARCH PAPER

Οι επιπτώσεις της ηλικίας, του φύλου και της εκπαίδευσης στις επιδόσεις του HVLT-R σε όλο το φάσμα της ενήλικης ζωής: Δεδομένα από την κοόρτη NEUROAGE

Φλώρα ΝΙΚΟΛΑΟΥ[1,2], Μιχάλης ΜΙΧΑΗΛΙΔΗΣ[1] , Τζουλιάνα ΠΡΟΚΟΠΙΟΥ[2] , Γιώργος ΜΕΤΑΞΑΣ[2], Φώφη ΚΩΝΣΤΑΝΤΙΝΙΔΟΥ[1,2]

[1] Τμήμα Ψυχολογίας, Πανεπιστήμιο Κύπρου
[2] Κέντρο Εφαρμοσμένης Νευροεπιστήμης, Πανεπιστήμιο Κύπρου

ΛΕΞΕΙΣ-ΚΛΕΙΔΙΑ

Μνήμη
Ηλικία
Φύλο
Εκπαίδευση
Αξιολόγηση

ΣΤΟΙΧΕΙΑ ΕΠΙΚΟΙΝΩΝΙΑΣ

Φλώρα Νικολάου
Πανεπιστήμιο Κύπρου
Καλλιπόλεως 75, Νέα Πτέρυγα, 1678, Λευκωσία
Nikolaou.flora@ucy.ac.cy

ΠΕΡΙΛΗΨΗ

Η μελέτη επιδιώκει να διερευνήσει την επίδραση της ηλικίας, της εκπαίδευσης και του φύλου στη μνήμη μιας ποικίλης ομάδας συμμετεχόντων που καλύπτει το ενήλικο εύρος, χρησιμοποιώντας το G-HVLT-R. Συμμετείχαν 1,055 Έλληνοκύπριοι ενήλικες, άνδρες και γυναίκες, ηλικίας 18 έως 80 ετών, από τη διαχρονική μελέτη NEUROAGE. Οι συμμετέχοντες υποβλήθηκαν σε μια σειρά από νευροψυχολογικά τεστ για την αξιολόγηση της γνωστικής και ψυχολογικής λειτουργίας, συμπεριλαμβανομένου του G-HVLT-R για την μέτρηση της συνολικής μάθησης και καθυστερημένης ανάκλησης, καθώς και των έργων Λογικής Μνήμης για την καθυστερημένη ανάκληση κατά την ανάκληση ιστορίας. Τα αποτελέσματα απέδειξαν διαφορές στην επίδοση μεταξύ της Φόρμας 1 και 2 και μεταξύ της Φόρμας 1 και 3 του G-HVLT-R. Οι αναλύσεις παλινδρόμησης αποκάλυψαν ότι η ηλικία είχε τους υψηλότερους συντελεστές, ακολουθούμενη από την εκπαίδευση και το φύλο. Ιδιαίτερα σημαντικό είναι το γεγονός ότι το G-HVLT-R έδειξε ισχυρή ταυτόχρονη εγκυρότητα, όπως αποδεικνύεται από υψηλούς συντελεστές συσχέτισης με τα έργα καθυστερημένης ανάκλησης Λογικής Μνήμης. Τα ευρήματα υπογραμμίζουν ότι, ενώ η ηλικία αποτελεί τον κυρίαρχο παράγοντα πρόβλεψης της απόδοσης, η εκπαίδευση και το φύλο σχετίζονται με την απόδοση σε όλη τη διάρκεια της ζωής. Επομένως, η δημιουργία νορμών που λαμβάνουν υπόψη τα δημογραφικά χαρακτηριστικά είναι ζωτικής σημασίας για την ακριβή αξιολόγηση νευροψυχολογικών παραμέτρων, ιδίως για άτομα με χαμηλή εκπαίδευση και σε μεγαλύτερες ηλικιακές ομάδες. Τέτοιες πληροφορίες προάγουν την ακριβή ανίχνευση των συνθηκών σε διάφορους πληθυσμούς και βοηθούν στον εντοπισμό ατόμων με ανάγκες για συγκεκριμένες θεραπευτικές παρεμβάσεις.

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