NEUROPSYCHOLOGICAL TEST ADAPTATION INTO GREEK: A COMPARATIVE STUDY OF COGNITIVE-LINGUISTIC PERFORMANCE IN OLDER ADULTS

By Diane Michelle Unkrich

This study investigated the effects of native language, culture, and aging on verbal and non-verbal memory performance in 26 native Greek and 32 native English speakers, ages 55 years and older, by comparing participants’ performance on a neuropsychological test battery. Results revealed English speakers performed significantly better on auditory span tasks and completed tasks requiring mental flexibility and fast processing of verbal information at a significantly faster rate than Greek speakers. English speakers also learned a significantly greater number of words on a verbal learning task. These results support the hypothesis that linguistic structure may impact short-term memory performance. Significant differences observed on verbal memory tasks requiring in-depth processing and on one non-verbal measure indicate the influence of differing cultural experiences on test performance. Age-related changes in cognitive performance were observed between participants ages 55-70 and 71+ years in both language groups on several measures of short-term memory.
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DEDICATION

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CHAPTER I  

Introduction  

_Cognitive-Linguistic Assessment_  

Cognitive-linguistic assessment utilizes neuropsychological measures to examine the relationship between brain function and behavior in a variety of cognitive domains. Major cognitive-linguistic functions evaluated by neuropsychological testing include attention, memory, learning, language, visuospatial abilities, perceptual motor abilities, executive function, reasoning, and problem-solving. Evaluation in each of these domains determines if cognitive performance is within normal limits or indicates underlying brain pathology (Sohlberg & Mateer, 1989).

Cognitive abilities may be assessed using tests for a specific function(s) or through a comprehensive neuropsychological battery (Lezak, 1995). Comprehensive neuropsychological batteries typically include norm-referenced, standardized assessment measures for evaluating most of the cognitive domains. A complete cognitive-linguistic or neuropsychological assessment results in a diagnosis indicating the degree of impairment, generates recommendations for rehabilitation and treatment, and establishes a prognosis for recovery of cognitive functions (Sohlberg & Mateer, 1989).

A number of variables may impact neuropsychological test performance, including personal beliefs, prior learning experiences, age, culture, and native language (Ardila, 1995). Therefore, a neuropsychological assessment will also include a thorough review of the patient’s medical, social, developmental, educational, cultural, and linguistic history. Each of these variables may potentially bias results on standardized assessment measures, if test norms are not representative of the patient’s culture, native language, education and age group. As a result, accurate assessment requires standardized measures with normative data representative of the population being tested (Haynes & Pindzola, 2004; Rey, Feldman, Rivas-Vazquez, Levin & Benton, 1999).
During the past few decades, there has been a rapid increase in the cultural and linguistic diversity of the U.S. population. Current demographic trends also reflect increases in average life expectancy, resulting in population growth among older adults (La Rue, 1992). Consequently, two important considerations for professionals, who conduct evaluations of communication and cognitive disorders include 1) the impact of culture and native language on cognitive-linguistic functions and 2) age-associated changes in cognitive performance.

Culture, Language, and Cognition

Numerous studies have substantiated the influence of culture and linguistic structure on neuropsychological test performance (Cheng, Kemper, & Leung, 2000; Chincotta & Underwood, 1997; Ishikawa & Nobe, 1998; Kosmidis, Vlahou, Panagiotaki, & Kiosseoglou, 2004; Naveh-Benjamin & Ayres, 1986; Rosselli, et al., 2002). Culture is often broadly defined as the beliefs, behaviors, values, and social norms shared by a particular group of people (Wong, Strickland, Fletcher-Janzen, Ardila, & Reynolds, 2000). Culture encompasses everything we learn as members of a particular society, including linguistic expression, and cognitive and behavioral skills (Ostrosky-Solis, Ramirez, & Ardila, 2004).

Cognitive-linguistic abilities typically measured in neuropsychological testing are learned abilities. Learning opportunities vary widely across cultures and circumstances, and take place in the context of an individual’s ecological environment, which includes language, culture, education and social class (Ardila, 1995; Pérez-Arce, 1999; Ostrosky-Solís, et al., 2004; Rosselli & Ardila, 2003; Wong, et al., 2000). Ecological conditions, including natural and social environments, determine what is relevant in one culture versus another, and thereby influence learning patterns (Ardila, 1995; Kosmidis, et al., 2004). As a result, cultural experience shapes cognitive functions involving processing, categorizing, classifying and encoding of new information (Rosselli, et al., 2002; Wiig, Becker-Redding, & Semel, 1983).

Differences in linguistic structure occur across languages, and collectively with culture, influence performance on cognitive tasks. Cross-linguistic differences in syllable structure, phonological structure, and articulation rate have been shown to influence performance on cognitive tasks of verbal learning and memory (Naveh-Benjamin & Ayres, 1986). Additionally, research demonstrates that the orthographic structure of a language can impact lexical organization and categorization (Bates, Burani, D’Amico, & Barca, 2001; Rosselli, et al., 2002). Language-based differences in input mode for processing and encoding of verbal information,
whether phonological, contextual or visual-semantic, have also been shown to impact a variety of cognitive functions including verbal learning and memory (Tavassoli, 1999).

Due to the impact of linguistic structure and previous cultural experience, normative data established in one language or for one cultural group may generate inaccurate interpretations when applied to another group (Ardila, 1995; Miller & McCay, 1996). The demonstrated influences of culture and linguistic structure on cognitive processing indicate a need to adjust normative data on many frequently used neuropsychological measures.

**Age-Associated Changes in Cognitive Performance**

Age is an additional, important variable in cognitive-linguistic function. Demographic trends indicate that adults ages 65 years and over represent the fastest-growing population requiring neuropsychological assessment (Hebben & Milberg, 2002). Healthy older individuals experience neuroanatomical and neurochemical changes in the brain as a result of aging (Kemper, 1984). These changes in the structure and functioning of the central nervous system generate normal age-related changes in attention, memory, learning, language and executive functions. Neuroanatomical changes may also place older adults, defined in this study as individuals ages 55 years and above, at greater risk for brain pathologies such as stroke, dementia, Alzheimer’s disease, and other neurological diseases. As a result, neuropsychological testing must be capable of distinguishing cognitive changes consistent with normal aging versus cognitive impairments indicative of underlying brain pathologies (Hebben & Milberg, 2002).

One concern in the accurate assessment of cognitive and language abilities in older adults is the availability of age-appropriate normative data. As a result of neuroanatomical changes, older adults perform differently than younger adults on cognitive tasks, especially on measures of learning and memory. It is inappropriate to compare cognitive functions in older individuals to normative data based on younger adults. Therefore, establishing normative data for older adults is essential (LaRue, 1992).

As previously discussed, cultural and language experiences can influence neuropsychological performance. Therefore, neuropsychological assessment of older adults must not only distinguish normal aging versus cognitive impairment, but must also consider the impact of native language and culture on cognitive performance.
Despite the influence of demographic variables such as age, education, culture, and native language, many neuropsychological measures have traditionally relied on normative data obtained from a cross-section of the populations of the United States, Canada or other English-speaking countries (Hebben & Milberg, 2002; Lowenstein, Argüelles, T., Argüelles, S., & Linn-Fuentes, 1994; Stanczak, Stanczak, & Awadalla, 2001; Wolfe, 2000). Consequently, many widely used neuropsychological measures are available only in English, are based on Western European and American cultural norms, and do not provide normative data for culturally and linguistically diverse populations.

In response to the increasing population diversification in the United States and the growing need for culturally and linguistically appropriate assessment, psychologists and speech-language pathologists have adapted a number of neuropsychological measures from English into other languages over the past decade. Additionally, international investigations have been conducted to adapt neuropsychological assessments for use with culturally and linguistically diverse populations.

A cross-cultural approach to cognitive-linguistic assessment has yielded test adaptations for numerous languages and populations including Chinese, Chamorro, Cree, Croatian, Czech, Danish, Dutch, Finnish, French, German, Hindi, Icelandic, Italian, Japanese, Malay, Spanish, Vietnamese, and Yoruba (Wolfe, 2000). To date, few studies have addressed neuropsychological test adaptation from English into the Greek language. Likewise, few studies have generated normative data specifically for measuring cognitive-linguistic performance in older Greek speakers.

At a basic structural level, Greek and English vary both in orthography and in grapheme to phoneme correspondence. In Greek, letters of the alphabet and numerical digits have a polysyllabic pronunciation (in contrast to primarily monosyllables in English) and the majority of words are polysyllabic, or contain two or more syllables. These cross-linguistic differences in syllable structure, word length, and articulation rate have been shown to affect basic neuropsychological tasks requiring speed of processing and encoding. Prior cross-cultural, cross-linguistic research has indicated that structural linguistic differences in orthography, pronunciation rate and syllable structure impact performance on verbal learning and memory tasks (Ellis and Hennelly, 1980; Ishikawa & Nobe, 1998; Naveh-Benjamin and Ayres 1986);
whereas non-verbal tasks, which are mediated by a different subsystem of memory and different cortical locations (portions of the right versus left hemisphere of the brain), remain ‘culture-invariant’ (Hedden, et al., 2002). As a result, differences are expected between Greek and English speakers on verbal memory tasks due to differences in linguistic structure, but not on non-verbal memory tasks.

The present study examined neuropsychological performance in Greek and English speakers by comparing performance on standard measures of verbal learning and memory. This study was the second part of a series of comparative studies involving Greek and English speakers. In an initial phase of the project, Dr. Constantinidou, bilingual speech-language pathologist, and a team of seven speech-language pathologists in Cyprus translated a battery of cognitive-linguistic measures into the Greek language. The battery was implemented in a population of young adult Greek speakers and English speakers, ages 18-50 years. Comparisons of results between the two languages revealed that native language can affect aspects of cognitive-linguistic functions, specifically verbal learning and memory. No significant differences were observed between the two language groups on non-verbal tasks.

**Significance of the Problem**

To date, neuropsychological test adaptation into the Greek language has been limited. Likewise, research using norm-referenced neuropsychological test adaptation scores to compare the Greek and English languages and the impact of each of these languages on cognition has been limited. To complete evaluations of the cognitive and linguistic function of Greek speakers, speech-language pathologists in Cyprus need normative data and assessment measures standardized on the Greek-Cypriot population. Clinicians working specifically with older adults need normative data regarding neuropsychological performance for the older Greek-Cypriot adult population.

Thus the present study utilized a neuropsychological test battery adapted into the Greek language to collect data from older adult Greek speakers, ages 55 years and above, from the island of Cyprus on measures of attention, memory, learning, word fluency, and paragraph recall. The assessment battery was comprised of measures typically used to evaluate adult patients with cognitive and language disorders related to neurological problems including stroke, head injury, Alzheimer’s disease, dementia, and other disorders. The present study additionally utilized norm-referenced neuropsychological test scores from older adult Greek and English speakers for cross-
cultural, cross-linguistic comparisons to determine if differences in linguistic structure impact verbal learning and non-verbal memory abilities.

Statement of Purpose

The purpose of the present study was to obtain data on measures of neuropsychological functions from healthy, older Cypriot Greek speakers and older U.S. English speakers, ages 55 years and above, to compare the effects of native language and aging on the cognitive aspects of verbal learning and memory. Additionally, this study obtained preliminary normative data on the neuropsychological performance of older Greek-Cypriot adults, ages 55 and above.

Research hypotheses

1. There will be a difference in performance between Greek-and English-speaking participants on tasks that require fast processing of linguistic information as a function of the polysyllabic structure of the Greek language.

2. Greek Cypriot subjects will recall fewer digits on the auditory span tasks than the English speaking participants.

3. English-speaking participants will complete tasks that require mental flexibility and incorporate verbal language at a significantly faster pace compared to Greek-speaking participants.

4. There will be no difference in performance on verbal tasks that incorporate in-depth processing of information between English-speaking and Greek Cypriot participants.

5. There will be no difference between the English- and Greek-speaking participants on non-verbal cognitive tests.

6. The two groups will use similar strategies to learn and remember new information.
CHAPTER II

Review of the Literature

Obtaining accurate neuropsychological assessment of culturally and linguistically diverse individuals requires knowledge of how culture and language impact cognitive-linguistic functions. Research indicates that the internal components and structure of a language influence how information is processed and encoded, thereby affecting learning and memory.

The following review of the literature focuses on how linguistic structure, culture, and previous experience impact certain aspects of cognitive functions, namely verbal learning and memory. The review begins with a description of attention, a prerequisite to learning and memory, and descriptions of the prominent models of memory. Cross-cultural and cross-linguistic studies related to the effects of native language and culture on verbal learning and memory are presented and discussed. Lastly, research related to age-associated memory changes in older adults is reviewed, this variable being a characteristic of the subjects in this study.

Attention

Attention is an active process, precipitated by a state of arousal or alertness. It involves the ability to focus on and perceive sensory input. Attention is a prerequisite to many cognitive tasks and cannot be easily separated from other cognitive functions. Sohlberg and Mateer (1987) define attention as ‘the capacity to focus on particular stimuli over time and to manipulate flexibly the information’. Collectively, level of arousal and perception influence the processing of incoming information and the encoding of this information for later retrieval. The ability to attend to and respond to stimuli is foundational for higher cognitive processes, including verbal learning and memory.

Memory

Memory is a complex cognitive function involving learning, retaining and recalling information from an event or experience. Memory entails encoding, storing, and retrieving perceptually processed verbal and non-verbal sensory input. Several models have been developed to define the stages of storage or processing levels of memory. The classical model and the information processing model are the most frequently cited models of memory.
Classical Model of Memory

The classical model of memory divides memory into three stages: short-term memory, working memory, and long-term memory.

Short-term memory

Short-term memory is a temporary, limited capacity store characterized by rapid input and retrieval (Baddeley, 1986). Initially, incoming sensory information undergoes perceptual processing and is held briefly in a sensory store. Two sensory stores involved in short-term memory are the visual (iconic) and auditory (echoic) stores (Parenté & DiCesare, 1991). The overall function of short-term memory is to briefly retain perceptually encoded information for processing by working memory.

The capacity of short-term memory, as discussed by Miller (1956; reprint 1994), is limited and does not exceed seven plus or minus two chunks of information. Tests of immediate or short-term memory include the forward condition of digit and spatial span tasks. Digit span forward tasks involve immediate repetition of a series of numbers and offer clinical information regarding auditory processing. Spatial span forward memory tests assess non-verbal memory through interaction with a series of randomly positioned blocks.

Working memory

Baddeley and Hitch (1974) expanded the unitary concept of short-term memory and developed a multi-component model of working memory. Working memory is a set of processes that permit the temporary holding and manipulation of information during cognitive tasks such as learning, reasoning, and comprehension. There are three components of working memory: the central executive, the phonological loop, and the visuo-spatial sketch pad.

The central executive is a supervisory, attention-controlling system, which coordinates activity within working memory and retrieves information from long-term memory. The phonological loop and visuo-spatial sketch pad are termed ‘slave’ systems under the control of the central executive. The phonological loop stores verbal information and the visuospatial sketch pad stores visual and spatial material (Baddeley, 1992).

The phonological loop consists of two components, the phonological store and an articulatory control process. The phonological store holds verbatim acoustic or speech-based information via a code representing distinctive phonological features. This store decays within an estimated two seconds and requires subvocal repetition or rehearsal by the articulatory control
process to maintain the memory trace. In instances where verbal material is presented visually, the articulatory control process registers and translates the material into the phonological code through subvocalization or subvocal speech (Baddeley, 1992).

Several effects generated by the phonological loop and its articulatory control process impact verbal learning and memory. The acoustic similarity effect demonstrates that differentiating and retaining dissimilar sounds is easier than discriminating and recalling similar sounds. That is, the more distinctive phonological features the items have in common, the more difficult they are to recall (Torgesen, 1996). Essentially, immediate recall of words or items is more difficult when the items are similar in sound.

The irrelevant speech effect supports the model that visually presented word items are encoded through subvocal speech. The advantage of speech rehearsal for visually presented words can be disrupted by production of irrelevant speech material (i.e., saying the word “the” repeatedly out loud during the learning trial). Interjection of irrelevant speech during visual word list learning results in lower recall (Baddeley, 1992). Interruption of access to the phonological code through irrelevant speech during acoustic presentation of verbal material is referred to as articulatory suppression and also results in reduced recall of the material (Baddeley, Lewis and Vallar, 1984).

The word length effect demonstrates that the spoken duration of words impacts immediate memory span, with shorter words being easier to recall than longer words. Baddeley, Thompson and Buchanan (1975) showed that ordered serial recall of single-syllable words was better than recall of lists containing multi-syllable words. This word-length effect can also impact digit span. Research indicates that recall of digit sequences varies in different languages based on the time it takes to articulate the digits (Hoosain, 1982; Naveh-Benjamin & Ayres, 1986). Therefore, languages with multi-syllabic digits or digits with longer vowel sounds take longer to articulate and rehearse, resulting in shorter digit spans.

The visuospatial sketch pad is the second slave system within working memory. This sub-system is important for the temporary processing and storage of visual and spatial material and verbal material that is encoded in the form of imagery. Non-verbal memory tasks such as spatial span tasks or paper-and-pencil copying of geometric figures are visuospatial in nature and are typical measures of non-verbal memory (Hedden, et al., 2002). Spatial span tasks require examinees to point to a series of blocks in the same order as the examiner. Similar to digit span
tasks, spatial span tasks have a forward and a backward condition. The backward spatial span condition requires storage and manipulation of material and, therefore, involves working memory. Tasks requiring figure copying include a delayed trial to assess visuospatial memory. In a typical neuropsychological assessment, it is necessary to obtain data from separate measures of verbal and non-verbal memory, because each function is mediated by different sub-systems.

*Long-term memory*

Long-term memory involves the storage and retrieval of information in instances of a delay or distracting stimuli. It has a large, potentially unlimited storage capacity and holds information in a permanent store, without the necessity of ongoing, active processing. There are several divisions within long-term memory. The first distinction, declarative and non-declarative memory, is made based on the type of information that is processed (Sohlberg & Mateer, 2001). Declarative memory, also referred to as explicit memory, represents an individual’s learned knowledge base, which is accessible to conscious recollection. Non-declarative memory constitutes memory without conscious awareness of having learned the material. Declarative memory is further classified into semantic and episodic memory. Semantic memory relates to factual and acquired knowledge. Episodic memory is a record of unique temporally and contextually based experiences, i.e., the time, place or context of an event (Kramer & Delis, 1998).

*Information Processing Model*

The information processing model defines memory in terms of levels of processing versus temporal stages of storage. The levels of processing of the memory system are attention, encoding, consolidation, storage, and retrieval. Attention, as discussed previously, originates with alertness and arousal and involves accessing incoming information, sustaining concentration, and withstanding distraction (Sohlberg & Mateer, 1989). A number of theories have divided attention into a variety of components including vigilance or sustained attention, information processing capacity, shifting attention, divided attention, and selective attention for screening out non-target information (Halperin, 1996). Sohlberg and Mateer (1989) developed a clinically oriented model of attention that divides attention into five main hierarchical components: focused attention, sustained attention, selective attention, alternating attention, and divided attention.
In the next stage, or encoding stage, of the information processing model, incoming sensory information is encoded in the system for later retrieval. Verbal information is encoded based on phonological and semantic characteristics, and visual information is encoded based on graphic composition. Craik and Lockhart (1972) suggested that manner of encoding influences the strength of a memory trace. Deeper levels of processing generate meaning-based or semantic associations and result in a stronger memory trace than sound association or phonological encoding of perceptual stimuli. Strategies to promote or facilitate in-depth encoding include organization of incoming information, chunking, and rehearsal.

The consolidation and storage stages of the information processing model entail the transfer of transient information to a location for permanent retention. In the storage stage, new memories are integrated into the existing cognitive-linguistic schema. Once stored, existing memory traces may be activated through the process of retrieval. Word list learning tests are frequently implemented to assess verbal learning and retrieval of retained information. These tests examine short-term and long-term retention and compare recognition abilities to free recall abilities. Retrieving a memory trace by recognition, or identification of previously presented material, is considered an easier task and may be intact despite the presence of difficulties with unaided free recall (Lezak, 1995).

Effects of Language and Culture on Verbal Learning and Memory

Previous research indicates that perception, attention, processing, encoding, and recall are impacted by orthography, linguistic structure, culture, and prior experience. In a study examining the use of the Mini Mental State Examination (MMSE) with 3,062 Spanish and English speakers, Escobar, et al., (1986) found that responses to attention items on the test were influenced by the language of the respondent, with Spanish speakers scoring significantly lower than English speakers.

Differences in input mode and perception are also evidenced by differing orthographic systems. Orthographic structures may be alphabetic or logographic. Alphabetic orthographies represent a grapheme to phoneme correspondence, while logographic orthographies are founded on ideographs or single written characters which represent a word or a morpheme (Ishikawa & Nobe, 1998). Logographic systems (Chinese, Japanese), unlike alphabetic orthographies (English, Italian), may require speakers to rely more heavily on visual aspects of words than on auditory input.
Ishikawa and Nobe (1998) investigated language-specific features of word memory in English (an opaque alphabetic orthography) and in Chinese and Japanese (logographic-ideographic systems). Sixteen word lists of seven nouns were presented both visually and auditorily for recall in the subject’s native language. English speakers recalled the highest number of words, followed by Japanese and then Chinese speakers. Japanese and Chinese speakers demonstrated higher recall with the visual representation, while English speakers recalled more words presented via the auditory modality. This study also examined the influence of syllable structure on word recall. For all three languages, words with simpler syllable structure were easier to remember than multi-syllabic words. These findings indicate that syllable structure and input modality (visual or auditory) are capable of impacting word learning and memory (Ishikawa & Nobe, 1998).

Another study examining how differing orthographies influence the processing of verbal information was completed by Tavassoli (1999). Tavossoli investigated processing, encoding, and recall in Chinese and English. In English, written and spoken words are encoded by subvocal rehearsal in the phonological loop of short-term memory. As a result, verbal memory and semantic access are mediated by the phonological code. In contrast, Chinese verbal processing is based on logographs (one-syllable morphemes), which correspond more closely to associative meaning than to phonological representation. Therefore, memory for written and spoken words in Chinese relies more heavily on the visual code and Chinese words are retrieved based on semantic association. Tavassoli demonstrated that temporal word memory was greater for English speakers than Chinese speakers on a written word versus pictorial word learning task. These findings suggest that phonological versus visual-semantic and contextual involvement may have significant effects on the encoding and retrieval of verbal information in different languages (Tavassoli, 1999).

Lee, Cheung, Chan, and Chan (2000) examined the influence of native language and orthographic structure on sustained visual-conceptual and visuomotor tracking skills required to complete Trail making tasks in Chinese and English. Trail making tasks require participants to connect a series of numbered and lettered circles as quickly as possible. Findings demonstrated that English speakers performed significantly better than Chinese counterparts on one version of the Trail Making Tests. The authors postulate that the temporal order of the English language
may have provided English speakers an advantage over Chinese participants due to the temporal orientation inherent in the task.

Cross-linguistic comparisons have also been conducted to examine the role of articulation rate and word length in verbal learning and memory. Several of these studies looked closely at the role of the phonological loop in cross-linguistic variations in short-term memory or working memory processing. Ellis and Hennelly (1980) demonstrated that memory span for words which take longer to articulate is shorter than for words with shorter articulatory duration. They examined digit span in English-Welsh bilinguals and found that digit spans were larger for English than Welsh. This is reflective of digit pronunciation rate, which was faster for English than for Welsh. Ellis’ and Hennelly’s findings indicated that cross-linguistic digit articulation rates vary, and as a result, digit span norms cannot be compared across languages. These authors suggested that measures used to assess short-term memory performance may need to have adjusted norms based on the subject’s language (Ellis and Hennelly, 1980).

Hoosain (1982) also confirmed that sound duration of verbal items can significantly impact short-term memory by examining digit span in Cantonese-English bilinguals. In this study digit span was greater for Cantonese than English, corresponding to the faster articulation rate of Cantonese digits compared to English digits.

A cross-linguistic study by Naveh-Benjamin and Ayres (1986) examined the relationship between number of syllables or phonemes per word and articulation rate by comparing digit span and reading rate in English, Spanish, Hebrew, and Arabic. Results showed that each additional syllable in a word increased reading rate by 120 msec. Digit span results were greatest for English, which has a mean syllable length of 1.0 per digit. Digit span was lowest for Arabic, which has mean syllable length of 2.25 per digit (Naveh-Benjamin & Ayres, 1986). The results showed that linguistic variations in word length, specifically syllable size and corresponding articulation rate, impact performance on memory span tasks.

Chincotta and Underwood (1997) examined digit span in native speakers of six languages (Chinese, English, Finnish, Greek, Spanish, and Swedish) with and without articulatory suppression. Chinese speakers had the highest digit span of all languages under conditions without suppression. Chinese digit names are monosyllabic and are shorter in articulation rate than the other languages in the study. Mean digit span for the remaining languages in the study ranked as follows, from largest span to smallest: English, Spanish, Finnish, Swedish and Greek.
Under conditions of articulatory suppression, which prevents subvocal rehearsal, digit span was equivalent across languages. This finding supports the working memory theory of subvocal rehearsal by the phonological loop, and supports the role of articulation rate in cross-linguistic difference in digit span.

Previous research has additionally examined the different strategies that speakers of different languages use for recalling words in verbal fluency tasks. Cross-linguistic differences in verbal fluency scores have also been attributed to word length differences, among other variables. Verbal fluency tests typically include phonemic fluency (words beginning with a certain letter) or semantic or category fluency (words corresponding to a category like animals, fruit, etc.) and require respondents to name as many items within each category as possible within one minute.

Rosselli, et al., (2002) compared verbal fluency strategies in Spanish and English speakers. Results revealed cross-linguistic differences in the type of words and the categorization process used by English and Spanish speakers. For phonemic fluency tasks, more grammatical words, such as prepositions and conjunctions, were produced by English speakers than Spanish speakers. This finding may be accounted for by differences in lexical organization between the two languages. Differences in responses for the semantic categories, especially for animal, demonstrated the influence of different cultural experiences. English speakers produced more wild animals, while the Spanish speakers produced more birds and insects.

Acevedo et al. (2000) examined verbal fluency and established corresponding normative data for older Spanish and English speakers. English and Spanish speakers generated similar verbal fluency scores on animal and fruit categories, but English speakers produced more items for the vegetable category. Similar differences in semantic verbal fluency were also found in a study of English and Spanish speakers by Rosselli, Ardila, Araujo, et al. (2000). Kempler, Teng, Dick, Taussig and Davis (1998) tested verbal fluency for animal names in the native language of Chinese, Hispanic and Vietnamese populations. The Vietnamese produced the most animals in one minute and the Spanish speakers produced the fewest. The syllable structure of each language is proposed to have contributed to the differences, with Vietnamese animal names consisting predominantly of one syllable and Spanish animal names containing two and three syllables per word.
Recognition of the influence of linguistic structure and cultural experiences on cognitive abilities has prompted neuropsychological test adaptations and the generation of normative data in a number of languages. To date, only one published study, Kosmidis, et al. (2004), has addressed neuropsychological test adaptation from English into Greek. Kosmidis, et al., (2004) limited the development of normative data to tasks of verbal fluency and did not investigate other cognitive functions. The results of the study revealed that Greek participants produced fewer words on verbal fluency tasks compared to data on speakers of other languages. The authors suggested this is due to the polysyllabic nature of the Greek language and the participants’ lack of familiarity with typical neuropsychological testing procedures.

The study at large involved comparisons of Greek and English speakers on a wide range of neuropsychological functions. As previously discussed, Greek and English differ in orthography, syllable structure and pronunciation rate. Syllable structure in the Greek language is longer for the letters of the alphabet, numerical digits and general word length than is syllable structure in English. Based on the results of prior cross-linguistic research, and based on the internal structural and phonological differences of the two languages, Greek- and English-speaking participants in the present study were expected to perform differently on verbal memory tasks. No differences were expected on tasks that required greater depth of processing and encoding based on semantic associations. As noted by Tavassoli (1999), contextual involvement and semantic encoding, which can be employed in verbal list learning tasks, result in deeper encoding than phonological encoding alone. Likewise, no significant differences were expected between the two language groups, Greek and English, on non-verbal memory tasks due to the involvement of differing sub-systems of memory.

Constantinidou, Peltier and Sarap (2002) compared the performance of 81 young Greek and English speakers (ages 18-50 years) on neuropsychological measures of attention, verbal learning and memory. Results indicated that there were significant differences between the two groups on several verbal learning and memory tasks. Significant differences were observed on Trail Making Tests A and B, Digit Span Forward and Backward, and the Mini-Mental State Examination, with English speakers scoring significantly higher than Greek speakers. No significant differences were observed on the non-verbal tasks administered, including the Rey-Osterreith Complex Figure Test and the Spatial Span Forward and Backward. No significant differences were observed between the two language groups on a verbal list learning task, the
Rey Auditory Verbal Learning Test. Results from this initial phase of the project documented differences in younger Greek and English speakers. Additional data pertaining to older adult speakers of each language were still needed.

**Age-Associated Changes in Memory**

Changes in cognition occur with aging and include changes in attention, memory, learning, language, and other higher cortical functions (Albert, 1984). Memory deficits are a frequent complaint in people over age 60, and particularly in those over 70 (Craik, 1984). Research indicates that certain aspects of memory function are more affected by normal aging than others; specifically free recall, episodic memory, explicit memory, and working memory (Knoefel & Adair, 2000).

In general, age-associated differences in memory are most evident when information is new, complex, or requires longer processing time (Bayles & Kaszniak, 1987). Sensory memory and long-term memory tasks involving automatic processing and recognition typically remain intact with age in contrast to age-related difficulties with new learning (Poon, 1985). Older adults demonstrate greater difficulties than their younger counterparts on tasks requiring divided attention and mental manipulation of the material, accounting for declines in working memory (Baddeley, 1986). Additional age-related memory deficits include reduced word naming, verbal fluency and visuospatial abilities (La Rue, 1992).

Age-related changes in memory may result from anatomical changes in the brain involving cortical atrophy. The brain’s volume begins to decrease rapidly around the fifth to sixth decade of life. Neuronal loss and shrinkage of cell size contribute to reduction in white matter, widening of the sulci, narrowing of the gyri and increased ventricular size (Lezak, 1995). The hippocampus and frontal lobes, two regions determined to be highly involved in the memory processes of organizing, encoding and retrieval, are especially disposed to neuronal loss (Craik & Jennings, 1992). Consequently, memory deficits in older adults may be due to the failure to sufficiently encode stimuli (Grady, et al., 1995). La Rue (1992) reviewed additional neuroanatomical changes associated with aging including dendritic changes, amyloid accumulation, neuritic plaques, neurofibrillary tangles, microvascular changes, and neurochemical changes. It should be noted, however, that these changes occur in degenerative and dementing diseases to potentially greater degrees, and further research is necessary for delineating normal versus abnormal neuroanatomical change.
Neuropsychological testing of memory in older adults typically includes measures to assess forward and backward digit spans, forward and backward visual spans, verbal learning and memory via free recall and delayed recall on word list tests, non-verbal memory via constructional figure reproduction, object naming and word fluency (Nussbaum, 1998). These measures, combined with appropriate normative data, distinguish between cognitive changes related to normal aging and cognitive impairments indicative of underlying brain pathologies (Hebben & Milberg, 2002).

In order to make clinical judgments between functionality and disorder, separate normative data are needed for the age-based sub-groups comprising the older adult population (LaRue, 1992). Ardila and Rosselli (1989) found statistically significant differences between age groups (spaced in 5-year increments) on 23 out of 29 neuropsychological tests administered to adults ages 50-70+. As previously discussed, many age-related neuropsychological changes become evident around ages 50 to 65, with accelerated effects after age 70 (Lezak, 1995), signifying the need for separate normative data for the upper age range of older adults.

Summary

Distinctions may be made in both the classical and the information processing models of memory regarding the roles of attention, perception, and encoding in the abilities to learn, store, and retrieve information. Previous research indicates that aspects of verbal learning and memory are influenced by culture and linguistic structure. Memory abilities and processing speed vary across languages depending on orthography, articulation rate, syllable structure, and word length. Cultural experiences also influence perception and processing mode and contribute to differences in learning and memory.

Normal age-associated changes in memory were reviewed, including neuroanatomical changes that accompany aging. The most common age-associated changes in memory occur in free recall, episodic memory, explicit memory, and working memory abilities. Performance on neuropsychological measures has been demonstrated to vary widely across the age sub-groups of older adults. Therefore, research indicates that accurate assessment of neuropsychological function in older adults requires age-based normative data to support clinical judgments of normal age-related changes versus cognitive impairment.
Statement of the Problem

Existing research demonstrates the influence of linguistic structure and cultural experience on cognitive-linguistic performance. Cross-linguistic differences in syllabic components, orthography and pronunciation rate have been shown to affect verbal learning and memory abilities. Results from comparative studies indicate that norms for verbal learning and memory abilities cannot be compared across languages and cultures. For this reason, it is imperative to complete neuropsychological test adaptations and to obtain culture and language specific normative data.

While a number of neuropsychological tests have been adapted for a variety of languages, there is currently a lack of assessment measures adapted into Greek and a lack of corresponding normative data to support clinical judgments of cognitive-linguistic function in Greek speakers. Due to age-associated changes in cognitive performance, separate normative data must be established for older Greek speakers. Cross-cultural and cross-linguistic research comparing cognitive-linguistic performance in Greek and English speakers is extremely limited. Consequently, comparisons of norm-referenced neuropsychological test scores from adult Greek and English speakers are needed to enhance the understanding of the influence of each of these languages on cognitive-linguistic performance.
CHAPTER III

Methods and Procedures

Participants

The participants for the present study included a total of 58 adults, ages 55 years and above. Twenty-six participants were native Greek speakers (15 men and 11 women) and thirty-two participants (11 men and 21 women) were native English speakers. Each language group, Greek and English, was divided into two groups based on age: 1) 55-70 years and 2) 71+ years, for comparisons of age-related cognitive-linguistic performance. The average age of the Greek speakers was 66.92 years (SD = 8.02; range 55-88 years). The average age of the English speakers was 70.03 years (SD = 6.39; range 58-79 years). The average number of years of education for the Greek speakers was 13.76 years (SD = 2.02; range 12-18 years). The average number of years of education for the English speakers was 14.65 years (SD = 1.87; range 12-18 years). There was no significant difference between the educational levels of the Greek and English participants ($t = -1.727, p = .090$) and no significant difference between the ages of the two language groups ($t = -1.641, p = .106$).

The Greek participants were obtained from their home island of Cyprus, from the Nicosia area, and were administered a complete neuropsychological battery in their native Greek language. U.S. citizens were obtained from Southwest Ohio and Northern Kentucky, and were tested in their native language, English. All participants were volunteers. The U.S. participants were recruited through fliers at local senior community centers, through the existing subject pool at the Department of Speech Pathology and Audiology at Miami University, or through personal contacts. The Greek-Cypriot participants were recruited through fliers at community and senior centers and through personal contacts. All subjects were interviewed to determine eligibility.

Inclusion Criteria for All Participants.

1. Healthy males and females ages 55+ years of age.
2. Negative history for uncorrected vision or hearing impairment, neurological or psychiatric disorder, cognitive or learning disability.
3. Native Greek and native English speakers.
4. Score of 26 or higher out of 30 on the Mini Mental State Exam (Folstein, Folstein & Hughes, 1975), a brief cognitive measure (see Appendix A).
Exclusion Criteria for All Participants.

1. Positive history for loss of consciousness, stroke or other neurological problem.
2. Uncorrected vision or hearing impairment.
3. Language or speech disorder.
4. Learning disability.
5. Psychiatric disorder.
7. Score of 13 or higher on the Beck Depression Inventory-II (Beck, 1996), a brief screening for the presence of depression (see Appendix B).

All participants were required to pass a vision and hearing screening. The vision screening required participants to correctly read aloud a list of five words presented in 10-point type (see Appendix C). Each participant’s hearing was screened at the level of conversational speech by requiring participants to accurately follow a set of verbal commands related to picture card stimuli (see Appendix D).

Measures

Neuropsychological Measures

A detailed neuropsychological assessment was administered to each participant in the Greek-Cypriot group and the U.S. group. Table 1 lists each test and the skills it evaluates. Each individual measure is described in more detail below.

Rey Auditory Verbal Learning Test (AVLT), (Rey, 1964, as cited in Lezak, 1995)

The AVLT is a measure of verbal learning and declarative memory. Standard administration includes five verbal presentations of a 15-word list followed by free recall on each trial, one presentation of an additional 15-word list and a final sixth free recall trial. A seventh delayed recall trial is included after a 30-minute interval, followed by a recognition trial. The combined trials assess immediate memory span, new learning, and delayed recall. The administration of the AVLT will be immediately followed by a participant questionnaire designed to examine verbal learning strategies.

The Rey-Osterreith Complex Figure Test (Rey, 1941, as cited in Lezak, 1995)

The Rey-Osterreith Complex Figure Test assesses visuospatial constructional skills and visual memory. The test is a paper and pencil measure consisting of a complex two dimensional line drawing containing 18 details, which the participant is instructed to copy. Immediate recall
is assessed by having the participant reproduce the figure after a three minute delay. Delayed recall is assessed after a 30-minute interval.

*Trail Making Tests A and B (Army Individual Test Battery, 1944, as cited in Lezak, 1995)*

Trail Making Tests A and B assess attention, visual scanning, and speed of eye-hand coordination (Mitrushina, Boone & D’Elia, 1999). Trail Making Test A is a paper- and-pencil measure, which requires participants to draw lines as quickly as possible to connect circles scattered across a page containing numbers 1-25. Trail Making Test B requires the participant to alternate connecting lines between circles containing numbers 1-13 and letters A-L. These tests are timed to provide assessment regarding speed of processing of verbal/visual information.

*Digits Forward and Digits Backward, Wechsler Memory Scale, Third Edition (WMS-III), (Wechsler, 1997)*

Digits Forward measures attention and span of immediate auditory recall by requiring participants to repeat a series of digits increasing in length over seven trials in the exact order as presented. Digits Backward requires participants to repeat digits in the opposite order as presented. Digits Backward requires mental flexibility and working memory.

*Spatial Span Forward and Backward Subtests, Wechsler Memory Scale, Third Edition (WMS-III), (Wechsler, 1997)*

Spatial Span Forward and Spatial Span Backward assess visuospatial attention and immediate visual recall by having participants follow the clinician’s model of tapping a series of randomly positioned blocks in exact order.

*Logical Memory Subtests, Wechsler Memory Scale Revised (WMS-R), (Wechsler, 1987)*

The Logical Memory Subtests from the Wechsler Memory Scale Revised (WMS-R) measure immediate recall and delayed recall of two separate stories, Story A and Story B. Each story has 25 scoring units and is read to the participants for immediate recall, Logical Memory I, and delayed recall following a 30-minute interval, Logical Memory II (Lezak, 1995).

*Verbal Fluency*

Two tests of verbal fluency were administered. A semantic test of verbal fluency required participants to generate as many different words in the animal category as possible in one minute. A phonemic verbal fluency test required participants to generate as many words as possible beginning with the letter /f/ for the English language and the letter /Φ/ for the Greek language, also within one minute.
Mini-Mental State Exam (MMSE), (Folstein, Folstein & Hughes, 1975)

The MMSE is a short standardized measure designed to determine the presence of a cognitive impairment or cognitive alterations in neurological, psychiatric, or geriatric patients (Lezak, 1995). The test uses verbal responses to evaluate orientation, attention, short-term memory, reading, writing, calculation, and visual-constructional tasks.
Table 1
Neuropsychological Battery

<table>
<thead>
<tr>
<th>Mental Status</th>
<th>Mini-Mental State Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Folstein, Folstein &amp; Hughes, 1975)</td>
</tr>
<tr>
<td>Verbal Learning and Verbal Memory</td>
<td>Rey Auditory Verbal Learning Test (AVLT), (Rey, 1964, as</td>
</tr>
<tr>
<td></td>
<td>cited in Lezak, 1995)</td>
</tr>
<tr>
<td></td>
<td>Digit Span Forward and Backward, Wechsler Memory Scale,</td>
</tr>
<tr>
<td></td>
<td>Third Edition (WMS-III), (Wechsler, 1997)</td>
</tr>
<tr>
<td></td>
<td>Logical Memory Subtests, Wechsler Memory Scale, Revised</td>
</tr>
<tr>
<td></td>
<td>(WMS-R), (Wechsler, 1987)</td>
</tr>
<tr>
<td></td>
<td>Verbal Fluency Task</td>
</tr>
<tr>
<td></td>
<td>Semantic task: Animal recall</td>
</tr>
<tr>
<td></td>
<td>Phonemic task: Word recall for /f/ (English), /Φ/ (Greek)</td>
</tr>
<tr>
<td>Verbal and Visual Processing</td>
<td>Trail Making Tests A and B (Army Individual Test Battery,</td>
</tr>
<tr>
<td></td>
<td>1944; as cited in Lezak, 1995)</td>
</tr>
<tr>
<td>Non-Verbal Memory</td>
<td>Rey-Osterreith Complex Figure Test (Rey, 1941, as cited in</td>
</tr>
<tr>
<td></td>
<td>Lezak, 1995)</td>
</tr>
<tr>
<td></td>
<td>Spatial Span Forward and Backward, Wechsler Memory Scale,</td>
</tr>
<tr>
<td></td>
<td>Third Edition (WMS-III), (Wechsler, 1997)</td>
</tr>
</tbody>
</table>
Procedures

All participants completed the neuropsychological measures listed in Table 1 in one testing session lasting approximately two hours. The full test battery measured the domains of attention, new learning, memory, and language. Testing and data scoring were under the supervision of Dr. Fofi Constantinidou. Trained graduate and undergraduate students in the Department of Psychology at the University of Cyprus administered the complete neuropsychological battery in Greek to participants in the Greek-Cypriot group. The U.S. participants were tested in English by trained graduate and undergraduate students in Speech Pathology and Audiology at Miami University, Oxford, Ohio. Testing took place in a quiet environment at the Department of Psychology at the University of Cyprus, the Miami University Speech and Hearing Clinic or the participant’s home. One break was provided during the testing session at the participant’s request to prevent mental fatigue.

Research questions

1. Will there be a difference in performance between Greek-and English-speaking participants on tasks that require fast processing of linguistic information as a function of the polysyllabic structure of the Greek language?
2. Will Greek Cypriot subjects recall fewer digits on the auditory span tasks than the English speaking participants?
3. Will English-speaking participants complete tasks that require mental flexibility and incorporate verbal language at a significantly faster pace compared to Greek-speaking participants?
4. Will there be a difference in performance on verbal tasks that incorporate in depth processing of information between English-speaking and Greek Cypriot participants?
5. Will the two groups use similar strategies to learn and remember new information?
6. Will there be a difference between the English- and Greek-speaking participants on non-verbal cognitive test?

Null hypotheses

1. There will be no difference in performance between Greek-and English-speaking participants on tasks that require fast processing of linguistic information.
2. There will be no difference between Greek speakers and English speakers on the recall of digits on the auditory span tasks.
3. There will be no difference between Greek speakers and English speakers on rate of completion for tasks requiring mental flexibility and verbal language.

4. There will be a significant difference in performance on verbal tasks that incorporate in depth processing of information between English-speaking and Greek Cypriot participants.

5. The two groups will differ in strategies used to learn and remember new information.

6. There will be a significant difference between the English- and Greek-speaking participants on non-verbal cognitive test.

Data Analysis

Statistical analyses were carried out using the Statistical Package for Social Science (SPSS 14.0 for Windows). Independent samples t-tests were conducted to compare the performance of the two language groups, Greek and English, on the measures in the neuropsychological battery. Additionally, a multivariate analysis of variance (MANOVA) was completed to compare both language groups on the multiple learning trials of the AVLT. To examine the influence of age on cognitive-linguistic performance, independent samples t-tests were conducted to compare the test performance between two age groups (55-70 years and 71+ years) for each language. Cell alpha levels were set at .05 for all analyses.
CHAPTER IV

Results

Independent samples t-tests were conducted to compare the performance of Greek- and English-speaking participants on the measures in the neuropsychological battery. Table 2 lists the t-test results. Results pertaining to each research question are presented following Table 2.

Table 2

Between Groups T-test Results Comparing Greek and English Speakers

<table>
<thead>
<tr>
<th>Neuropsychological Measure</th>
<th>Greek N = 26 M (SD)</th>
<th>English N = 32 M (SD)</th>
<th>t-value</th>
<th>df (degrees of freedom)</th>
<th>P (significance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Span Forward</td>
<td>7.96 (2.06)</td>
<td>10.53 (1.84)</td>
<td>-4.991</td>
<td>56</td>
<td>.001*</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>5.61 (2.22)</td>
<td>7.62 (2.41)</td>
<td>-3.258</td>
<td>56</td>
<td>.002*</td>
</tr>
<tr>
<td>Spatial Span Forward</td>
<td>7.88 (1.92)</td>
<td>8.46 (1.48)</td>
<td>-1.306</td>
<td>56</td>
<td>.197</td>
</tr>
<tr>
<td>Spatial Span Backward</td>
<td>7.00 (2.31)</td>
<td>7.75 (1.75)</td>
<td>-1.402</td>
<td>56</td>
<td>.167</td>
</tr>
<tr>
<td>Trail Making Test A (seconds)</td>
<td>66.64 (22.00)</td>
<td>36.68 (10.92)</td>
<td>6.723</td>
<td>55</td>
<td>.001*</td>
</tr>
<tr>
<td>Trail Making Test B (seconds)</td>
<td>138.88 (54.42)</td>
<td>74.87 (19.81)</td>
<td>6.163</td>
<td>55</td>
<td>.001*</td>
</tr>
<tr>
<td>RCFT Copy</td>
<td>30.36 (5.23)</td>
<td>33.87 (3.28)</td>
<td>-3.115</td>
<td>56</td>
<td>.003*</td>
</tr>
<tr>
<td>RCFT Recall</td>
<td>13.90 (8.02)</td>
<td>18.45 (7.08)</td>
<td>-2.291</td>
<td>56</td>
<td>.026*</td>
</tr>
<tr>
<td>Logical Memory 1A</td>
<td>13.28 (4.65)</td>
<td>14.18 (3.68)</td>
<td>-.822</td>
<td>55</td>
<td>.415</td>
</tr>
<tr>
<td>Logical Memory 1B</td>
<td>11.20 (3.67)</td>
<td>13.68 (3.37)</td>
<td>-2.656</td>
<td>55</td>
<td>.010*</td>
</tr>
<tr>
<td>Logical Memory 1 Total</td>
<td>23.80 (7.37)</td>
<td>27.87 (6.40)</td>
<td>-2.229</td>
<td>55</td>
<td>.030*</td>
</tr>
<tr>
<td>Logical Memory 2 A</td>
<td>10.36 (4.24)</td>
<td>11.96 (4.21)</td>
<td>-1.426</td>
<td>55</td>
<td>.160</td>
</tr>
<tr>
<td>Logical Memory 2B</td>
<td>9.40 (5.70)</td>
<td>11.87 (3.54)</td>
<td>-2.009</td>
<td>55</td>
<td>.049*</td>
</tr>
<tr>
<td>Logical Memory 2 Total</td>
<td>18.68 (7.53)</td>
<td>23.78 (6.94)</td>
<td>-2.653</td>
<td>55</td>
<td>.010*</td>
</tr>
<tr>
<td>Mini-Mental State Examination</td>
<td>27.80 (1.26)</td>
<td>29.03 (1.822)</td>
<td>-4.440</td>
<td>56</td>
<td>.001*</td>
</tr>
<tr>
<td>Verbal Fluency, semantic</td>
<td>13.80 (3.54)</td>
<td>17.62 (4.60)</td>
<td>-3.471</td>
<td>56</td>
<td>.001*</td>
</tr>
<tr>
<td>Verbal Fluency, phonemic</td>
<td>11.50 (4.23)</td>
<td>14.18 (4.91)</td>
<td>-2.201</td>
<td>56</td>
<td>.032*</td>
</tr>
</tbody>
</table>

M=mean; SD=standard deviation
* denotes p < .05 level of significance
Research Question 1:

Will there be a difference in performance between Greek-and English speaking participants on tasks that require fast processing of linguistic information as a function of the polysyllabic structure of the Greek language?

Independent samples t-tests were completed to compare the Greek and English-speaking participants on Trail Making Tests A and B, which are measures that involve fast processing of phonologically-based linguistic information, specifically numerical digits and letters of the alphabet. Participants were required to connect a series of numbered and lettered circles as quickly as possible, thereby assessing speed of processing of verbal/visual information. This is a timed measure and the scores represent time in seconds for completion. A significant difference ($\alpha = .05$) was observed between the Greek and English speakers on Trail Making Test A $t(55) = 6.723$, $p = .001$ and on Trail Making Test B $t(55) = 6.163$, $p = .001$. The English-speaking participants appeared to benefit from the monosyllabic structure of English (versus the polysyllabic structure of Greek) for digits and letters by completing both versions of the Trail Making Tests at a significantly faster pace than Greek-speaking counterparts.

Research Question 2:

Will Greek Cypriot subjects recall fewer digits on the auditory span tasks than the English-speaking participants?

Digits Forward and Digits Backward assessed participants’ immediate auditory span for a series of numerical digits and are measures of verbal working memory. Scores relate to the number of digits correctly repeated for each condition (forward or backward). Independent samples t-tests were performed for each condition to determine if there was a significant difference between the digit spans of the Greek and English speakers. Results indicated that the English-speaking participants recalled a significantly greater ($\alpha = .05$) number of digits on the Digits Forward $t(56) = -4.991$, $p = .001$ and Digits Backward $t(56) = -3.258$, $p = .002$ compared to Greek the speakers in the study.

Research Question 3:

Will English-speaking participants complete tasks that require mental flexibility and incorporate verbal language at a significantly faster pace compared to Greek-speaking participants?
Trail Making A and Trail Making B tests assess not only speed of processing, as mentioned in research question one, but also attention, sequencing, and mental flexibility. Trail Making A required participants to sequence numerical digits as quickly as possible, while Trail Making B required participants to shift cognitive sets and alternate between number and letter sequences. The results of the statistical analyses indicated that the English speakers completed Trail Making A at an average of 36.68 seconds compared to an average of 66.64 seconds for the Greek-speaking participants \( t(55) = 6.723, p = .001 \). Similarly, English speakers completed Trail Making B at a significantly faster pace with an average of 74.87 seconds, while Greek speakers completed the task in an average of 138.88 seconds \( t(55) = 6.163, p = .001 \).

The word fluency, or verbal fluency, tasks in the present neuropsychological battery were timed tests which required participants to generate as many words as possible in 60 seconds for a semantic and phonemic category. Word fluency tasks require activation of a variety of language functions including existing lexical knowledge, mental organization, and speed of response. English speakers generated an average of 17.62 words for the semantic category compared to the average of 13.80 words for Greek speakers. English speakers had an average of 14.18 words for the abstract phonemic category compared to an average of 11.50 words for Greek-speaking participants. Results of independent samples t-tests revealed English speakers generated significantly \((\alpha = .05)\) more words than Greek speakers for both the semantic fluency task \( t(56) = -3.471, p = .001 \) and the phonemic fluency task \( t(56) = -2.201, p = .032 \). 

**Research Question 4:**

Will there be a difference in performance on verbal tasks that incorporate in depth processing of information between English-speaking and Greek Cypriot participants?

The Logical Memory Subtests of the Wechsler Memory Scale-Revised were administered to measure immediate recall and delayed recall of details from two separate stories, which were read aloud to participants. The ability to recall paragraph level material, which has been presented auditorily, involves in-depth semantic encoding and contextual association. The effects of the in-depth semantic encoding inherent in these tasks were expected to supersede the differences that result from phonology and syllable structure.

Scores were obtained from Greek- and English-speaking participants on the immediate recall of 2 stories (Story 1 A and Story 1 B) and the combined total scores (A and B total). There was no significant difference \((\alpha = .05)\) between the Greek and English speakers on an
independent samples t-test for Story 1 A $t(55) = -.822, p = .415$. However, English speakers scored significantly higher ($\alpha = .05$) than Greek speakers on Story 1 B $t(55) = -2.656, p = .010$ and Story 1 Total $t(55) = -2.229, p = .030$.

Scores were also obtained for the delayed recall of each of the two stories. Similar to the pattern for immediate recall, there was no significant difference ($\alpha = .05$) between the Greek and English speakers for the delayed version of Story A $t(55) = -1.426, p = .160$. However, English speakers scored significantly higher ($\alpha = .05$) than Greek speakers on the delayed recall of Story B $t(55) = -2.009, p = .049$ and on the total score $t(55) = -2.653, p = .010$.

**Research Question 5:**

**Will there be a difference between the English- and Greek-speaking participants on non-verbal cognitive tests?**

Based on the involvement of different subsystems of memory for verbal versus non-verbal tasks and the lack of phonological representation in non-verbal tasks, differences were not expected between the two language groups on the non-verbal measures in the study. Two measures of non-verbal abilities were administered as part of the neuropsychological battery, the Rey-Osterreith Complex Figure Test (RCFT) and the Spatial Span Forward and Backward.

The means of the Greek and English speakers on two conditions of the RCFT, the immediate copy trial and the 30-minute delayed recall trial, were compared in the statistical analysis. The results of independent samples t-test for each condition revealed a significant difference ($\alpha = .05$) between the Greek- and English-speaking participants on both the copy trial $t(56) = -3.115, p = .003$ and recall trial $t(56) = -2.291, p = .026$, with English speakers scoring significantly higher than Greek speakers.

The Spatial Span Forward and Backward additionally measured non-verbal abilities by requiring participants to repeat the examiner’s model and point to a series of randomly positioned blocks in exact order for each condition, forward and backward. There was no significant difference ($\alpha = .05$) between the Greek and English speakers on separate independent samples t-tests for the Spatial Span Forward $t(56) = -1.306, p = .197$ or for the Spatial Span Backward $t(56) = -1.402, p = .167$. 

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Research Question 6:
Will the two groups use similar strategies to learn and remember new information?

The AVLT, a word list learning task, was administered to all participants as a measure of verbal learning. Participants were verbally presented a list of 15 words over five trials. A MANOVA was conducted to compare the performance of the Greek and English speakers across the five learning trials of the AVLT. The Hotelling’s Trace Test revealed a significant ($\alpha = .05$) trials effect for both groups, indicating both groups benefited from the five learning trials and learned significantly more words across trials $F(4,53) = 99.744, p = .001$. The trials by group interaction effect was found not to be significant at $F(4,53) = .920, p = .459$, indicating both Greek and English speakers had similar learning patterns across the five trials. The between groups effect was significant at $F(1,56) = 6.912, p = .011$, indicating English-speaking participants benefited more from the repeated trials of the AVLT and learned more total words per trial compared to Greek speakers. Table 5 displays the means and standard deviations for Greek and English speakers across the five trials. Figure 1 displays the graphic profile plot of the five trials for each group.

Table 3
Means for the Repeated Trials of the AVLT

<table>
<thead>
<tr>
<th></th>
<th>Trial 1 M (SD)</th>
<th>Trial 2 M (SD)</th>
<th>Trial 3 M (SD)</th>
<th>Trial 4 M (SD)</th>
<th>Trial 5 M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greek (N = 28)</td>
<td>5.26 (1.61)</td>
<td>7.84 (1.99)</td>
<td>9.11 (2.04)</td>
<td>10.00 (2.26)</td>
<td>10.34 (2.34)</td>
</tr>
<tr>
<td>English (N = 32)</td>
<td>6.09 (2.27)</td>
<td>8.90 (2.38)</td>
<td>10.78 (2.35)</td>
<td>11.65 (2.52)</td>
<td>11.96 (2.45)</td>
</tr>
</tbody>
</table>

SD = standard deviation
Results for the age-related comparisons:

An additional purpose of this study was to investigate the effects of aging on the cognitive aspects of verbal learning and memory. As indicated in the review of the research literature, aging results in changes in cognitive performance. These changes are first evident around the sixth decade of life, with accelerated effects developing after the seventh decade of life. To examine the influence of aging on participants’ performance on the measures in the battery, participants in each language group were divided into two age groups: 1) 55-70 years and 2) 71+ years.

For the age-based comparisons, several participants in the 55-70 year age group were removed from each language group to adjust the range and increase the difference between the age groups. Four participants were removed from the Greek group and two participants were removed from the English group. For the age-based comparisons there were 15 Greek speakers ages 55-70 (range 55-68 years) and 9 were age 71+ years (range 72-88 years). There were 13 English speakers ages 55-70 (range 55-67 years) and 15 were 71+ years (range 71-79 years).
Table 4 displays the means and standard deviations for the Greek and English speakers, grouped by age.

### Table 4

**Mean (SD) Performance on the Neuropsychological Battery by Age Level**

<table>
<thead>
<tr>
<th>Neuropsychological Measure</th>
<th>Greek 55-70 (n = 15)</th>
<th>Greek 71+ (n = 9)</th>
<th>English 55-70 (n = 13)</th>
<th>English 71+ (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>8.13 (1.84)</td>
<td>7.44 (2.55)</td>
<td>10.53 (1.50)</td>
<td>10.80 (2.14)</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>5.80 (2.56)</td>
<td>5.11 (1.83)</td>
<td>8.15 (2.40)</td>
<td>7.20 (2.59)</td>
</tr>
<tr>
<td>Spatial Span Forward</td>
<td>8.06 (1.83)</td>
<td>7.00 (1.73)</td>
<td>8.38 (1.75)</td>
<td>8.40 (1.29)</td>
</tr>
<tr>
<td>Spatial Span Backward</td>
<td>7.93 (2.08)</td>
<td>5.33 (2.06)</td>
<td>8.07 (1.84)</td>
<td>7.53 (1.68)</td>
</tr>
<tr>
<td>Trail Making Test A</td>
<td>65.64 (25.97)</td>
<td>69.00 (18.33)</td>
<td>32.23 (7.83)</td>
<td>42.20 (11.86)</td>
</tr>
<tr>
<td>(seconds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail Making Test B</td>
<td>124.78 (52.77)</td>
<td>161.55 (58.12)</td>
<td>68.76 (16.55)</td>
<td>79.66 (20.16)</td>
</tr>
<tr>
<td>(seconds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCFT Copy</td>
<td>32.06 (3.67)</td>
<td>27.50 (6.87)</td>
<td>35.34 (8.51)</td>
<td>32.83 (4.31)</td>
</tr>
<tr>
<td>RCFT Recall</td>
<td>16.46 (8.66)</td>
<td>10.38 (6.36)</td>
<td>20.76 (7.60)</td>
<td>16.86 (6.95)</td>
</tr>
<tr>
<td>Logical Memory 1A</td>
<td>14.26 (4.89)</td>
<td>11.33 (4.03)</td>
<td>16.38 (2.84)</td>
<td>12.33 (3.37)</td>
</tr>
<tr>
<td>Logical Memory 1B</td>
<td>11.86 (4.32)</td>
<td>10.00 (2.29)</td>
<td>15.30 (3.59)</td>
<td>12.53 (2.89)</td>
</tr>
<tr>
<td>Logical Memory 1 Total</td>
<td>25.00 (8.16)</td>
<td>21.33 (5.89)</td>
<td>31.69 (5.82)</td>
<td>24.86 (5.37)</td>
</tr>
<tr>
<td>Logical Memory 2 A</td>
<td>11.26 (4.36)</td>
<td>8.77 (4.02)</td>
<td>14.30 (3.68)</td>
<td>9.86 (3.77)</td>
</tr>
<tr>
<td>Logical Memory 2B</td>
<td>11.46 (6.12)</td>
<td>6.00 (3.31)</td>
<td>13.84 (3.36)</td>
<td>10.73 (2.78)</td>
</tr>
<tr>
<td>Logical Memory 2 Total</td>
<td>21.06 (7.93)</td>
<td>14.77 (5.67)</td>
<td>28.15 (5.95)</td>
<td>20.46 (5.52)</td>
</tr>
<tr>
<td>Mini-Mental State Exam</td>
<td>27.86 (1.30)</td>
<td>27.77 (1.20)</td>
<td>29.30 (.630)</td>
<td>28.80 (.941)</td>
</tr>
<tr>
<td>Verbal Fluency, semantic</td>
<td>14.46 (3.99)</td>
<td>12.55 (2.35)</td>
<td>19.23 (5.55)</td>
<td>16.53 (3.96)</td>
</tr>
<tr>
<td>Verbal Fluency, phonemic</td>
<td>12.66 (4.23)</td>
<td>9.00 (3.08)</td>
<td>14.84 (3.05)</td>
<td>14.53 (6.12)</td>
</tr>
</tbody>
</table>

M=mean; SD=standard deviation

Separate independent samples t-tests were performed for both languages to determine if there was a significant difference in the cognitive-linguistic performance of participants over 71+ years of age compared to their younger counterparts, ages 55-70 years. Results of between groups t-tests for the Greek speakers, revealed Greek participants ages 55-70 obtained significantly higher ($\alpha = .05$) scores than their 71+ year old Greek-speaking counterparts on the following measures: Spatial Span Backward; The Rey-Osterreith Complex Figure Copy Trial; Logical Memory 2 B; Logical Memory 2 Total; and Verbal Fluency (phonemic). Table 5
displays the significant t-test statistics for the age-based comparisons for the Greek-speaking participants.

Table 5
Between Groups T-test Results Comparing Greek-Speaking Participants by Age, 55-70 years (N = 15) and 71+ years (N = 9)

<table>
<thead>
<tr>
<th>Neuropsychological Measure</th>
<th>t-value</th>
<th>df (degrees of freedom)</th>
<th>P (significance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial Span Backward</td>
<td>2.968</td>
<td>22</td>
<td>.007*</td>
</tr>
<tr>
<td>RCFT Copy</td>
<td>2.134</td>
<td>22</td>
<td>.044*</td>
</tr>
<tr>
<td>Logical Memory 2 B</td>
<td>2.455</td>
<td>22</td>
<td>.022*</td>
</tr>
<tr>
<td>Logical Memory 2 Total</td>
<td>2.073</td>
<td>22</td>
<td>.050*</td>
</tr>
<tr>
<td>Verbal Fluency, phonemic</td>
<td>2.254</td>
<td>22</td>
<td>.034*</td>
</tr>
</tbody>
</table>

* denotes p < .05 level of significance

Results of between groups t-tests for the English-speaking participants revealed that English speakers ages 55-70 obtained significantly higher (α = .05) scores than their 71+ year old English-speaking counterparts on the following measures: Trail Making A; The Rey-Osterreith Complex Figure Copy Trial; Logical Memory 1 A, 1B and 1 Total; Logical Memory 2 A, 2 B and 2 Total. Table 6 displays the significant t-test statistics for the age-based comparisons for the English-speaking participants.

Table 6
Between Groups T-test Results Comparing English-Speaking Participants by Age, 55-70 years (N = 13) and 71+ years (N = 15)

<table>
<thead>
<tr>
<th>Neuropsychological Measure</th>
<th>t-value</th>
<th>df (degrees of freedom)</th>
<th>P (significance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail Making Test A (seconds)</td>
<td>-2.578</td>
<td>26</td>
<td>.016*</td>
</tr>
<tr>
<td>Logical Memory 1A</td>
<td>3.404</td>
<td>26</td>
<td>.002*</td>
</tr>
<tr>
<td>Logical Memory 1B</td>
<td>2.622</td>
<td>26</td>
<td>.032*</td>
</tr>
<tr>
<td>Logical Memory 1 Total</td>
<td>3.226</td>
<td>26</td>
<td>.003*</td>
</tr>
<tr>
<td>Logical Memory 2 A</td>
<td>3.139</td>
<td>26</td>
<td>.004*</td>
</tr>
<tr>
<td>Logical Memory 2 B</td>
<td>2.678</td>
<td>26</td>
<td>.013*</td>
</tr>
<tr>
<td>Logical Memory 2 Total</td>
<td>3.541</td>
<td>26</td>
<td>.002*</td>
</tr>
</tbody>
</table>

*denotes p < .05 level of significance
CHAPTER V
Discussion

This study examined neuropsychological performance in older Greek and English speakers, ages 55 years and above, by comparing participants’ performance on standard measures of verbal learning and memory. The primary objectives of this study were (a) to determine if differences in the linguistic structure of each language, Greek and English, as well as cultural differences, impact verbal learning and non-verbal memory abilities and (b) to obtain preliminary normative data on the neuropsychological performance of older Greek-Cypriot adults, ages 55 and above. Additionally, the study examined age-related cognitive-linguistic performance by comparing test scores between two age groups (55-70 years and 71+ years) for each language.

Cross-Cultural, Cross-Linguistic Comparisons

The study compared Greek and English speakers on several cognitive-linguistic tasks that involved (a) fast processing of linguistic information; (b) digit recall; (c) mental flexibility; (d) in-depth processing of verbal information; (e) verbal learning; and (f) non-verbal memory skills. The results of the present study demonstrate that there were significant differences between how the two language groups performed on several cognitive-linguistic measures in the battery.

There was a significant difference in the performance of Greek- and English-speaking participants on tasks that required fast processing of linguistic information. English speakers completed Trail Making Tests A and B, which required attention, mental flexibility, and fast processing of verbal and visual information, at a significantly faster rate than Greek speakers. The Trail Making Tests require the processing of letter and number words through phonological encoding. Word length impacts the rate of phonological encoding, with words of longer syllable length and sound duration taking longer to process than monosyllabic words (Ellis and Hennelly, 1980). Given that Greek numbers and letters contain more than one syllable compared to primarily monosyllables in English, this result suggests the Greek speakers needed more processing time due to the multi-syllabic structure of the Greek words.

Similar results were found for the auditory span tasks, Digits Forward and Digits Backward. English-speaking participants had significantly longer digit spans for both the forward and backward conditions compared to Greek speakers. The recall of digits requires subvocal rehearsal in short-term and working memory. The spoken duration of words during
rehearsal impacts memory span. The findings in this study suggest that Greek multi-syllabic digits take longer to articulate and rehearse than the English monosyllable digits and therefore resulted in shorter digit spans for Greek speakers. These results are consistent with former studies on digit span, which suggested that words with longer articulation rate result in shorter digit spans (Chincotta & Underwood, 1997; Naveh-Benjamin & Ayres, 1986). Likewise, similar results were obtained in the former phase of this project, which found larger digit spans and faster processing on the Trail Making tests for English speakers in a sample of Greek and English speakers, ages 18 to 50 years. The differences observed between the Greek and English speakers on digit span tasks, as well as tasks requiring fast processing and mental flexibility, may be attributed to linguistic structural differences and indicate the need for separate, language-specific normative data for assessing these abilities.

The verbal fluency tasks administered in the present study also required speed of response and additionally involved linguistic organization and categorization. Greek speakers scored significantly lower on both the phonemic and semantic verbal fluency tasks compared to their matched English-speaking counterparts. These results correspond with previous studies which found cross-linguistic and cross-cultural differences in verbal fluency scores (Acevedo et al., 2000; Rosselli et al., 2002). The results of the present study are also consistent with suggestions that differences in verbal fluency scores may be due to differences in syllable structure and differing cultural experiences with the process of test taking (Kosmidis et al., 2004). Additionally, the difference between the groups may be attributable to differing educational experiences and the corresponding ease or lack of familiarity with tasks requiring rapid accessing of the linguistic lexicon.

Based on the differences involved in encoding phonological versus semantic information, no significant differences were expected between Greek- and English-speaking participants on tasks in the neuropsychological battery which required in-depth processing of linguistic information. The Logical Memory subtests 1 and 2 are paragraph recall tasks, which require the encoding of verbal linguistic information based on semantic characteristics versus phonological characteristics. Recall for details from a paragraph-length story requires meaning-based, semantic encoding and contextual association. The contextual nature of the tasks and the inherent organization of a paragraph facilitate in-depth encoding or semantic encoding, which can result in a stronger memory trace than phonological encoding alone (Craik & Lockhart, 1972).
Therefore, the structural, phonological characteristics of a language were not expected to impact performance on these tasks.

Results indicated there were no significant differences between the Greek and English speakers in this study on Logical Memory Story 1 A or 2 A (immediate and delayed recall of Story A). However, significant differences were observed for Logical Memory Story 1 B and 2 B (immediate and delayed recall for Story B). Likewise, significant differences were observed between the two languages for the Logical Memory Total scores. The differences in the results for Story A versus Story B may be due to the story content and the impact of cultural experiences. Story A describes a scenario of a woman with young children, who was robbed on her way home from work. In contrast, Story B describes a scenario of a vehicular accident, which takes place on a deserted highway. The vehicle in Story B is a commercial ten-ton truck and the details involve the specifics of commercial transportation. The results (no significant difference for Story A compared to Story B) suggest the potential influence of culture on these tasks. Participants from the U. S. would be readily familiar with the scenarios in both stories, including large-vehicle highway transportation; whereas residents from the island of Cyprus may not have been able to make the same associations due to differing cultural experiences, even though the story was adapted to the culture.

The Greek- and English-speaking participants in this study were also compared on a task of verbal learning, the AVLT. The AVLT assesses learning patterns for new verbal information by presenting a 15-word list over five trials. Word list learning tasks also require in-depth encoding. As expected, similar learning patterns were observed for both the Greek and English speakers. Both groups benefited from the repeated trials of the list of words and learned more words as the trials progressed. However, English-speaking participants learned more total words per trial than the Greek speakers in the study. Given that English- and Greek-speaking participants had similar learning patterns, but differed on the total number of words learned, the difference in performance between the two language groups could be attributed to linguistic structural differences. However, this assumption is inconsistent with results from the former, initial phase of this project with younger Greek- and English-speaking participants. In the former phase, there were no significant differences between Greek and English speakers, ages 18-50 years, on the total number of words learned on the AVLT. The differences in total words learned between the two groups in the present study may be due to the Greek and English speakers using
different strategies to learn and remember the words, or to differences in the effects of aging on verbal learning performance between the two populations.

Several non-verbal tasks were administered as part of the neuropsychological battery in this study. Since non-verbal tasks do not contain linguistically-based material, it was expected that the Greek- and English-speaking participants would not differ significantly in their performance on non-verbal tasks. Results of the study revealed there were no significant differences between the two language groups on the Spatial Span Forward and Backward subtests; however, the two groups differed significantly on the copy condition and the recall condition of the RCFT. The RCFT and Spatial Span measures are constructed differently, with the Spatial Span requiring visual sequencing on a three-dimensional board and short-term memory abilities. The RCFT requires significant organizational abilities in addition to visuoconstructional skills to copy the figure, and visual working memory for the recall condition. Thus, differences in the nature of these tasks may have impacted performance.

Hedden et al. (2002) found similar results to the present study on the Spatial Span tasks, with no significant difference seen between participants from the U. S. and China on this three-dimensional non-verbal task. Differences in performance on the RCVT have been observed, however, between culture groups. In a critical review of non-verbal cross-cultural studies, Rosselli and Ardila (2003) cited significant differences seen between Columbian Aruacos and Canadian samples on the RCFT. Canadian participants and participants from western countries performed more than two standard deviations above non-western participants. Differences on the RCFT may be due to lack of familiarity with recall for non-sense line drawings in contrast to three-dimensional tasks. While the U. S. and Cyprus are both westernized nations, differences in performance on the RCFT may be attributed to cultural differences. In a previous study with Greek-Cypriot subjects, younger participants performed similarly to English subjects. Perhaps the differences observed in older adults may be related to differences in the educational and cultural experiences of older Cypriots and their level of familiarity and potential exposure to these types of tasks.

While it is widely accepted that non-verbal tasks are language and culture invariant, several investigators have found non-verbal cross-cultural differences (Ostrosky-Solís, Ramirez, & Ardila, 2004; Rosselli & Ardila, 2003). The results from the non-verbal measures in this study concur with cautions presented in the research literature about generalizing non-verbal abilities.
across cultures (Rey, Feldman, Rivas-Vazquez, Levin & Benton, 1999). More comprehensive and extensive investigations are needed to assert the universality of non-verbal cognitive skills. In addition, future studies should explore the effects of age on non-verbal abilities within a cultural group and within educational practices.

In addition to the results discussed above, there was a significant difference between the two language groups in the present study on the Mini-Mental State Examination (MMSE). The MMSE is a brief measure that assesses orientation, registration, attention, calculation, word recall, language, and visuoconstructual copy abilities to determine the presence of cognitive impairment. Results indicate that the English speakers scored significantly higher than Greek speakers on this measure. Similar results were also obtained with the younger Greek-Cypriot and U. S. participants in the former phase of this project, with English speakers scoring significantly higher than Greek-speaking participants. These outcomes are potentially due to the impact of language and culture on several tasks within the MMSE.

In a study comparing Hispanic and white non-Hispanic subjects, Escobar, et al. (1986) found that ethnicity and language influenced performance on the MMSE. There was a significant effect of ethnicity and language on several of the orientation items, the language item of sentence repetition, and the attention and calculation item, with Hispanic Spanish-speaking subjects scoring significantly lower than non-Hispanic English-speaking subjects. The authors cited cultural artifacts as contributors to the above results.

In the present study, differences in performance between the Greek- and English-speaking participants were seen on the word recall, attention and calculation, and visuoconstructual design copy tasks. The word recall task required verbal recall of three common words after completion of the calculation task. For the calculation task, participants counted backward from 100 by 7 for a total of five trials (i.e., 100, 93, 86, 79, 72, and 65). The visuoconstructual task involved copying a design of two intersecting pentagons. Twenty-four of the 26 Greek speakers in this study missed items on the word recall, with eight of the 24 missing all three words. In comparison, 19 of the 32 English speakers missed words on the recall task, with only one participant missing all three words. Eight of the 26 Greek speakers made errors on the calculation task compared to one English-speaking participant. Six of the 26 Greek speakers incorrectly completed the design copy and received no points for that item. All English-speaking participants copied the visuoconstructual design correctly.
Linguistic structural differences may have impacted the participants’ performance on the word recall and calculation tasks of the MMSE in a similar manner to the numeric digit span and the verbal word learning tasks in this study. Given that Greek speakers performed significantly lower on the RCFT, a visuonstructual copy design task, than English speakers, the difference in this non-verbal item on the MMSE also reflects the potential impact of varying cultural and educational backgrounds between the Greek-Cypriot and U.S. adult populations.

**Age-Related Cognitive-Linguistic Performance**

Participants in the Greek and English language groups in this study were separated into two age groups (ages 55-70 and 71+ years) for comparisons of age-related performance on the measures in the neuropsychological battery. Results indicated that there were significant differences on some measure between the two age groups for both the Greek speakers and English speakers, with the older age group in both languages scoring significantly lower than the younger age group. For the Greek speakers, significant differences were seen between the two age groups on two visual-spatial tasks, on Story B paragraph recall and on one verbal fluency task. For English speakers, significant differences were seen on version A of the Trail Making Tests (a visual/verbal task) and on all parts of the paragraph recall tasks. These differences in performance are consistent with former research on aging and cognition. La Rue (1992) identified several age-related memory deficits including reduced word naming, verbal fluency, and visuospatial abilities. The decline in performance seen in the older age group in both languages on the paragraph recall tasks is consistent with age-associated deficits in new learning and learning material that is complex and requires longer processing time (Bayles & Kaszniak, 1987; Poon, 1985; Baddeley, 1986).

While there were declines in the means between the age groups (across language groups) on most of the measures in the present battery, not all changes were significant. Constantinidou and Baker (2002) reported that older subjects performed within one standard deviation on the lower end of younger subjects’ mean scores on a similar battery of neuropsychological tests. Similar age-related changes are well documented in the literature. However, patterns of aging need to be explored systematically across cultures due to the combination of many factors. Overall, the results of this study identified changes in cognitive performance in Greek- and English-speaking adults over age 71 compared to their counterparts in the fifth and sixth decades.
of life. These results support the need for the collection of normative data for the older adult age ranges on neuropsychological measures.

**Implications of the Study**

Neuropsychological test adaptation into the Greek language has been very limited and there is a significant need for corresponding normative data for the Greek-Cypriot population. The results of this study indicate that Greek speakers perform differently on several cognitive-linguistic tasks compared to English speakers. The differences observed between the Greek and English speakers on digit span tasks, as well as tasks requiring fast processing and mental flexibility, may be attributed to linguistic structural differences and indicate the need for separate, language-specific normative data for assessing these abilities.

Results of this study suggest that cultural differences between the Greek-Cypriot and U.S. participants may have impacted performance on several verbal and non-verbal memory tasks. In light of differing cultural experiences, the clinical administration of neuropsychological tests must consider the cultural and ecological experiences of examinees. The adaptation of neuropsychological measures into other languages requires careful attention to cultural variables, in addition to linguistic structure.

The data collected on the Greek-Cypriot participants in this study provide preliminary clinical data for assessing the neuropsychological performance of older Greek-Cypriots, ages 55+ years. Such data, combined with knowledge of age-related changes in cognitive performance, will assist professionals working to evaluate older adults with suspected cognitive-linguistic disorders.

**Limitations**

An objective of the present study was to establish preliminary normative data for the Greek-Cypriot population on a battery of neuropsychological tests. One limitation to this objective is the small sample size. Normative data collected from a larger sample would increase the accuracy of the data and the representation of the populations under investigation. Nonetheless, the sample from the present study was able to provide preliminary clinical data for professionals assessing the neuropsychological performance of older Greek-Cypriot adults.

Another limitation of this study was the educational level of the participants. The average number of years of education was 13.76 years for the Greek-Cypriot participants and 14.65 years for the U.S. participants. While the two language groups in this study are closely matched in
education, the levels of education represented in the sample are not stratified across the potential levels of education for the 55 years + age groups within each country.

An additional limitation relates to the regional demographics of both language groups. Participants in this study were from specific, limited regions in the United States and on the island of Cyprus. A more diverse sample is needed to avoid potential regional effects and to provide a broader representation of both culture groups.

**Future Research**

Cultural relevance, learning opportunities, ecological demands and familiarity with testing situations (Ardila, 1995) are factors capable of influencing performance on neuropsychological tests. Given the influence of linguistic and cultural variables on cognitive performance, future research should continue to focus on the adaptation of neuropsychological measures into the Greek language, as well as other languages.

Further research is still needed for cross-cultural, cross-linguistic comparisons of cognitive-linguistic abilities in adults across the life span. The present study focused on the performance of older Greek and English speakers and did not explore cross-cultural, cross-linguistic comparisons of the neuropsychological test performance of young adults and older adults. A future line of investigation would be to compare the data collected in the former phase of this project (Greek and English speakers, ages 18 to 50 years) to the data from the present study (Greek and English speakers, ages 55 years and above). Different results were obtained in the present study on several verbal and non-verbal measures compared to the former study with younger participants, ages 18-50 years. Therefore, the effect of age on these cognitive functions needs to be explored further.

Additionally, cross-cultural, cross-linguistic studies investigating other languages should focus on comparing the performance of older and younger adults.

While demographic trends indicate increasing life spans, the collection of normative data on many neuropsychological measures for the upper age limits (ages 75+ years) in all cultural and linguistic groups is still limited. Future research should focus on not only obtaining normative data for the upper age limits, but comparing adults in the upper age limits across languages and cultures.

The average educational level of the participants in this study was fairly high. Additional research is needed to examine the performance of participants from lower educational groups on
the measures in the neuropsychological battery. This line of investigation would yield clinical
data for Greek-Cypriots that could be stratified by education level, as well as facilitate
comparisons of the effects of education on the measures in the battery.

More extensive comparative studies will be needed to investigate if the findings of the
present study can be generalized to other languages. Likewise, more extensive studies with larger
population samples are needed to augment the available clinical data for assessing the
neuropsychological performance of Greek-Cypriots.
References


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APPENDIX A

Mini-Mental State Examination

<table>
<thead>
<tr>
<th>Patient Score</th>
<th>Maximum Score</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>What is the (year) (season) (date) (day) (month)?</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Where are we (country) (state) (country) (city) (clinic)?</td>
</tr>
</tbody>
</table>

Registration

|               | 3             | Name three objects, allotting one second to say each one. Then ask the patient to name all three objects after you have said them. Give one point for each correct answer. Repeat them until he hears all three. Count trials and record number. |
| Number of trials | ___          | APPLE …BOOK…COAT |

Attention and Calculation

|               | 5             | Begin with 100 and count backwards by 7 (stop after 5 answers): 93, 86, 79, 72, 65. Score one point for each correct answer. If the patient will not perform this task, ask the patient to spell “WORLD” backwards (DLROW). Record the patient’s spelling. Score one point for each correctly placed letter. |

Recall

|               | 3             | Ask the patient to repeat the objects above (see Registration). Give one point for each correct answer. |

Language

<p>|               | 2             | Naming: Show a pencil and a watch, and ask the patient to name them. |
|               | 1             | Repetition: Repeat the following: “no ifs, ands, or buts.” |
|               | 3             | Three-Stage Command: Follow the three-stage command. “Take a paper in your right hand: fold it in half and put it on the table.” |
|               | 1             | Reading: Read and obey the following: “Close your eyes.” (written on reverse side of examination sheet). |</p>
<table>
<thead>
<tr>
<th>Type</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
<td>1</td>
</tr>
<tr>
<td>Copying</td>
<td>1</td>
</tr>
</tbody>
</table>

Writing: Write a sentence (on reverse side of examination sheet).

Copying: copy the design of the intersecting pentagons (on reverse side of the examination sheet).
Appendix B

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APPENDIX C

Visual Screening

Instructions to the subject: Read aloud the words written on the page.

  greet
  severe
  window
  borrow
  absent
APPENDIX D

Hearing Screening

PART A

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CORRECT WITHOUT CUE</th>
<th>LATENCY SECS</th>
<th>INTELLIGIBLE</th>
<th>ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pencil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whistle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toothbrush</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hanger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mushroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Criterion for Part A = 80% accuracy*

PART B

<table>
<thead>
<tr>
<th></th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Point to the pencil, then to the mushroom.</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>2. Point to the hanger, then to the whistle.</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Point to the toothbrush, then to the pencil.</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

*Passing Criterion for Part B = 66% accuracy*

OVERALL SCREENING RESULTS: PASS FAIL (circle one)