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Effects of Bilingualism on Executive Functioning in a Georgian-American Sample: A Latent Variables Approach. Preliminary Normative Data

Irma Campbell
Philadelphia College of Osteopathic Medicine

Philadelphia College of Osteopathic Medicine

School of Professional and Applied Psychology

Department of Clinical Psychology

EFFECTS OF BILINGUALISM ON EXECUTIVE FUNCTIONING IN A GEORGIAN-AMERICAN SAMPLE: A LATENT VARIABLES APPROACH. PRELIMINARY NORMATIVE DATA

By Irma Campbell

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DISSERTATION APPROVAL

This is to certify that the thesis presented to us by _______Irma Campbell________

on the ___7th ___ day of ____May_, 2020___, in partial fulfillment of the

requirements for the degree of Doctor of Psychology, has been examined and is

acceptable in both scholarship and literary quality.

COMMITTEE MEMBERS' SIGNATURES

[redacted]

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"If the human brain were so simple that we could understand it, we would be so simple that we couldn't."

Emerson M. Pugh

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ABSTRACT

Over the past several decades, bilingual advantage has been a topic of continuous debate among neuroscientists and linguists. Bilingualism was thought to negatively affect one's cognitive development. Although a number of studies have shown positive effects of bilingualism on executive functioning, this view has been often challenged on methodological grounds. The current study examined monolingual and bilingual Georgian-American immigrant participants (*N* = 130). The results of this study showed that the bilingual individuals performed superior to the monolingual participants on three measures of executive functioning. In addition, the level of performance on measures of executive functioning that emerged in bilingual participants was found to be associated with the level of proficiency in their second language. Thus, the better performance on all measures of executive functioning emerged in bilingual participants with the greater proficiency in their second language in comparison to their monolingual counterparts or those with relatively inferior second-language proficiency. The findings indicate that bilingualism positively impacts cognitive shifting, inhibition, and updating and that there is a positive relationship between the levels of bilingualism and executive functioning. Normative data on performance on measures of executive functioning in a Georgian-American population sample were established.

Keywords: bilingualism, executive functioning, neuroplasticity, Georgian bilinguals, normative data, measures of executive functioning, trail making test, Stroop test, Ruff Figural Fluency Test, Georgian language, cultural neuropsychology

CHAPTER 1: INTRODUCTION

Statement of the Problem

Nearly 7,000 languages are spoken around the world (Boroditksy, 2011; Ryan, 2013), and more than half of the world's population speaks at least two languages (Grosjean & Miller, 1994). According to Ryan (2013), in 2010, in the United States alone, "59.5 million people spoke a language other than English" (p. 5). Furthermore, the number of dual-language speakers is expected to continue to grow within the United States (Ryan, 2013). However, the cognitive effects of bilingualism remain largely unclear and continue to be a source of heated debate within the scientific community.

Effects of bilingualism on cognitive functioning, whether in the domain of language, executive functioning, or overall intelligence, have been debated since the mid-19th century (Arsenian, 1945). For instance, "In the 1950s and 1960s bilingualism was viewed as a major obstacle to cognitive development and thus made largely responsible for the academic failure of immigrant children from non-English-speaking homes" (Watzinger-Tharp, 1994, p. 168). Although evidence in support of benefits of bilingualism began to accumulate in contemporary research, the notion of bilingual advantage in executive functioning received many challenges from the researchers because of methodological weaknesses often shown in the studies (Paap & Greenberg, 2013; Paap et al., 2016).

Paap et al. (2016), for instance, noted that sample size, lack of power, publication bias, and presence of confounding factors, including biological and environmental variables (e.g., genetic aspects, age, gender, culture, education, experience with playing music, and video games), are largely accountable for the unclear results. Additionally, previous studies that compared bilingual and monolingual groups have been criticized for using a categorical approach in contrast to assessing bilingualism on a continuum. Many authors underlined the lack of clear understanding of the connection between language and its influence on executive functioning (Paap et al., 2016; Treccani & Mulatti, 2015). Other studies that have demonstrated bilingual advantage in cognitive functioning were faulted for including only balanced bilingual participants (e.g., Peal & Lambert, 1962), thereby introducing their own set of biases (i.e., better executive functioning may be confounding second-language acquisition; Cox et al., 2016; Paap et al., 2015). Furthermore, many studies used culturally mismatched group samples or assessed mainly Chinese-English bilingual persons, consequently placing culture as a potential confound (Carlson & Meltzoff, 2008).

Nevertheless, with parallel rises in mortality and neurocognitive disorders (Brayne, 2007), inconsistent findings on bilingualism deemphasize and delay needed new formulations of innovative preventive practices directed against the degenerative process of dementia. Furthermore, with the increasing population diversity in the United States, unclear outcomes of bilingualism research often reverberate in unclear educational, as well as immigration, policies. Bilingualism is not profusely accepted throughout the United States among policy makers and educators (Gómez Sará, 2017; McCardle, 2015). Attempts to adopt second-language learning in many countries around the world have been met with opposing opinions (Gómez Sará, 2017). The issue of whether to preserve linguistic diversity or pursue linguistic homogeneity is a longstanding matter (Arsenian, 1945). Contrasting findings in the literature on bilingualism complicate the debate between supporters of diversity, multiculturalism, and integration and those who promote assimilation.

Purpose of the Study

The present study investigated whether there is a presence of a bilingual advantage in executive control in a sample of Georgian-American participants. As mentioned earlier, bilingualism is a matter of degree. As such, this study examined possible bilingual advantage in executive functioning by considering linguistic variables on a continuum (i.e, discarding a categorical approach to bilingualism).

The second and simultaneous goal of the study was to obtain normative data for a Georgian-American sample on specific tests of executive functioning.

Research Questions and Hypotheses

Based on the literature review, on Green's (1998) inhibitory model, and on Miyake et al.'s (2000) model of executive functioning, several hypotheses were tested in the present study:

Research Question 1: Does greater language fluency in bilingual individuals (as measured with a phonemes F, A, and S (FAS; defined later) predict comparative performance on measures of executive functioning?

Hypothesis 1: Levels of the second-language fluency in bilingual individuals (performance on FAS test) will correlate with the performance on measures of executive functioning.

Research Question 2: If executive advantage is found in the Georgian-English bilingual individuals, does it extend to all or just some aspects of executive functioning?

Hypothesis 2:

1. Georgian bilingual individuals will outperform their monolingual counterparts on measures of inhibitory components of executive functioning as measured by the Stroop Color and Word Test.
2. Georgian bilingual individuals will show better performance on measures of the switching component of executive functioning, as evaluated by the Trails B Test, in comparison to their monolingual counterparts.

3. Georgian bilingual individuals will perform better than monolingual participants on measures of the updating component of executive functioning, as assessed by the Ruff Figural Fluency Test (RFFT).

Research Question 3: What is the normative performance of a Georgian-American sample on a selected measure of executive functioning, and how does it compare to North American norms?

Hypothesis 3: The Georgian-American sample will show a performance different from that of North American norms on a selected measure of executive functioning in the study.

CHAPTER 2: REVIEW OF THE LITERATURE

Historical Perspective

Language may be conceptualized as one of the most powerful tools in human existence. It is a vehicle for human progression (Arsenian, 1937). As Arsenian (1945) stated, "It is through language and its development, both in the race and in the individual, that concepts and meaning arise to multiply and extend the scope of thinking" (p. 65). Two opposing views on whether language is a necessary aspect in one's cognitive development have been dominating the literature for decades. At one end of the debate were supporters of Piaget's (1970) theory of cognitive development, which did not require an interdependence of language and thought (as cited in Cummins, 1976). On the other side of the argument were advocates of Vygotsky's (1962) theory, which stated that language is a necessary attribute in the development of a coherent and reasonable thought (as cited in Cummins, 1976). While the discourse about the relationship between language and its impact on cognition has continued, the research has extended to exploration of effects of bilingualism on cognition.

The studies that investigated consequences of bilingualism on intelligence can be traced back to the early 1920s (Barac et al., 2014; Hakuta & Diaz, 1985; Saer et al., 1922). Previous studies assumed that bilingualism negatively impacted various functions of the brain. For instance, Saer et al. (1924) observed a cognitive advantage in monolingual rural children in comparison to their bilingual rural counterparts. However, the authors found no differences in cognitive abilities between urban monolingual and bilingual children or between urban monolingual and bilingual adult university students. Similarly, monolingual advantage was found on various measures of intelligence tests when rural bilingual and monolingual university students were compared (Saer et al., 1924). It was determined by these authors that managing two languages simultaneously is detrimental to one's general cognitive abilities.

Similarly, in his comprehensive literature review of earlier studies on the effects of bilingualism on academic and linguistic abilities, Cummins (1976) documented evidence of bilingual disadvantage on cognitive measures. For example, the author cited a study conducted by Tsushima and Hogan (1975) showing that verbal and academic skills were significantly reduced in Japanese-English bilingual children when compared to the monolingual controls.

Many researchers, however, began to address methodological flaws of prior findings, and the pendulum from negative impact of bilingualism on overall intelligence gradually began to shift in the opposite direction. To explore the impact of bilingualism on overall intellectual functioning, Peal and Lambert (1962) compared 10-year-old French-English bilingual children to same-aged French monolingual children on verbal and nonverbal intelligence tasks. In contrast to earlier studies, the authors compared balanced bilingual children (i.e., balanced proficiency in native and second language, discussed later) to monolingual children and found bilingual advantage on both verbal and nonverbal intelligence tests.

Researchers who began to correct for verbal fluency in their studies found significantly better performance on nonverbal measures among the bilingual groups. Cummins (1976) referenced the Gowan and Torrance (1965) study, which found a higher performance in bilingual children when they were instructed in their native language in comparison to when instructions were given in the second language.

Theoretical Framework: Inhibitory Control Theory.

Green (1986) proposed an inhibitory control model and postulated that during word production two appropriate names that share perceptual and functional properties are simultaneously activated. However, a target word name dominates and inhibits a “candidate name” by reducing the level of its activation. According to this model, bilingual speakers select an intended language while inhibiting an unintended one. As noted in Bartolotti et al. (2017), while monolingual persons encounter phonological competition, “competition between languages includes an *additional* [italics added] component of non-target language activation” (p. 135).

Nosari and Novick (2017) further extended Green’s (1986) inhibitory control model and described the mechanisms involved in the control system, using spreading activation models or connectionist networks. They pointed out that although speech production in healthy speakers occurs without a conscious effort, a self-correction of occasional speech errors is indicative of a presence of *monitoring* and *control* systems. As the authors explained, because of the structural interconnectedness of the semantically related features, several conceptually similar representations become simultaneously activated. As such, a monitoring system is required to resolve interference among the semantically similar active words to correctly select an intended word or phoneme, which in turn requires a control system. The authors noted that a primary role of the monitoring system is “correcting errors already made and preventing such errors from recurring” (p. 406).

A single process, such as inhibition of nontarget language, however, has not been fully accepted as a satisfactory explanation in the bilingual literature. La Heij (2005) elucidated that an additional activation of the target language, rather than just an inhibition of nontarget language, is the mechanism used in bilingual speakers. Similarly, expanding on the single inhibitory process model, Timmer et al. (2017) suggested that an additional process associated with language selection must be present. As both languages remain active (Green, 1986) and while attention to nontarget language is inhibited, “bilinguals also demonstrate facilitation through activation of the non target language” (Bialystok, 2010, p. 94), suggesting that more than one mechanism is involved in executive control advantage (Bialystok, 2010).

In sum, two distinct language systems remain continuously active in the bilingual brain. The selection of a relevant language requires a sophisticated mechanism, such as ongoing inhibition of the nontarget language and selection of an appropriate one. A continuous practice of suppression of the irrelevant language is thought to enhance executive control in bilingual persons. Thus, according to inhibitory linguistic control theory, bilingual persons have an advantage in executive control because of a continuous practice of suppression of the nontarget language and activation of the target language.

Nonverbal Functioning: Connection to Language

In her contemporary research, Bialystok (2015) noted that the efforts of bilingual speakers to continuously resolve a conflict between simultaneously active languages involve a nonverbal cognitive domain. She elaborated that two contrasting languages are a source of “novelty. . . attracting more attention” (p. 121). Such increased attention establishes and strengthens the representational structure of the two languages, thereby enhancing executive functioning by maintaining attention to the target language. This view is in line with Navon’s (1977) findings of attentional dominance to global over local detail (as cited in Bialystok, 2010).

Similarly, according to a Georgian author, Imedadze (1960), and to Leopold (1949), ‘“the simultaneous acquisition of two languages in early childhood might lead to a faster separation of sound and meaning, thereby directing the bilingual child’s attention to the essential or conceptual attributes of object”’ (as cited in Cummins, 1976). In other words, according to Imedadze (1960) and Leopold (1949), an advantage of bilingual children seems to be reflected in their abilities to direct attention to conceptual rather than phonetic qualities of language and to the attributes of both languages (as cited in Cummins, 1976). Thus, exposure to a wider range of experiences and the ongoing processes of switching between the two languages enhance cognition in a bilingual child (Cummins, 1976).

Executive Functioning

Executive function, as described in Friedman and Miyake (2017), involves a high level of cognitive processing, which governs lower level processes and is distinguished from general fluid intelligence (Paap & Sawi, 2014). It is expressed in cognitive abilities, such as shifting attention between relevant stimuli, response inhibition to salient stimuli, interference control, working memory, and updating (Friedman & Miyake, 2017). In general, mental tasks, such as shifting, inhibition, and updating, are considered to encompass executive functioning. Executive-functioning skills, known to entail a set of cognitive processes that govern thoughts and behaviors, vary with age and are more evolved in early adulthood in comparison to infancy and old age (Yow & Li, 2015). Chan et al. (2008) summarized the definition of executive functioning as “an umbrella term comprising a wide range of cognitive processes and behavioral competencies which include verbal reasoning, problem-solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilization of feedback, multitasking, cognitive flexibility, and the ability to deal with novelty” (p. 201). Frontal and prefrontal cortices are the most common cortical areas associated with executive functioning (Luria, 1966; Miyake et al., 2000;

Paap & Sawi, 2004). However, the cortex, basal ganglia, thalamus, and cerebellum also are noted to be involved in executive functioning (Rabinovici et al., 2015).

Models of Executive Functioning: Unity and Diversity. Using Teuber's (1972) notion of unity and diversity, Miyake et al. (2000) assessed conflicting evidence of possible unity and diversity (defined later) of executive functions. The authors examined three of the domains of executive functioning: updating, shifting, and inhibition. The researchers defined inhibition as the ability to inhibit automatic response. Shifting is the ability to flexibly move between two or more tasks, and updating refers to the ability to monitor and appropriately revise information held in working memory. Employing confirmatory factor analysis, the authors compared the three-factor model to a model that assumes that the three executive functions are common (one-factor model) and that assumes that two factors are common (two-factor model). As hypothesized, the authors found that the fit of the three-factor model was significantly better in comparison to the other two models. According to Miyake et al. (2000), executive function receives a contribution from separable updating and shifting components and a nonseparable inhibition component (i.e., unity and diversity). Thus, the authors concluded that in addition to unity (defined as shared contributing roles of domains of executive functions to overall executive functioning), the three executive functions are characterized by diversity (defined as distinct roles of domains of executive functions). In other words, inhibiting, updating, and shifting contribute to common executive functioning.

Similar findings emerged in Perrone-Bertolotti et al.’s (2017) study that showed that executive functioning consists of a set of abilities that include response suppression, inhibitory control, shifting, and working memory. Thus, these separate cognitive components collectively contribute to executive functioning, allowing individual differences either in overall executive-functioning skills or within each component (Paap & Sawi, 2014).

Analogously, McCloskey (2006) in his comprehensive model of executive function highlighted that executive functioning varies not only with regard to functions across the domains (e.g.., cognition, action, perception) but also with regard to developmental stages (e.g., infancy, adulthood). Therefore, as the author suggested, while exectuive control strongly depends on the specific cognitive domain, it also depends on the individual’s developmental age. Consequently, the multidimensional nature of exectuive functioning, as expected, requires a methodical selection of assessment measures (McCloskey, 2016).

Bilingualism

Bilingualism is a “widespread phenomenon” and has been defined in the literature as the use of two languages (Arsenian, 1945, p. 66; Gathercole, 2015). Classification of bilingualism in the literature is often based on features of the second-language usage, including fluency and proficiency, frequency of use, age of acquisition, and length of exposure (Luk et al., 2011). Some authors have suggested that effects of bilingualism on cognition depend on those features. Specifically, simultaneous versus gradual language acquisition, frequency of language usage in various contexts, and the assigned superiority of one of the languages may have different contributions to cognitive abilities of a bilingual person (Cummins, 1976). Additionally, Arsenian (1945) asserted that bilingualism “is not a uniform phenomenon; not all bilinguals use their two languages with equal degree of efficiency, and the degree of efficiency will vary in the life of the very same individual” (p. 70). Similarly, Yow and Li (2015) noted that monolingualism and bilingualism are not discrete all-or-none variables, rather “bilingualism is a *dynamic* [italics added] experience that is composed of multiple dimensions” (p. 3).

More recently, research distinguished between the types of bilingualism. According to Kousaie et al. (2017), individuals who learned two languages from birth are referred to as *simultaneou*s bilingual individuals. When they acquire second language “following mastery of their first language” (p. 49), those individuals are considered *sequential* bilingual individuals. Acquirers of a second language after the age of 3 years are considered *late* bilingual individuals (Genesee et al., 2004). Conversely, bilingual individuals who were exposed to a second language between the ages of 0 and 3 years are referred to as *early* bilingual individuals (Palomar-García et al., 2015).

Furthermore, De Bruin et al. (2015) stressed that bilingual persons vary not only in time of language acquisition and proficiency, but also in second-language use. Based on frequency of use, the authors distinguished between the *active* (high use of a second language) and *passive* (low use of a second language) bilingual individuals. Similarly, Yow and Li (2015) explained *balanced* bilingualism, which, according to the authors, denotes equal usage of and proficiency in two languages.

Mixed Findings on Bilingualism and Methodologies

Arsenian (1945) summarized the methods used in early studies to assess effects of bilingualism on cognition. He explained that the early measures used to compare intellectual development of bilingual and monolingual children often included verbal tasks, nonverbal tasks, or a combination of the two. In addition, while some studies used cross-sectional design, others were conducted longitudinally and followed bilingual individuals from nursery-school to graduate-school levels.

According to Arsenian (1945), on the verbal measures used to assess intelligence, bilingual children scored lower than their monolingual counterparts. However, these discrepancies on the verbal measures among bilingual and monolingual children were temporary, and as the author noted, the gap dissipated with increase in age and education. Also, as the author noted, the disparity in findings on verbal intelligence between the bilingual and monolingual individuals was higher in children from rural areas than children from urban areas. Thus, educational opportunities and social aspects seemed to be noteworthy factors in Arsenian's (1945) findings. In sum, subsequent to examining and summarizing 100 studies, the author found no difference in intelligence between bilingual and monolingual children.

Carlson and Meltzoff (2008) highlighted a rapid development of inhibitory control in bilingual children. The authors noted that the inhibitory processes in bilingual children stem from their continuous experience of diverting attention away from nontarget stimuli when faced with conflictual information. They argued that inhibitory control is the “key component of executive functioning” (p. 283). In her study of cognitive development and control of bilingual children, Bialystok (1999) compared bilingual and monolingual preschoolers on nonverbal tasks. The researcher examined preschoolers on the Dimensional Change Cards Sort task, which requires children to sort cards by certain dimensions and switch to another dimension when prompted. Thus, successful completion of the task requires an ability to switch between the sorting rules. The author found that Chinese-English bilingual children demonstrated higher levels of control in comparison to English monolingual preschoolers. She attributed these findings to a greater attentional control in bilingual children.

Relative bilingual advantage on executive control in children was also documented in Carlson and Meltzoff’s (2008) study. The study participants, who consisted of a bilingual (Spanish-English) group, an immersion group (children instructed in either Spanish or Japanese languages at their school), and a control group (English monolingual), were assessed on multiple measures of executive functions. After controlling for lower verbal scores and parental education, the researchers found that the bilingual (Spanish-English) group outperformed their counterparts on measures of executive functioning.

Favorable effects of bilingualism on executive functioning were also shown in adults. Bialystok et al. (2004) examined effects of bilingualism in late adulthood. The authors investigated whether a bilingual advantage reduced age-related cognitive decline. The researchers explained that executive control begins to weaken with age because of weakened attentional control, thereby allowing attention to target stimuli while ignoring unwanted stimuli. The study, using the Simon arrows task, compared monolingual and bilingual 40-year-old and 70-year-old adults. The results revealed that bilingual individuals outperformed monolingual participants on measures of executive functioning. The authors elaborated that bilingual older adults showed faster reaction times on the Simon arrows task when compared to monolingual counterparts on the same measures.

Bilingual advantage was not found in the Duñabeitia et al. (2014) study. Using Stroop tasks (Stroop, 1935), the authors investigated inhibitory control of bilingual and monolingual children on linguistic and nonlinguistic tasks. A total of 504 high-school students from Spain were recruited in the study and were matched on age and overall measures of cognitive skills. According to the authors, the participants were administered the Spanish version of the Kaufman Brief Intelligence Test. Additionally, the measures of the students’ overall reading, arithmetical, and attention-related abilities were obtained through their teacher's assessment on a Likert-like scale. The response reaction times in both groups did not reveal a lesser interference in bilingual children in comparison to monolingual children. Duñabeitia et al. (2014) concluded that both groups of children performed similarly on the measures. However, when the authors performed a series of analyses on the error data, they noted that bilingual children showed a larger congruency effect (e.g., performed better on congruent tasks - when word and the color of the ink it was printed in matched). These findings were attributed to the baseline differences of the participants, as no group differences were found on the incongruent tasks (i.e., when word and color of the ink it was printed in did not match). Duñabeitia et al. (2014), citing Hilchey and Klein's (2011) meta-analytical work, did not discredit bilingual advantage. Rather, the authors implied the possibility of bilingual advantage in an older age group.

However, a study that investigated bilingual advantage in shifting ability among a population of older bilingual individuals who learned a second language later in life showed no difference in older adult groups. In their study, Ramos et al. (2017) investigated impacts of language and shifting ability in the older population. The participants had acquired a second language within the previous academic year. The authors administered a color-shape switching task pre and post test to measure. The experimental group was compared with controls who did not attend any language-learning courses. In contrast to the Bialystok et al. (2004) study, the findings did not reveal any significant differences in switching reaction times between pretest and posttest administration in the older population of participants. The authors concluded that the bilingualism did not exert any effect on switching ability in the older adults.

The literature has suggested that frequency of switching between the two languages, age at second-language acquisition, and degree of bilingualism in bilingual speakers are associated with performance on task-switching measures (Prior & Gollan, 2011; Yow & Li, 2015). Using a color-shape task, Prior and Gollan (2011) compared task-switching performance in Spanish-English and Mandarin-English bilingual individuals. The more frequently switching Spanish-English group was found to have better performance on the measure of executive functioning in comparison to the less frequently switching Mandarin-English language group.

Similar results were found in Yow and Li's (2015) study, which examined not only the frequency of second language use, but also the degree of bilingualism. Using four computerized measures of executive functioning (i.e., Stroop, Eriksen Flanker, number-letter switching, and *n*-back task), the authors examined inhibition, shifting, and updating and monitoring in English-Mandarin bilingual individuals. The authors found a positive correlation between age of second-language acquisition and executive function. Specifically, the researchers noted that early bilingualism, second-language acquisition before age 7 years (distinct from other researchers' definitions of early bilingualism; see Palomar-García et al., 2015), was associated with better performance on inhibition and set-shifting tasks.

Similar cognitive advantages were found to exist in late bilingualism. Vega-Mendoza et al. (2015), employing attention tasks, investigated late (i.e., nonbalanced) bilingual individuals in their first year of second-language acquisition and also at increased second-language proficiency at their fourth year of second-language learning. The authors noted that a bilingual advantage emerged in the fourth year, but not in the first year of the acquisition of the second language.

While no consensus exists on the ideal study design to examine the effect of bilingualism on executive function (Baker, 2011; Hakuta, 1986), a number of authors continue to voice their concerns about the confounding variables when conducting such studies. De Bruin et al. (2015), upon examining effects of bilingualism on executive function, showed the importance of the distinction between language knowledge and language use. The authors compared active and inactive bilingual individuals with a group of monolingual older adults on two tasks. The Simon arrows task was used to investigate interference suppression, while a task-switching paradigm was administered to examine switching costs (i.e., reaction times) between bilingual and monolingual participants. The authors did not find any significant bilingual advantage on the Simon arrows task. However, they noted an emergence of a significant advantage on the task-switching paradigm and a disadvantage on the nonswitch trials only in active bilingual individuals. This advantage, however, according to the researchers, dissipated after correcting for differences on switch (defined as switching between color and shape) and nonswitch trials (defined as two consecutive color or shape decisions).

Similarly, as stated in the De Bruin et al. (2015), the differences between active and inactive bilingual individuals did not emerge in the Simon arrows task. However, significant differences were noted between active bilingual individuals only and monolingual individuals on switching tasks. The authors discredited the obtained differences between bilingual and monolingual participants to specificity of switching and attributed them to “using and switching between two languages rather than purely knowing two languages” (p. 23).

Bilingual-monolingual differences were observed, however, in a similar, more recent study using event-related potentials during the switching task. Timmer et al. (2017) compared bilingual and monolingual participants on nonverbal and verbal task switching. As predicted, the authors found that while monolingual individuals exhibited late processing (i.e., longer response times), bilingual individuals, in addition to accuracy, showed an earlier processing (i.e., shorter response times) effect for the switching cost in both nonverbal and verbal tasks. The authors attributed these findings to bilingual individuals’ lifelong practice of attention to contextual cues required for switching to a target language. In addition, the authors highlighted an overlap in both verbal and nonverbal processes in bilingual individuals. This finding is consistent with literature that supports the view that the processes in the linguistic and nonlinguistic domains are comparable (e.g., Bialystok et al., 2012).

Transfer Problem

The supporters of bilingual advantage believe that selection of a target language or inhibition of a nontarget language within the context requires a form of cognitive control. As noted in Hartsuiker (20l5), lifelong use of the control processes in one domain strengthens cognitive control in the other domain. In other words, the supporters of bilingual advantage on executive function assume that continued engagement in the inhibitory process in one cognitive domain appears to transfer to other cognitive domains that also require inhibitory control (e.g., see Greenberg et al., 2013). Yow and Li (2015) went even further to suggest that "bilingualism may be a unique type of *executive-function training* that is successful in transferring language management skills to the global measures of executive functioning" (p. 10).

However, the process of extension of skills from one cognitive domain to another, which is also known as a transfer process, has been challenged by a number of researchers. Hartsuiker (20l5) argued that there is a lack of clarity of transfer process and domain generality. The author expressed skepticism with regard to the notion of transfer of skills from one domain to another and raised a scientific question: "Does music training improve cognitive control?" (p. 337). The answer to Hartsuiker's (2015) inquiry was supplied in Nosari and Novick's (2017) article. The authors defended domain generality of the language monitoring and control system.

They argued that while the various types of representations are domain specific (e.g., visual and verbal information), the monitoring and control systems of most domains operate and detect errors under the similar mechanism as the aforementioned language monitoring and control system.

Similarly, Li et al. (2014) emphasized the differences between linguistic training and other skills training, such as juggling. While noting that both produced changes in brain structure and function, the authors determined that linguistic skills may be different from other cognitive domains because of differences in practice intensity, frequency, and length of time. The authors reasoned that because of the well-known overlap between language and executive functions, enhanced linguistic abilities might parallel the enhancement of nonlinguistic abilities, to which they referred as a cross-domain effect (Li et al., 2014).

Brain-Imaging Studies

Le et al. (2014) claimed that a neural overlap among the language-specific and nonverbal tasks is substantial. The authors reviewed evidence from functional magnetic resonance imaging (fMRI) studies showing common neural paths involved during the monitoring process of both verbal and nonverbal tasks. According to the authors, the common areas include the presupplementary motor area, the anterior cingulate, and the ventrolateral prefrontal cortex. The ventrolateral prefrontal cortex also activated during the control process in production tasks when the speaker was to decide between the competing responses or in comprehension tasks during the conflict resolution tasks, such as the Stroop Color and Word Test. Consequently, the authors reasoned that the neural overlap between the domains points to a possibility of transfer of skills from one domain to another, as long as the same cognitive operations are engaged (e.g., conflict resolution).

Paap et al. (2015) questioned the contribution of imaging studies to bilingualism. The authors argued that there are misalignments between neural and behavioral differences, and hence neuroimaging studies provide insufficient evidence for bilingualism advantage. The misalignment problem, however, was challenged and refuted in Gold (2015), who deemed Paap et al.'s (2015) argument "unreasonable" (p. 369). He underlined the lack of currently known connection between the other variables (e.g., education, socioeconomic status, and diet) and certain brain areas that had been explored in the literature earlier than bilingualism.

Nevertheless, as Gold (2015) stated, the differences that have emerged in the imaging studies are indicative of presence of the bilingual advantage. The author cited other imaging studies (e.g., Gold et al., 2013) and highlighted a behavior-imaging correlation based on a lower response in the frontal region and faster task switching, and a higher white-matter volume and a lower interference effect in bilingual subjects. Functional reconfiguration of the brain has been well documented in other imaging studies, which showed that acquisition of a second language appears to have an impact on the *universal language neural network* (defined as preSylvian fissure, Broca's and Wernicke's areas; see Wong et al., 2016).

The cortical changes often depend not only on type of stimuli, but also on timing of the input. Wong et al. (2016) reviewed imaging studies that examined effects of bilingualism on structural, functional, and connective networks of the brain and found that bilingual individuals had increased gray- and white-matter volume and greater activation in frontoparietal areas and basal ganglia, providing support for stronger executive functioning in bilingual individuals. In addition, proficiency and age of acquisition of a second language had an impact on the neural networks, such as the left inferior parietal regions, left temporal pole, and hippocampal structures (Wong et al., 2016).

Similarly, Berken et al. (2017) explored effects of age on language acquisition and brain plasticity. The authors found that 2-day-old infants processed speech sounds bilaterally with right auditory cortex dominance. However, the inferior frontal gyrus (IFG) and temporal regions of the brain that are implicated in speech processing have been found to be similar in both 3-month-old infants and adults. The authors noted that concurrent exposure to two languages from birth (i.e., simultaneous bilingualism) resulted in structurally and functionally different neuronal pathways in the brain in comparison to the pathways in those who experienced sequential bilingualism (i.e., exposure to second language after learning the first language).

Evidence has shown separateness of two languages in Broca’s area. Berken et al. (2017) noted greater activation in speech motor areas during the second language use in late bilingual individuals when compared to first language use or to monolingual individuals. On the other hand, early bilingual individuals exhibited reduced activation in the IFG during speech production. In addition to structural and functional differences between early and late bilingual individuals, the authors noted existence of higher connectivity between left and right IFG regions in early bilingual individuals, providing evidence for cognitive adeptness in early bilingual individuals.

Furthermore, the authors highlighted superior inhibition and attentional control in simultaneous bilingual individuals. They stated that because the right IFG is involved in response inhibition, the enhanced attentional control and inhibition of irrelevant language during speech production are promoted by enhanced connectivity between these IFG regions. Thus, presence of an enhanced executive functioning in early bilingual individuals in comparison to late language learners was inferred from the findings in the Berkern et al. (2017) study.

However, changes in cortical structure were also observed with learning a second language later in life. Using fMRI, Bartolotti et al. (2017) examined effects of initial stages of late language acquisition on cortical structure in bilingual individuals. In the study, English monolingual individuals were taught Spanish words. The authors compared auditory processing of English (native) words and Spanish (newly learned) vocabulary. The study found activation in different regions of the brain. Specifically, an increase in hippocampal activity was observed during the early stages of the second-language acquisition, while posterior parietal regions were active during the native-language comprehension trials. Also, the authors observed native-language interference while processing newly learned language, corresponding to delayed response. The authors explained that hippocampal involvement is associated with early stages of a second-language vocabulary acquisition.

Bartolotti et al.'s (2017) study results are consistent with Cummins's (1976) threshold hypothesis, highlighting the difficulties in the initial stages of second-language learning because of interference from the simultaneously active native language. As noted in Bartolotti et al. (2017), mastering inhibition of the native language allows management of the cross-linguistic interference. The emerged findings of differences in cortical areas in monolingual participants' abilities to manage cross-linguistic interference, as the authors interpreted, were suggestive of unique ability of managing interference between two languages.

Georgian Language

Georgian language, with earliest inscriptions dating back to the 5th century, is structurally, orthographically, and grammatically distinct from Indo-European, Semitic, and Asian languages (see Slobin, 1992). Although Georgian language is autochthonous in its origin, various scholars ventured its commonality with the North Caucasus or Basque languages (Imedadze, & Tuite, 1992). Georgian language is considered distinct from many other languages. For example, unlike with the English language, word order in Georgian language is largely characterized by a freedom and flexibility (Skopeteas et al., 2009).

In contrast to an Indo-European Russian language, which has a Slavic origin, direction and orientations of a subject/object in relation to the speaker in Georgian are expressed with various prefixes (e.g., ‘mo’-toward the speaker, ‘mi’- away from the speaker; Tomelleri, 2006). The Georgian alphabet consists of 33 letters (28 consonants and five vowels). As words can consist of a string of consecutively grouped consonants (e.g., Tbilisi [Tb-ilisi- capital of Georgia], mdebareobs [md-ebareo-bs- located]; Aronson, 1990), most noun words typically end with a vowel sound. The third-person genders are absent in Georgian language and represented with one word (i.e., ი ს [is] he or she; მ ი ს ი [misi] his/hers; მ ა ნ [man]him/her). Furthermore, according to Imedadze and Tuite (1992), since early times, Georgians have continued to place great importance on “verbal skills, improvisation, recitation of poetry, storytelling, [and] giving [a] toast” (p. 40).

CHAPTER 3: METHOD

The purpose of the present study was to explore the impact of bilingualism on executive functioning in a Georgian-English bilingual population. The study was cross-sectional in design. Given the multifaceted nature of bilingualism, the present study used simple linear regression analyses. A methodological approach not only allowed examination of variables on a continuum (i.e., from no knowledge to perfect language knowledge), but also facilitated comparison of performance on executive functioning between groups, as well as within the groups (van Heuven & Coderre, 2015). As such, a regression analysis approach is strategic in capturing both participant-specific characteristics (e.g., individual differences) and item-specific characteristics (e.g., degree of bilingualism), allowing better comprehension of effects of bilingualism on executive functioning (van Heuven & Coderre, 2015).

Participants and Settings

This study sample included 130 foreign-born bilingual (Georgian-English) and monolingual (Georgian) volunteers from the Republic of Georgia living in the United States. The sample included 35.4% male and 64.6% female participants born in the Republic of Georgia. Individuals ranged in age from 18 to older than 65 years of age. Education level of the study participants ranged from having a high-school education to a doctoral degree and beyond. The number of years that participants resided in the United States ranged from 1 year to more than 20 years. The detailed characteristics of the sample are shown in Figuress 1 through 4. Of the 130 participants, the smaller number of the sample included monolingual Georgian participants (i.e., spoke only Georgian). Bilingual participants who spoke English varied in their acquired language fluency, ranging from poor to perfect (see Figure 5).

The study participants were recruited through community organizations (e.g., schools, churches, medical offices, Consulate Office of Georgia), personal social networks, snowballing technique, advertisements, and flyers. The tests were administered at various quiet locations, including participants' homes, libraries, and the investigator's work office (depending on the participants' preferences).

Inclusion and Exclusion Criteria

Participants were included in the study if they were at least 18 years old, had at least a high-school degree, and had lived in the United States for a minimum of 1 year. The participants were screened and excluded from the study if they reported a history of medical, neurological, or psychiatric disorders that could potentially interfere with test performance (e.g., head injury, learning disability, substance use, tremors, depression, major vascular medical conditions).

Measures

A demographic questionnaire was used to obtain necessary demographic information (i.e., age, education, gender, number of years residing in the United States., and self-rated proficiency).

Controlled Oral Word Association Test (COWAT)

The Controlled Oral Word Association Test (COWAT; Benton et al., 1983) was administered to measure the degree of English fluency of bilingual participants. Hence, the self-reported monolingual participants were not administered COWAT. The COWAT is a test that measures a phonemic (or letter) fluency. For this measure, the letters F, A, and S (FAS) were used based on available normative data (Loonstra et al., 2001; the terms *COWAT* and *FAS* are used interchangeably in this research). The bilingual participants were asked to name words that begin with designated letters, within a minute, with exclusion of numbers, proper names, or the same words with different endings.

Stroop Color and Word Test

The Stroop Color and Word Test (Golden, 1978) was administered to examine inhibiting aspects of executive functioning (Miyake & Friedman, 2012). Verbal instructions were given to the participants in their preferred languages (i.e., either in English or Georgian). In the word-reading section, the participants were asked to read words printed on the page as fast as they could, until stopped by the examiner. Similarly, participants were to name the color of the print, in the color-naming section. Finally, in the word-color segment, the participants were asked to name the color of the print of the word, inhibiting the actual word. The task requires the ability to inhibit attention to irrelevant but noticeable visual stimuli. The obtained number of words read by participants were analyzed and interpreted. The Stroop Color and

Word Test was translated to the Georgian language (translation approved by Stoelting Co.). The Georgian Stroop Color and Word Test followed the format of the English version, preserving colors and only translating words to Georgian.

Trail Making Test

The study participants were administered the TMT Parts A and B (Army Individual Test Battery, 1944; Reitan, 1992). Part A measures visual attention and psychomotor speed, and Part B is used to assess executive control, specifically cognitive flexibility (Jacobson et al., 2011). The TMT-A is composed of encircled numbers from 1 to 25 that are randomly scattered on a page. The participants were to connect the numbers in ascending order. Similarly, the TMT-B, which involves both numbers from 1 to 13 and letters from A to L, requires examinees to quickly draw a line from one circle to the next, shifting between numbers and letters in ascending (for numbers) and sequential (for letters) order without lifting the pencil. The performance was evaluated through the completion time of each part of the TMT and the number of errors made by the examinee. While both Parts A and B of the TMT measure visual search and motor speed, the executive portion of the TMT-B requires shifting, inhibition, planning, working memory, and attention (see Bialystok, 2010). The TMT was also translated to the Georgian language. (Given that the TMT is in the public domain, the approval for its translation was not required.) The Georgian TMT followed the English TMT format, preserving Western Arabic numerals (1 to 25) and replacing English alphabet letters with Georgian alphabet letters (e.g., ა ,ბ ,გ , დ.).

The Ruff Figural Fluency Test

The RFFT(Ruff, 1988) is a measure of nonverbal fluency that examines executive functioning (Izaks et al., 2011). It is a timed test, consisting of five trials, 60 seconds each. On the test protocol are rows of squares within which are located five dots; dots on some pages are accompanied by various distractors. The examinees have to produce as many unique designs as possible connecting two or more of these dots using straight lines. The calculated number of total unique designs measures their performance. A total number of repetitive designs were calculated and noted as “perseverative errors.” Furthermore, “error ratio” was obtained by dividing the total number of perseverative designs by the number of unique designs. RFFT instructions were translated and back translated (approval provided received from PAR). The Stroop Color and Word Test, TMT, and RFFT were translated because these measures are currently not available in the Georgian language.

Constructs

Grounded in Miyake et al.’s (2000) three-factor model of executive function, the present study used a latent variables approach and examined three distinct components of executive functioning: shifting, updating, and inhibition. Miyake et al, (2000) defined mental shifting as “shifting back and forth between multiple operations, the disengagement of an irrelevant task set and the subsequent active engagement of a relevant task set” (p. 55). The authors used a number-letter task as a measure of this construct. Similarly, the present study used Trail Making Test B (TMT) to measure shifting between numbers and letters.

The construct of updating was defined as “updating and monitoring of working memory representations” (Miyake et al., 2000, p. 56). The present study used the Ruff Figural Fluency Test (RFFT; Ruff et al., 1987) to tap into appropriate revision of items held in the working memory. Lastly, inhibition, another aspect of executive function, is the “ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary” (Miyake et al., 2000, p. 5). The Stroop Color and Word Test (Golden, 1978) is a commonly used measure for inhibition tasks (Miyake et al., 2000) and was used in this study.

Procedures

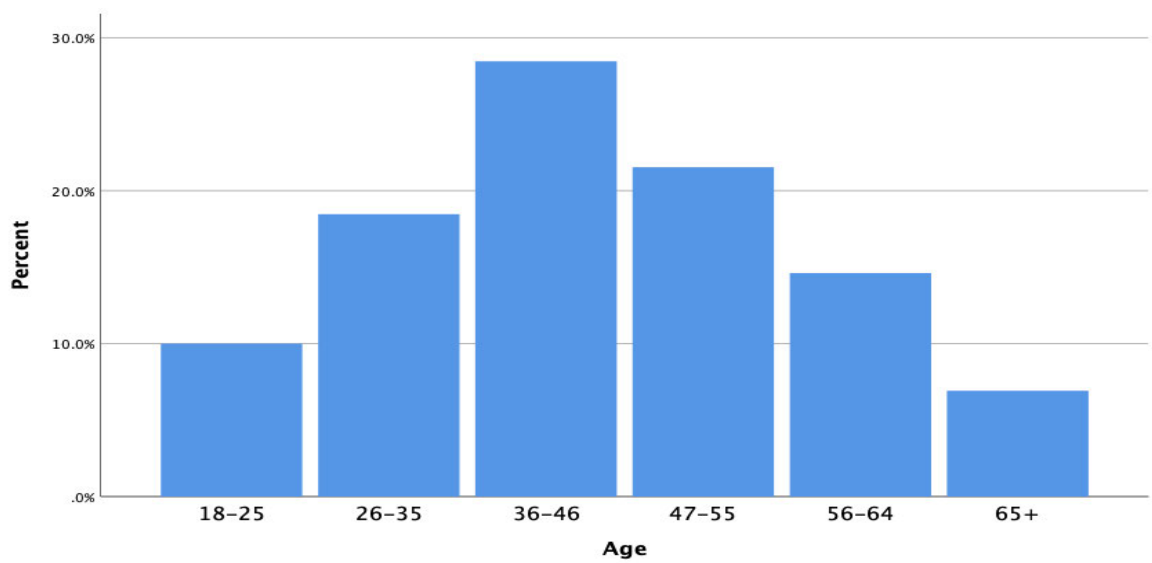
Prior to the testing procedure, all participants were informed about the objective of the study and procedures, and their written informed consent was obtained. The participants who were met at their chosen locations (i.e., their homes, libraries, the examiner’s work office) were tested by the examiner only (i.e., no other testers were designated for test administration). The bilingual participants were given a choice to select either an English or a Georgian version of the TMT, Stroop Color and Word Test, and RFFT administration, while self-identified monolingual participants were given instructions in their native language. The participants were verbally instructed in their respective languages to complete the tests as quickly and accurately as possible. The test administration followed the guidelines presented in Spreen and Strauss (1998). The testing lasted approximately 25 minutes. The participants were debriefed after the testing in regard to the overall goal of the study, and their general questions were answered. The data were deidentified (i.e., the participants were assigned their individual numbers), scored, and entered into an SPSS data set for further analysis.

CHAPTER 4: RESULTS

The SPSS software was used to perform the subsequent data analysis. Descriptive analyses were run on demographic variables, including age, gender, and education level, to describe the sample. The study was composed of 130 Georgian-American participants aged between 18 and 65 years and older. The majority of the study members were in the 36- to 46-year age range, and fewer participants were older than 65 years (see Figure 6).

Figure 1.

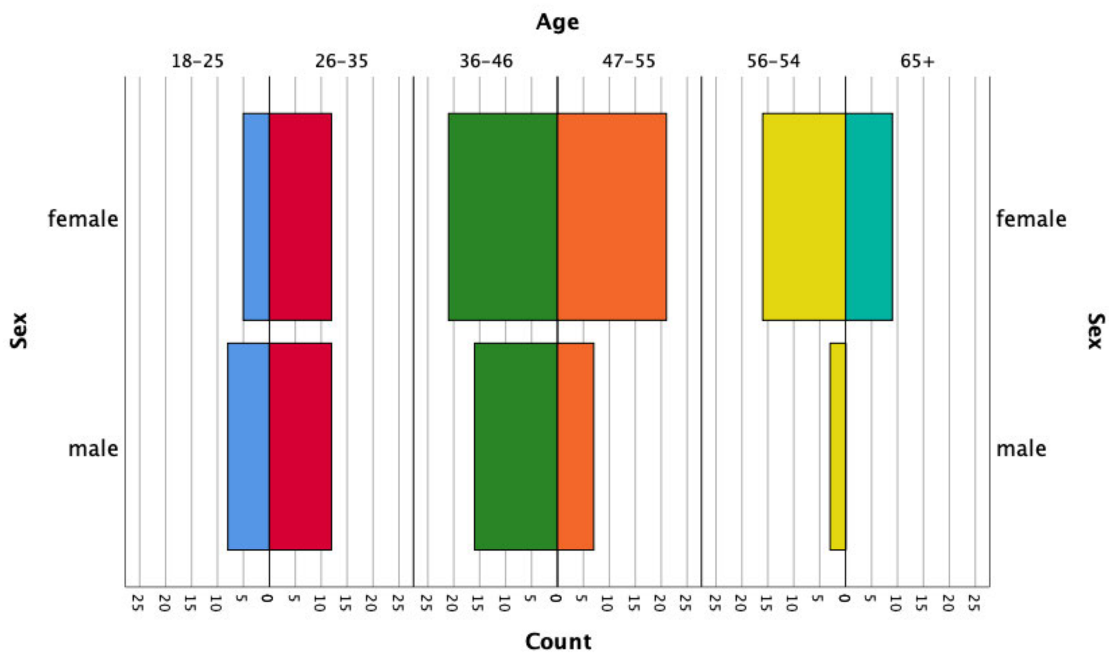
Demographic Data (Age)



With regard to gender, the majority of the study sample included female individuals, with a lesser number of male participants (see Figure 2).

Figure 2

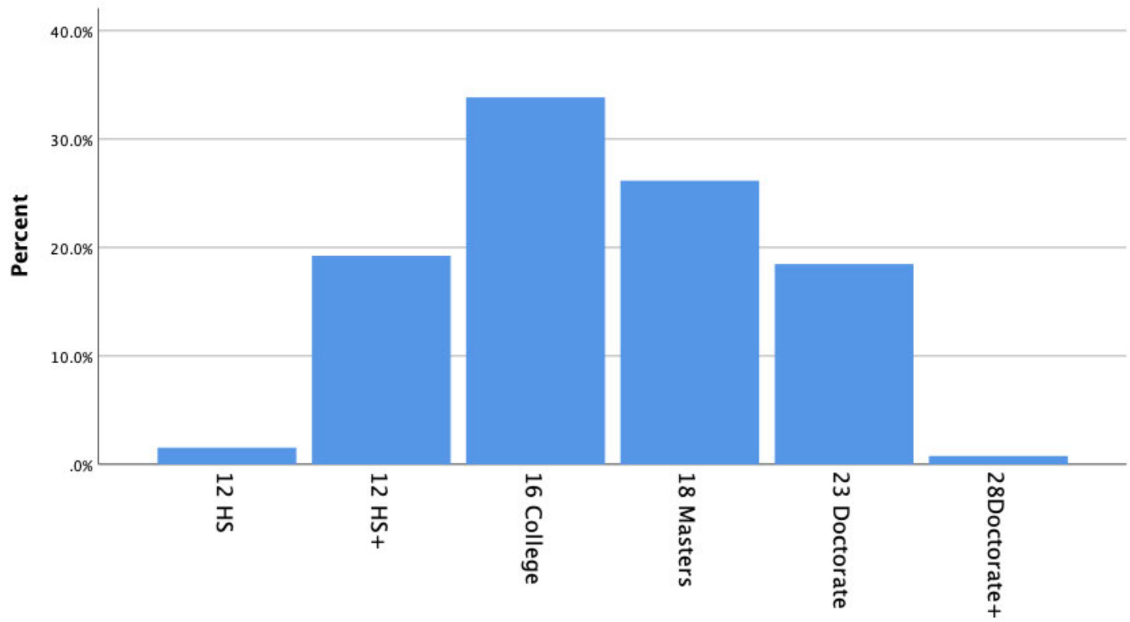
Demographic Data (Gender by Age)



The participants included in the study varied in their education levels. Of the individuals in the study, 80% attained degrees ranging from a college to a doctoral level, and the minority of the examinees were high-school graduates (see Figure 3).

Figure 3

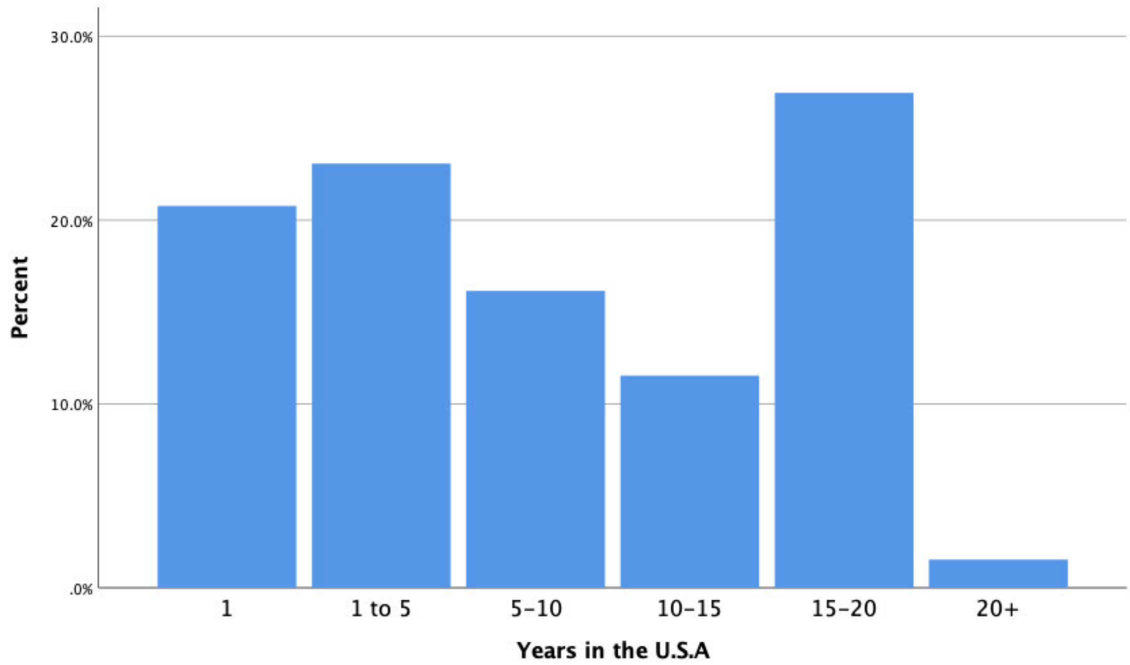
Demographic Data (Educational Attainment)



With regard to the number of years that participants resided in the United States, 43.9% reported living as many as 5 years in the United States, whereas the remainder of the participants was U.S. residents for greater than 5 years (see Figure 4).

Figure 4

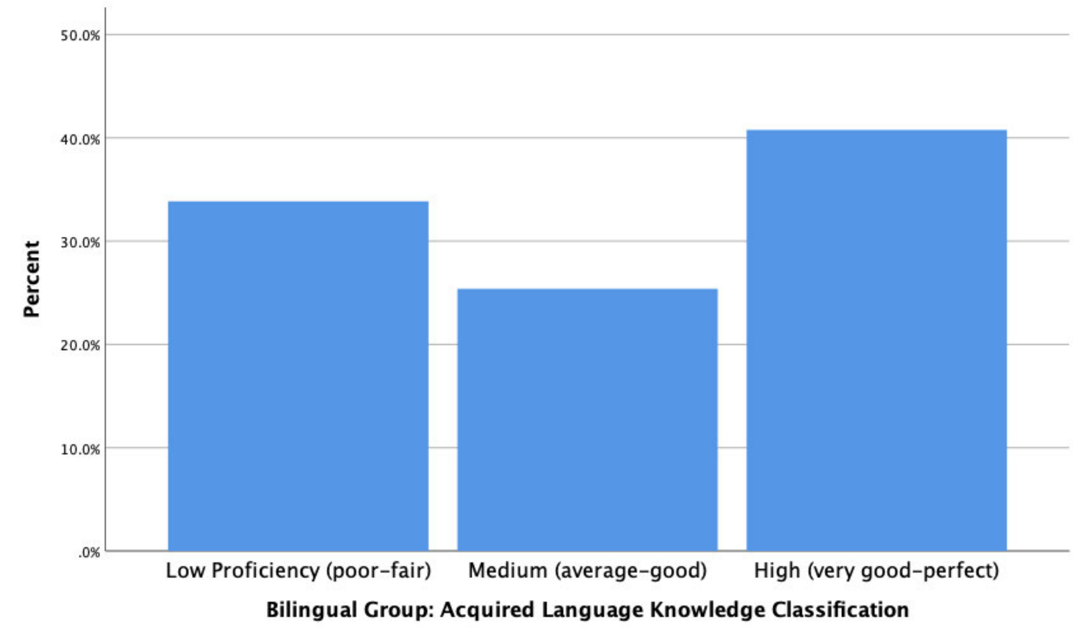
Demographic Data (Years Lived in the United States)



With regard to English language proficiency, 23% of the sample reported no knowledge of another language (i.e., spoke only the Georgian language) and were classified as monolingual individuals. The rest of the sample was composed of a bilingual group with varied levels of proficiency in English (see Figure 5).

Figure 5

Language Fluency on FAS



Note. Language fluency was measured with the phonemes F, A, and S (FAS).

Simple linear regressions analyses were conducted to determine whether English language proficiency predicted different aspects of executive functioning (i.e., inhibition, switching, and updating). Simple linear regressions are a statistical method that allows the examination of the relationship of the outcome or dependent variable with relevant variables on a continuum.

Before running the linear regressions analyses, the assumptions of normality, linearity, homoscedasticity, and multicollinearity were examined. To avoid violation of the assumption of multicollinearity (i.e., close relatedness of variables) between the variables, a Pearson product-moment correlation coefficient was used (Field, 2013). The level of significance was set at $p < .05$.

A power analysis for the simple linear regression indicated that 123 participants were needed to achieve adequate power at 0.05 significance level with a medium effect size.

To test the first hypothesis that the fluency in a second language (performance on the FAS measure) predicts performance on executive-functioning measures, three simple linear regressions were conducted. In this study, the construct of executive functioning was subdivided into three separate segments. Specifically, inhibitory control was assessed with the Stroop Color and Word Test, shifting was measured with the Trail Making Test, Part B (TMT-B), and updating was assessed with the Ruff Figural Fluency Test (RFFT). To reduce the problem of multiple comparisons, a Bonferroni correction was used in the study.

To test participants' inhibitory control (Stroop Color and Word test) based on second-language fluency (FAS), a first simple linear regression was calculated. A significant regression equation was found, $F(1, 128) = 38.534$, $p < .000$, with an R^2 of .231. Thus, language fluency accounted for 23% of variance for inhibitory control.

A second simple linear regression was conducted to investigate participants' switching ability based on second-language fluency. The results were statistically significant, $F(1, 128) = 27.426$, $p < .000$, with an R^2 of .176. Hence, language fluency accounted for 17% of variance for shifting ability.

A third simple linear regression was run to examine participants' updating skills based on second-language fluency. A significant regression equation was found, $F(1, 128) = 105.270$, $p < .000$, with an R^2 of .649. Accordingly, 64% of variance for updating ability was accounted for through second-language fluency.

In sum, the bilingual participants performed superior to their monolingual counterparts on the measures of executive functioning.

To test whether performance on neuropsychological measures was significantly impacted by demographic variables (i.e., age, education level, gender and number of years lived in the United States) irrespective of bilingualism, further analyses were conducted. Specifically, regression techniques were used to evaluate the potential effects of age, educational attainment, gender and number of years in the United States on raw scores. Each demographic variable was entered into separate regression equations as an independent variable, and each primary score obtained on separate measures of executive functioning was the dependent variable. The percentage of variance in obtained scores (as reflected by the R^2 value) was accounted for by age, education level, gender, and number of years resided in the United States.

The further analysis showed that bilingualism was a significant predictor of inhibitory control ability, Beta = .258, $t(2.909)$, $p < .004$. Also, however, age, Beta = -.431, $t(-4.799)$, $p < .000$, and education level, Beta = .264, $t(3.445)$, $p < .001$, predicted the inhibitory-control ability. Years lived in the United States, Beta = -

.110, *t*(-1.366), or gender Beta = .186, *t*(2.365), did not significantly affect inhibitory-control skills.

Further analysis shows that a significant and only predictor for cognitive-shifting ability was level of bilingualism, Beta = -.312, *t*(-3.163), *p* < .002. Thus, age, Beta = .149, *t*(1.495), *p* < .138; gender Beta = .132, *t*(1.626), *p* < .106; education level, Beta = -.115, *t*(-1.350), *p* < .179; or years lived in the United States, Beta = .074, *t*(.831), *p* < .408, did not significantly affect shifting ability.

The further analysis shows that bilingualism level significantly predicts updating ability, Beta = .451, *t*(5.524), *p* < .000. Levels of education, Beta = .267, *t*(3.784), *p* < .000, also showed significance in predicting updating skills. However, age, Beta =

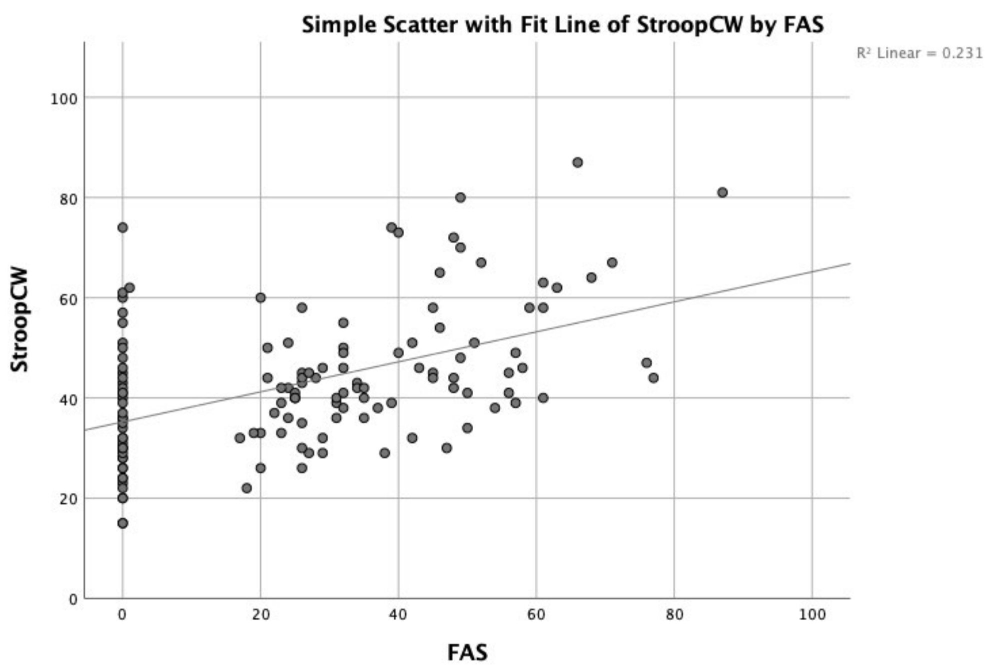
- .217, *t*(-2.621), *p* < .010; gender Beta = - .099, *t*(-1.370), *p* < .173; or years lived in the United States, Beta = .060, *t*(.813), *p* < .418, did not significantly predict shifting ability.

In sum, the only variable that significantly affected shifting ability was bilingualism. Updating abilities were affected by bilingualism and levels of education, whereas the inhibitory control was affected by bilingualism, age, and levels of education.

To test the second hypothesis and examine the type of relationship between the levels of second-language proficiency and a quality of performance on each measure of executive functioning (i.e., inhibiting, shifting, and updating), a Pearson product-moment correlation was computed. There was a strong, positive correlation between the second-language fluency and the levels of inhibition ability, $r = 0.481$, $n = 130$, $p = 0.000$ (see Figure 6).

Figure 6

Relationship Between Performance on Stroop Color and Word Test and FAS Measures

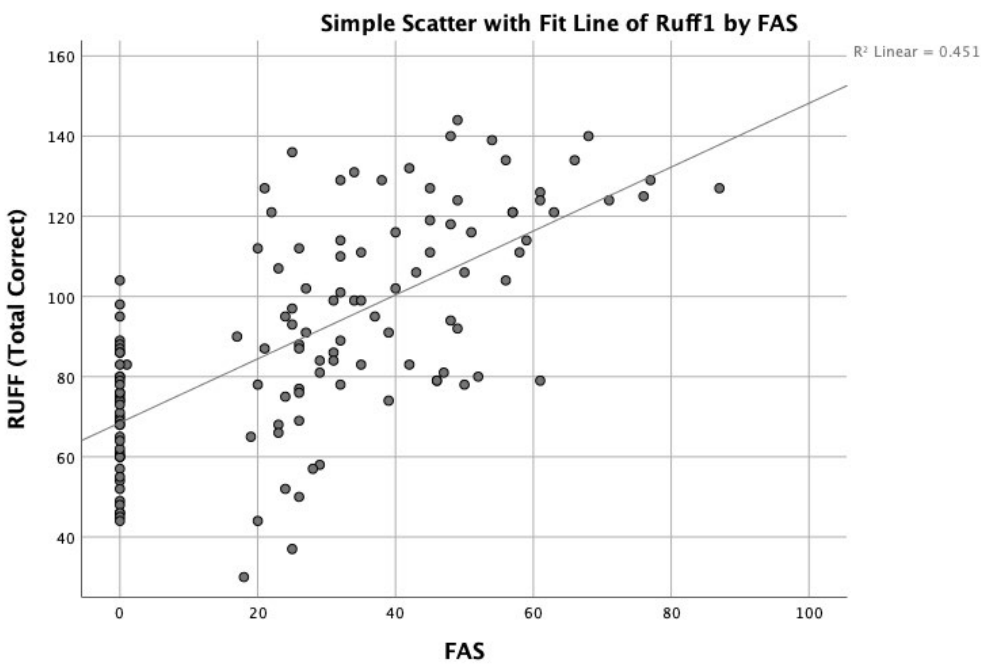


Note. FAS is the measure used for verbal fluency.

Similarly, there was a strong positive correlation between the second-language fluency and updating, $r = 0.672$, $n = 130$, $p = 0.000$ (see Figure 7).

Figure 7

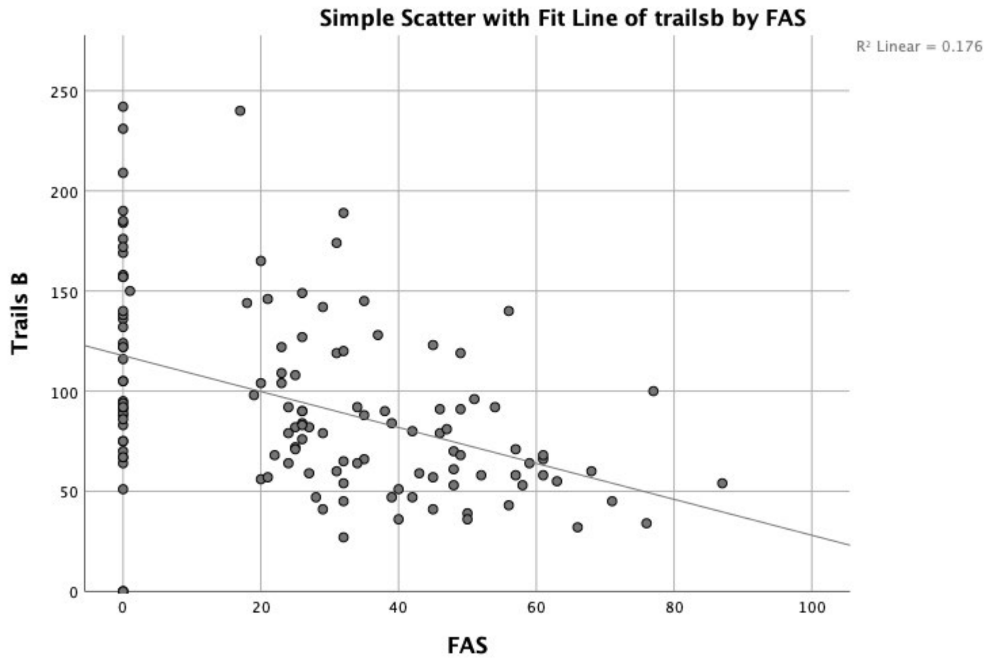
Relationship Between performance on Ruff Figural Fluency Test RFFT and phonemic fluency FAS measures



Lastly, there was a strong negative correlation between the acquired-language proficiency and shifting, $r = -0.420$, $n = 130$, $p = 0.000$ (see Figure 8).

Figure 8

Relationship Between Performance on Trail Making Test B and FAS Measures



Thus, as seen on the scattergrams, there was a significant relationship between fluency and each measure of executive function. The performance on measures of FAS and the Stroop Color and Word Test, as well as on FAS and the RUFF, showed a positive direction, while the performance on the FAS and the TMT-B showed negative direction. In sum, as expected, with increased fluency, the performance on measures of executive function was associated with better performance on measures of inhibitory control and updating and faster reaction times on measures of shifting.

Table 1 shows the mean (*M*), standard deviation (*SD*), standard error, lower bound, upper bound, minimum, and maximum value for age of the participants' performance on the Controlled Oral Word Association Test (COWAT; FAS).

Table 1

Summary Performance on FAS by age

Age	*n*	*M*	*SD*	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
18-25	13	39.31	(14.952)	4.147	30.27	48.34	0	58
26-35	24	23.63	(21.439)	4.376	14.57	32.68	0	59
36-46	37	36.41	(22.002)	3.617	29.07	43.74	0	87
47-55	28	28.54	(22.698)	4.290	19.73	37.34	0	77
56-64	19	10.42	(14.315)	3.284	3.52	17.32	0	35
65+	9	2.56	(7.667)	2.556	3.34	8.45	0	23

Table 2 presents the statistical values for the participants' performance on the Stroop Color and Word Test.

Table 2

Summary Performance on Stroop Color and Word Test by Age

Age	*n*	*M*	*SD*	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
18-25	13	48.38	(11.087)	3.075	41.68	55.08	32	74
26-35	24	46.00	(14.087)	2.875	40.05	51.95	20	74
36-46	37	48.46	(15.205)	2.500	43.39	53.53	26	87
47-55	28	43.43	(11.374)	2.149	39.02	47.84	26	67
56-64	19	33.00	(6.289)	1.443	29.97	36.03	22	42
65+	9	26.89	(9.089)	3.030	19.90	33.88	15	40

Tables 3 and 4 demonstrate normative data for the individuals' performances on the TMT, Parts A and B, respectively. Lastly, the normative performance of the study participants on the RFFT measure by age is illustrated in Table 5.

Table 3

Summary Performance on Trail Making Test A (seconds) by Age

Age	*n*	*M*	*SD*	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
18-25	13	24.15	(10.115)	2.805	18.04	30.27	9	48
26-35	24	31.83	(12.964)	2.646	26.36	37.31	13	65
36-46	37	26.05	(8.442)	1.388	23.24	28.87	14	49
47-55	28	29.96	(9.739)	1.841	26.19	33.74	19	56
56-64	19	44.74	(23.570)	5.407	33.38	56.10	20	120
65+	9	57.89	(13.968)	4.656	47.15	68.63	35	79

Table 4.

Summary Performance on Trail Making Test B (in seconds) by Age

Age	*n*	*M*	*SD*	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
18-25	13	70.46	(38.875)	10.782	46.97	93.95	27	158
26-35	24	91.25	(38.753)	7.910	74.89	107.61	0	150
36-46	37	82.22	(41.841)	6.879	68.27	96.17	32	240
47-55	28	95.36	(37.727)	7.130	80.73	109.9	45	172
56-64	19	121.63	(54.55)	12.516	95.34	147.93	56	231
65+	9	120.67	(82.674)	27.558	57.12	184.22	0	242

Table 5

Summary Performance on Ruff Figural Fluency (RFFT) by Age.

Age	*n*	*M*	*SD*	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
18-25	13	99.46	(24.534)	6.805	84.64	114.29	69	139
26-35	24	84.96	(20.773)	4.240	76.19	93.73	30	124
36-46	37	104.70	(23.531)	3.868	96.86	112.55	52	144
47-55	28	92.79	(26.322)	4.974	82.58	102.99	44	131
56-64	19	69.74	(21.131)	4.848	59.55	79.92	37	112
65+	9	58.11	(8.824)	2.941	51.33	64.89	46	70

Note. Perforamnce on the Ruff Figural Fluency Test (RFFT) corresponds to Number of Correct Designs.

To examine the third hypothesis to see if the performance on a selected measure of executive functioning is different between the North American and Georgian- American groups, the comparison was made on the measure of shifting ability (TMT-B). This measure was selected because it was the only measure that was unaffected by demographic variables of the study participants. As seen in Table 6, the responses of the Georgian-American group required longer reaction times for shifting in comparison to those of the North American sample. Table 6 shows that the mean performance in seconds on the TMT-B in the Georgian-American sample was below the mean of the North American sample.

Table 6

Comparison Between Georgian-American and North American Norms

Trails B; Georgian-American Norms				Trails B; North American Norms			
Age	*n*	*M*	*SD*	Age	*n*	*M*	*SD*
18-25	13	70.46	(38.875)	18-24	155	48.97	(12.69)
26-35	24	91.25	(38.753)	25-34	33	50.68	(12.36)
36-46	37	82.22	(41.841)	35-44	39	58.46	(16.41)
47-55	28	95.36	(37.727)	45-54	41	63.76	(14.42)
56-64	19	121.63	(54.55)	55-59	95	78.84	(19.09)
65+	9	120.67	(82.674)	65-69	97	91.89	(28.89)

Georgian-American Sample. [a] *Tombaugh (2004, p. 207 – p.208).*
Performance in seconds

CHAPTER 5: DISCUSSION

Interpretation and Implication

The literature has proposed that investigation of bilingualism from distinct language families (e.g., a Indo-European language vs. an Afro-Asiatic language) rather than from similar roots might shed more light on its effects on cognitive functioning, and even on cognitive reserve (Van den Noort et al., 2019). Additionally, Li e al. (2014) have suggested that knowing two typologically distinct languages (i.e., two less similar languages) may have a larger impact on neural patterns of bilingual individuals. The present study is unique in that it extended research to remarkably unrelated language groups (e.g., Kartvelian vs. West Germanic) that to this investigator's knowledge has not been examined in the previous studies that investigated the relationship between bilingualism and executive control.

The idea that bilingualism enhances executive functioning has been debated over the years. Several previous studies showed that bilingual individuals perform better than monolingual individuals on the measures of executive functioning (Anderson et al., 2018; Barac et al., 2016; Friesen, 2012; Seçer, 2016). However, these assumptions were disputed with questions centered on imperfect methodologies in many of the investigations, including comparison of participants from different cultures and dissimilar immigration statuses, examining second-language proficiency categorically (rather than on a continuum), investigating orthographically similar linguistic groups, and studying executive functioning within a single construct (Morton & Harper, 2007; Paap & Sawi, 2014; van den Noort et al., 2019).

The present study attempted to address the previously listed shortcomings and included participants from comparable cultural backgrounds and emigration status, examined second-language knowledge on a continuum, and used a unique approach to study separate aspects of executive functioning in bilingual and monolingual individuals.

Borrowing from Miyake and Friedman's (2012) latent variable approach, the present study examined whether bilingual participants performed better than monolingual participants on three distinct components of executive functioning using discrete assessment measures. The inhibitory linguistic control theory model posits that two linguistic processes are simultaneously active in bilingual individuals (see Green, 1998). The literature asserts that inhibiting irrelevant language while concurrently selecting a relevant one is an ongoing process. Bilingual individuals' continuous engagement in these processes augments different aspects of executive functions (i.e., inhibiting, shifting, and updating). Consequently, performance on measures of executive functions was expected to be more advanced in the bilingual participants in comparison to their monolingual counterparts.

Consistent with the inhibitory linguistic control theory and with many studies that found bilingual advantage (Bialystok et al., 2008; Prior & MacWhinney, 2010), the results from the current investigation, as was hypothesized, found that bilingual individuals outperformed their monolingual counterparts on all three measures of executive functioning. The overall results from the present study correspond to those that indicated that bilingualism has a positive effect on executive functioning. As proposed in the literature, the outcomes from this study imply that concurrent activation of two languages followed by suppression of the unintended language and production of a relevant linguistic output contributes to executive functioning in the areas of inhibiting, shifting, and updating (Bialystok, 2001; Bialystok et al., 2005).

Furthermore, as predicted, the current study showed that high proficiency in the second language paralleled with better outcomes (e.g., faster responses) on measures of executive function, compared to lesser proficiency in the second language. Similar findings were noted in Festman et al. (2010), which concluded that cognitive advantage in bilingual individuals was associated with stronger fluency in their second language. Likewise, the findings in this study suggest that performance on the separate measures of executive functioning increased with an increase in fluency of a second language. Actively speaking two languages requires continuous shifting, inhibiting, and monitoring of the irrelevant language. These cognitive tasks in which bilingual individuals are repetitively engaged are thought to train the same components of executive control, including shifting, inhibiting, and updating (Miyake et al., 2000).

The neuropsychological research literature has established that cultural factors can significantly affect performance on different neuropsychological measures (Puente & Agranovich, 2004; Puente & Perez-Garcia, 2000). To control for potential effects of demographic variables (i.e., age, educational attainment, gender, and the number of years lived in the United States), regression techniques were used. The study showed that bilingualism was a significant predictor for all three measures of executive functioning. However, the Trail Making Test, Part B (TMT-B) was the only measure that was unaffected by any other demographic variable. The performance of the current study participants on the TMT-B was compared with that of North American norms by age. As predicted, the North American cohort showed faster reaction times on this measure in comparison to the Georgian-American participants. Similar outcomes were noted in Agranovich and Puente (2007), a study that examined test performance between Russian and American volunteers. The authors associated the role of cultural differences (e.g., familiarity with timed measures) in the performance outcomes. In addition, one should note that results of studies that did not find bilingual advantage (e.g., Kousaie et al., 2015) are likely the consequence of the cultural differences of the subjects who were examined in the study (i.e., French vs. English native speakers) rather than of their cognitive performance. Hence, as suggested in the literature, importance of cultural differences should be considered when interpreting the results of test performance by individuals of various backgrounds.

The current study also compared the normative performance of a Georgian-American sample to North American norms on other measures, including the Trail Making Test Part A (TMT-A); the Ruff Figural Fluency Test (RFFT), and the verbal fluency test (FAS). (Note, a comparison with the Stroop Color and Word Test was not performed because of the differences in methodological design of sample stratification of the available North American norms.) As shown in Appendices A and B, no significant intergroup differences in performances on these measures were found. Thus, performance on the TMT-A, as well as on the RFFT, was not affected by cultural differences. Cognitive ability, such as attention (as measured by TMT-A), may be a basic and essential cognitive function that is similarly developed and used across the cultures. Similarly, updating is a cognitive skill that is used frequently within these cultures. As would be expected, however, on the measure of verbal fluency, the North American sample outperformed the Georgian- American group (Appendix C).

One of the clinical utilities of the current study is that it provides a set of norms on measures of executive functioning in a Georgian-American bilingual (Georgian-English) and a monolingual (Georgian) population. To the best knowledge of the examiner, such norms were not currently available and will aid culturally informed neuropsychological practices to determine whether performances on these measures correspond to normative functioning.

The study assessed performance not only between monolingual and bilingual individuals, but also among the bilingual individuals of varied language proficiency. In addition, the study used bilingual and monolingual immigrants from the same culture, thus minimizing confounding effects of cultural differences. Furthermore, the measures of executive functioning, although widely used, have been reported to have a low correlation among each other (see Friedman & Miyake, 2017). As such, employing multiple measures for each executive function in the current study may help to draw firmer conclusions.

As the present study supports the notion that bilingualism enhances executive functioning, the opposite effect needs to be ruled out. For example, the possibility that superior executive functioning may aid the acquisition of and fluency in a second language cannot be entirely excluded and should be further explored.

Research investigating bilingual advantage on executive functioning has yielded mixed results. Most studies used a categorical approach and compared bilingual groups with monolingual groups. In line with the idea that bilingualism is a matter of degree, not category (Yow & Li, 2015), the current study investigated the effects of bilingualism on a continuum. Specifically, the study examined whether the bilingualism (i.e., level of a second-language proficiency) predicted the executive control (i.e., performance outcomes on measures of executive functioning). Based on the notion of unity and diversity (Miyake et al., 2000), this study assessed multiple components of executive functioning in bilingual individuals employing various measures of executive functioning. The study intended to explore whether there is an advantage to bilingualism across all or specific domains of executive functioning. As such, the study examined possible contributions of bilingualism to inhibition, shifting, and updating (Miyake et al., 2000).

Based on the results of the present study, bilingual individuals showed cognitive advantage in comparison to their monolingual counterparts. Furthermore, bilingual individuals with greater proficiency in their second language showed better performance (i.e., shorter reaction times and more item responses) on measures of executive functioning. Remarkably, in comparison to the North American sample, the Georgian bilingual individuals showed slower response times on the measure of cognitive shifting. Such incongruity may be attributed to cultural differences rather than to cognitive performance.

Knowing a second language has been argued to be a protective factor against early onset of cognitive decline in older adults. Barulli and Stern (2013) highlighted a notion of cognitive reserve to explain repeatedly found discrepancies between one's brain pathology and performance in cognitive domains. Individuals with greater cognitive reserve, in comparison to those with lesser cognitive reserve, have shown less cognitive decline under the analogous brain pathology (Barulli & Stern, 2013). Based on Green's (1998) inhibitory control theory, Duncan and Phillips (2016) explained that bilingual experiences contribute to one's cognitive reserve, as bilingual individuals, in attempts to inhibit irrelevant language, continuously exercise components of executive function, such as attention control and inhibitory control. Based on the results of this study, bilingual individuals' advantage as shown on the performance of measures of executive functioning in comparison to the performance of monolingual participants suggests potential benefits from learning another language to mitigate prospective cognitive decline.

Understanding mechanisms of how linguistic processing affects brain function will promote an understanding of neuronal plasticity. The study hoped to advance the knowledge of effects of a second language on executive functioning. Such knowledge is important for conceptualization of how environmental changes, such as bilingualism, can improve brain function (i.e., executive functioning).

The current study investigated Georgian-English bilingual and monolingual groups, thereby encompassing two typologically and phonetically dissimilar languages (i.e.,, English and Georgian). The Georgian language, whether with its idiosyncratic phonological system or its complex grammar, is "the only written member of the non-Indo-European Kartvelian (South Caucasian) linguistic family" (Aronson, 1990, p. 11) and is considered one of the unique and oldest languages in the world.

Limitations

The cross-sectional nature of the study was one of the limitations of the present investigation, as cross-sectional design limits the understanding of long-term effects of bilingualism on executive function. Furthermore, study results do not account for individual differences, such as motivation, circumstances, or exposure to learn a second language that may impact one’s fluency. Also, the obtained results may be specific for the population sample, precluding generalizability to other populations. The study sample did not contain male individuals who were 65 years and older. In addition, the sample was composed only of Caucasian participants from a homogenous nation. Lastly, given that the majority of the study sample was composed of relatively well-educated participants, the generalizability of the results may also be circumscribed.

Future Directions

Prospective investigation is needed to elucidate possible causal relationships between lifelong bilingualism and its possible effects on executive functioning and whether such effects serve as a protective factor against cognitive decline in older adults. Also, a comparison study of bilingual individuals whose residence remains in their native countries with those who emigrated would shed some light on differences between the frequency of language usage and executive functioning. Furthermore, comparing structurally and lexically similar and distinct languages may also help an understanding of whether linguistic intensity of distinct languages (e.g., phonologically vs. grammatically distinct linguistic difficulties) exerts different effects on cognitive functioning.

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Appendix A

Table 7

Comparison Between Georgian-American and North American Norms

Trails A (in seconds) Georgian – American Norms

Age	*n*	*M*	*SD*
18-25	13	24.15	(10.115)
26-35	24	31.83	(12.964)
36-46	37	26.05	(8.442)
47-55	28	29.96	(9.739)
56-64	19	44.74	(23.570)
65+	9	57.89	(13.968)

Trails A (in seconds) North American Norms

Age	*n*	*M*	*SD*
18-24	155	22.93	(6.87)
25-34	33	24.40	(8.71)
35-44	39	28.54	(10.09)
45-54	41	31.78	(9.93)
55-59	95	35.10	(10.94)
65-69	97	39.14	(11.84)

[a] Tombaugh (2004, p 207- p 208).

The table in Appendix A shows the performance of the Georgian-American sample on the measure of speeded visual-motor scanning (Trail Making Test, Part A). Note no significant differences in mean times observed.

Appendix B

Table 8

RFFT Comparison Between Georgian-American and North American Norms

Georgian-American Norms (By Age)

Age	*n*	*M*	*SD*
18-25	13	99.46	(24.534)
26-35	24	84.96	(20.773)
36-46	37	104.70	(23.531)
47-55	28	92.79	(26.322)
56-64	19	69.74	(21.131)
65+	9	58.11	(8.824)

North American Norms [a] (By Age/Education)

Age	*≤12 years* *n = 27* *M SD*	*13-15 years* *n = 28* *M SD*	*≥16 years* *n = 30* *M SD*
16-24	103.30 (24.21)	107 (18.68)	114.77 (19.72)
25-39	82.60 (18.77)	99.07 (24.52)	104.31 (28.69)
40- 54	92.93 (20.82)	95.82 (17.51)	105.17 (16.37)
55-70	72.28 (20.36)	73.83 (18.69)	82.93 (20.60)

([a]Ruff,1996 p. 27-43)

The table in Appendix B shows the performance of the Georgian-American sample on the Ruff Figural Fluency Test. Note no significant differences in mean times were observed.

Appendix C

Table 9

FAS Comparison Between Georgian-American and North American Norms

Georgian-American Norms (By Age)

Age	*n*	*M*	*SD*
18-25	13	39.31	(14.952)
26-35	24	23.63	(21.439)
36-46	37	36.41	(22.002)
47-55	28	28.54	(22.698)
56-64	19	10.42	(14.315)
65+	9	2.56	(7.667)

North American Norms [a] *(By Age/Education)*

Age	*n*	*M*	*SD*
16-19	19	39. 3	(12.0)
20-29	106	41.2	(09.2)
30-39	132	43.1	(11.4)
40-49	121	43.5	(12.2)
50-59	144	42.1	(11.1)
60-69	220	38.5	(13.7)
70-79	334	34.8	(12.8)
80-89	200	28.9	(11.7)
90-95	24	28.2	(11.0)

[a]Tombough, Kozak, and Rees, 1999, p. -170)

The table in Appendix C shows the performance of the Georgian-American sample in comparison to that of the North American sample. As anticipated, the native speakers generated more words per 180 seconds on this measure in comparison to the Georgian-American group.