Is There a Bilingual Advantage: Testing the Role of Language Mode

by

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B.S., Northwestern State University of Louisiana, 2010
M.S., Kansas State University, 2015

AN ABSTRACT OF A DISSERTATION

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Abstract

Bilingualism refers to an ability to speak two or more languages and the daily experience involved in coordinating these two languages can have a strong effect on bilinguals' cognition. For decades, research strongly supported the idea of bilingual advantage; however, recent studies have found no bilingual advantage. Not surprisingly, such conflicting findings raised concerns about the validity of previous research as well as several other methodological issues. For instance, simple cognitive tasks like the Simon task are commonly used in bilingualism research, but they may not best capture bilinguals' daily experience using the two languages. Bilinguals are constantly suppressing one language while engaged in other tasks, which is better captured by complex working memory (WM) tasks. Most importantly, previous work has not empirically evaluated the effects of language mode on bilinguals' cognitive performance. Language mode refers to the state of activation of each language. Bilinguals may be in monolingual mode if only one of their languages is activated, whereas they may be in bilingual mode if both of their languages are activated. Previous work has proposed that language mode can have an effect on performance. Thus, the main objective of this dissertation was to evaluate the possible effects of bilingualism on complex WM performance while controlling for language mode and various demographic variables.

The Pretest provided initial evidence that language mode affected performance on a simple cognitive task like MPWI. Therefore, a similar language mode manipulation was used in the Main study while testing performance on several complex WM tasks (CSPAN, OSPAN, and RotSpan) and the Simon task for monolinguals, bilinguals in bilingual mode, and bilinguals in monolingual mode. No significant differences were observed between *all* bilinguals and *all* monolinguals on any of the measures. However, significant differences were observed once

language mode was accounted for. That is, bilingual participants in bilingual mode outperformed both bilingual participants in monolingual mode and monolingual participants on measures of complex WM. Further, there were no differences between monolinguals and bilinguals in monolingual mode. Thus, being in monolingual mode and fully suppressing one language may require more inhibition resources than bilingual mode in which both languages are active, and as a result, there may be fewer resources left to complete the complex WM span tasks. Importantly, the current work shed light on the hotly debated issue of the existence of a bilingual advantage by identifying a third variable that may explain the conflicting results in the literature. That is, no bilingual advantage was observed, but the current data provide evidence of a *bilingual mode* advantage.

Keywords: bilingualism, language mode, working memory, bilingual advantage, language fluency, language proficiency

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Chapter 1 - Literature Review

Language and memory are two essential parts of our lives. Language allows humans to communicate, share ideas, create, and do such basic tasks as shop for groceries and read. While most humans learn at least one language in their lives, some have an opportunity to learn multiple languages. Bilingualism refers to an ability to speak two or more languages. As Bialystok et al. (2012) reports, more than half of the world's population is currently at least bilingual.

Bilingualism

Bilingualism is referred to as an ability to speak and understand two languages (multilingualism is the ability to speak and understand two or more languages). Bilingualism also shares features with other experiences that all humans may encounter on a daily basis, such as driving a car, walking, reading, singing, playing music etc. Fluent bilinguals who have mastered both languages (LL) are able to speak fluently in either of the languages, rarely mixing the two. Even non-fluent bilinguals, who are people learning a new language, can choose which language to speak, though it may require extra effort on their part. Importantly, both fluent and non-fluent bilinguals share an experience that monolinguals do not experience: they know more than one language.

If a person can speak more than one language (L), an interesting question arises about how bilinguals manage the two languages. One of the first theories to address this question proposed that bilinguals switch from one language (L1) to another (L2). For example, Macnamara and Kushnir (1971) described an input and an output switch, such that only one language could be active at any given time. In other words, if L1 was activated, then L2 would be turned off, and vice versa. If bilinguals are able to successfully turn off the unused language,

then they should perform as well as monolinguals on various tasks, as long as they had equal knowledge of L1 and L2. However, even for fluent bilinguals, the to-be-turned-off language seems to interfere with task performance. For example, fluent bilinguals reliably exhibit switch costs (Green, 1998; Mavian & Spivey, 2003; Monsell, 2003). For instance, Mavian and Spivey (2003) presented Russian-English bilingual participants with three types of objects: a target object (e.g. marker), an object whose name was phonologically similar to the target in English (e.g. marble), and an object whose Russian translation was similar phonologically to the target but did not have a similar meaning (e.g. stamp which is "marka" in Russian) while tracking their eye movements. This cross-language information was irrelevant to the task; however, Russian-English bilinguals made initial eye-movements to the cross-language distractor demonstrating that both languages are active at the same time and bilinguals have to exert effort to inhibit one of them.

In response to such findings, Green (1998) proposed an inhibitory control (IC) model in which bilinguals select and coordinate their language use. Bilinguals may be prepared to speak both languages, but since only one language has been selected (based on the task or who the person is talking to), the other language is inhibited. Most researchers now agree that bilinguals do have both languages activated at the same time, though to a different extent (Green, 1998; Grosjean, 1998; 2011).

The inhibitory model was recently expanded by Green and Abutalebi (2013) who proposed the Adaptive Control Hypothesis, which identifies eight distinct processes important for L inhibition: goal maintenance, conflict monitoring, interference suppression, salient cue detection, selective response inhibition, task disengagement, task engagement, and opportunistic planning. Presumably, these processes are activated to different degrees depending on the

context of language use. Green and Abutalebi (2013) identified three such interactional contexts: single language, dual language, and dense code-switching (i.e. a speaker alternating between two or more LL).

In a similar vein, Grosjean (1998) argued that the extent to which a language is activated depends on which language mode a bilingual is in. According to Grosjean (1998), "a mode is a state of activation of the bilingual's languages and language processing mechanisms" (p. 136). Bilinguals may be in a completely *monolingual mode* if they are interacting only with monolinguals. They can be in this monolingual mode with either their L1 or L2, as long as only one language is active. At other times, bilinguals may be in a *bilingual mode* if they are interacting with other bilinguals or during language mixing. Language mixing can occur when a word in L2 cannot be translated into L1. For example, the best way to translate the word "truck" into Russian is to use a Russian alternative of the word "car". However, while a truck is a car, the word "car" definitely does not carry over the full meaning of "truck". In this case, a bilingual might be in Russian monolingual mode as the entire conversation is carried out in Russian; however, once they say an English word "трак" ("truck"), according to Grosjean, they are in a bilingual mode. Importantly, according to Grosjean (2011), a person is in a bilingual mode if they were exposed to both languages at any level (e.g. a simple "hello" in L1 followed by a conversation in L2 will lead bilinguals into the bilingual mode; Grosjean, 2011).

Thus, the two languages can be at different levels of activation: one language can be completely inhibited in a monolingual mode, or both LL could be fully active in the bilingual mode. Furthermore, while in the bilingual mode, one language may be at a higher level of activation than the other (an intermediate mode). Previous studies that evaluated language mode have demonstrated that L mode affects the number of disfluencies and guest language syllables

produced (i.e., when syllables from the suppressed language appear in the active language, Grosjean, 1997), the rate at which languages are mixed, e.g. using both LL in the same sentence (Lanza, 1992); and how often participants language switched (Grosjean, 1998). Yet to date, no study has evaluated the effect of language mode variable on the so-called bilingual advantage.

Different factors increase the likelihood that someone is in bilingual mode, specifically in a research setting. One factor is demonstrating the knowledge of a foreign language, which Grosjean (2011) notes, is difficult to hide. For example, a bilingual researcher, only using L1 while communicating with the bilingual participant, may slip and show that he/she understands L2. Another factor is a way in which a research study is advertised. Often, they are advertised as bilingualism studies, which may automatically prime bilingual mode in the bilingual participants as they walk into the experiment. Further, just being on the campus of a university with a large number of bilingual students, faculty, and international clubs may be enough to elicit bilingual mode (Grosjean, 2011). However, studies evaluating the bilingual advantage have yet to account for these factors.

From a methodological point of view, this is an issue of covert versus overt recruitment. Interestingly, differential expectations may play a role when we consider the two groups (monolinguals and bilinguals). Most studies begin with a questionnaire asking participants about their language background. Answering these questions could make participants aware of the fact that their knowledge of another language may play a role in the study (and put them in a bilingual mode). In addition to eliciting bilingual mode, these types of questions may also activate stereotypes about bilingualism (e.g., that bilinguals perform better on cognitive tests). Research on stereotype threat has shown that activating stereotypes can influence cognitive behavior. For instance, women exposed to a stereotype that women are bad at math perform

worse than women who were not exposed to such a stereotype (as mentioned in Conway et al., 2005). Given the widespread attention to the bilingualism advantage and possible cognitive reserve in academia and mainstream media, it is possible that such stereotypes affect their performance in the laboratory. However, no study has explicitly evaluated this potential effect. Manipulating whether bilinguals are in bilingual or monolingual mode is one way to address this issue.

Grosjean (2011) claimed that language mode can influence and perhaps even account for any effects observed in bilingualism research. This claim is of key importance for the current proposal and will be further discussed later.

Bilingual (Dis)Advantage

Goodenough (1926) stated that "the use of foreign language in the home is one of the chief factors in producing mental retardation as measured by intelligence tests" (p. 393). This was one of the first times bilingualism was mentioned in the research literature. The belief of its negative effects on cognitive abilities remained prevalent until the beginning of 1960 when Peal and Lambert (1962) found out that "experience with two language systems seems to have left him [the bilingual child] with a mental flexibility, a superiority in concept formation, a more diversified set of mental abilities" (p.20).

Peal and Lambert's claim spurred a wealth of research evaluating the effects of bilingualism in children's metalinguistic awareness, which is the explicit knowledge of the linguistic structure and the ability to access it intentionally (Bialystok & Craik, 2010). These studies demonstrated that bilingual children were better than monolingual children at interpreting grammatical violations in semantically anomalous sentences such as *Apples grow on noses* (Bialystok, 1988; Bialystok et al., 2005; Bialystok & Craik, 2010). Bialystok (1988) concluded

that bilingual children were more successful at inhibiting the irrelevant meaning of the sentence and focusing on the grammar instead. Better inhibitory control is still an important mechanism in modern bilingualism research. In the following years, Bialystok and colleagues found that bilingual children outperformed monolingual children on a variety of tasks such as locating hidden shapes, card sorting, and inhibiting irrelevant information (Bialystok, 1988; Bialystok, Martin, & Viswanathan, 2005; Bialystok & Craik, 2010; Bialystok, Luk, & Craik, 2012), which provides support for the original claim by Peal and Lambert (1962).

Research with adults has initially revealed similar results: bilinguals tend to outperform monolinguals on a variety of cognitive measures. While the Toronto group led by Ellen Bialystok definitely played a pioneering role in the area of cognitive effects of bilingualism, other groups replicated their results (e.g., Alladi et al., 2013; Bak et al., 2014; Costa et al., 2009; Gold, Kim, Johnson, Kriscio, & Smith, 2013; Gollan & Ferreira, 2009). This work has demonstrated that bilinguals outperform monolinguals on a variety of attentional control measures such as the Stroop task, the Simon task, and the flanker task (Bialystok, Craik, & Luk, 2008); task switching measures (Prior & MacWhinney, 2010); and measures of letter fluency (Luo, Luk, & Bialystok, 2010). Further, although aging research has demonstrated that older adults' response times are slower than young adults, this effect is reduced in older bilinguals as compared to older monolinguals (Bialystok and Craik, 2010, Fig. 2b). This result sparked the idea that bilingualism may protect against age-related cognitive decline – an idea hotly debated today.

Thus, a wealth of research has demonstrated a bilingual advantage in inhibition, attentional control and processing speed for individuals ranging from young children to older adults. However, research has also shown that bilinguals have lower vocabulary knowledge (Bialystok et al., 2012; Bialystok et al., 2014). Specifically, bilinguals of all ages are slower and less accurate on picture-naming tasks, and they are slower to comprehend and produce words (Bialystok, 2001; Bialystok et al., 2012; Bialystok et al., 2014).

While the literature reviewed above makes a strong case for positive cognitive effects of bilingualism (with the exception of vocabulary knowledge), several recent studies found no bilingual advantage such that bilinguals and monolinguals performed similarly on a variety of tasks, similar to the ones used in previous studies (deBruin, Bak, & Della Sala, 2015; Paap & Greenberg, 2013; Paap, Johnson, & Sawi, 2015; Raiu & Azuma, 2015). Not surprisingly, such findings raised concern about the validity of previous research and several variables that need to be accounted for in bilingual research. In particular, Paap and Greenberg (2013) mentioned that variables such as L proficiency and demographics must be considered. We agree and propose that L mode must also be accounted for.

Problems in Bilingual Research

Language Proficiency

First and foremost, attempts should be made to hold certain characteristics of the sample constant across studies, particularly language proficiency (Paap & Greenberg, 2013).Several research camps, such as Bialystok and colleagues as well as Paap and Greenberg, use strict criteria in that they only select highly fluent bilinguals who use both languages regularly (often daily; Bialystok, 2009; Paap & Greenberg, 2013). Fluent bilinguals have used two languages throughout their lives (most of Bialystok's participants learn L2 at the age 6 at the latest).

Therefore, if bilingualism produces any cognitive benefits, it should be observed in this group as they had the most experience with L inhibition and switching. However, one cannot discount non-fluent bilinguals. These individuals could provide important insights into how much time or practice is necessary before the advantages of bilingualism (if they exist) are observed.

Initial evidence that the bilingualism advantage develops over time comes from a study conducted by Vega-Mendoza, West, Sorace, and Bak (2015). They worked with late, non-balanced bilinguals who have acquired a second L during adulthood (as opposed to learning a second L as a child) and, thus, were more proficient in one of the languages. They evaluated how these non-balanced bilinguals performed on measures of attentional task switching. Interestingly, no differences were found between monolinguals and bilinguals who were in their first year of L studying; however, a significant difference emerged between monolinguals and bilinguals in their fourth year of language studying. Thus, it seems that the bilingual advantage emerges with experience, but more studies are needed.

It is important, though, to clarify differences between language proficiency and language fluency. *Language proficiency* refers to an ability to use vocabulary, discourse structure, and gestures to communicate meaning in a specific context (Del Vecchio & Guerrero, 1995). On the other hand, *language fluency* refers to the ease with which participants produce L2, characterized by native-likeness of speech as well as eloquence (Housen, Kuiken, and Vedder, 2012). However, not every research lab accounts for both in the same way. For example, Bialystok et al. (2004) used an extensive language background questionnaire and the Peabody Picture Vocabulary Test – Revised (Bialystok et al., 2004). At the same time, Paap and Greenberg (2013) used their own language proficiency scale and their own set of language use questions. It is difficult to compare the results of the studies when such sample characteristics like language

proficiency and fluency are assessed using different measures. Therefore it is important to establish a set of measures that have been used in previous research to be used in future studies.

Demographics

Besides language proficiency, certain demographic characteristics could have an effect on study results. Confounding variables such as socio-economic status (SES), parental education, and immigration status have been mentioned by deBruin et al. (2015) and Paap et al. (2015). As Bak (2016) says, bilingualism "can be associated with position in society…from discriminated and marginalized minorities to leading intellectual elites" (p. 32). In any case, it is difficult to compare mono- and bilingual groups without equating for SES. For example, deBruin et al. (2015) reported that mono- and bilingual children matched on SES performed equally well on the Simon task, whereas children with a higher SES showed a bilingual advantage compared to children with really low SES.

Relatedly, bilinguals and monolinguals whose parents had higher levels of education (another proxy for SES) may have had more exposure to various opportunities as they were growing up. For example, some monolinguals may not speak another language but they may have had an opportunity to travel around the world. Such cultural experiences should also be accounted for (deBruin et al., 2015; Paap et al., 2015). Finally, immigration is another possible confounding variable given that immigrants may have more practice with adapting to new situations (deBruin et al., 2015; Paap et al., 2015).

Language Mode

Another variable mentioned above that may be extremely important to bilingualism research is language mode. None of the studies published to date, whether supporting or refuting the idea of bilingual advantage, has accounted for the possible language mode that participants

may be in. Presumably one language is inhibited while the other language is active (Green, 1998; Grosjean, 1998, 2011; Green & Abutalebi, 2013); however, does the degree of inhibition depend on the L mode? If so, does the degree of inhibition then affect cognitive performance?

Language mode may explain why some studies observed a bilingual advantage whereas others have not. For example, if a bilingual person is in a completely *monolingual* mode using only L1, L2 is completely suppressed since it is not used at all in monolingual mode. On the other hand, if a bilingual person is in a *bilingual* mode, s/he has to *continuously* suppress L2 since both languages are activated. The question is: is the inhibitory mechanism more active in the bilingual mode, when L2 has to be continuously suppressed on a moment-by-moment basis? Or is the inhibitory mechanism more active in the monolingual mode, when L2 is now completely suppressed? The current studies will evaluate whether language mode influences bilingual's performance on cognitive tasks.

Tasks

Finally, many cognitive tasks can be used to assess the bilingual advantage. The Simon task and Stroop task are some of the most commonly used tasks in bilingualism research (Bialystok & Craik, 2010; Paap & Greenberg, 2013). Both tasks are thought to measure executive control abilities such as inhibiting irrelevant information or monitoring goal-setting cues. For the Simon task, participants typically respond to two targets presented on the screen. For example, participants may be presented with a "Z" or a "/" on either the left or right side of the screen, and they have to respond by pressing the corresponding keys on the keyboard. A congruent trial is when the target location matches the side where the key is located, whereas an incongruent trial is when the target location when the target appears on the opposite side.

Performance is usually measured as the difference in reaction times (RTs) between incongruent and congruent trials.

For the Stroop task, participants are often presented with a name of a color in a font color that is either congruent (e.g., the word "orange" presented in orange font) or incongruent (e.g., the word "orange" in blue font). The task measures how well participants are able to inhibit their initial responses (pressing the color that they see vs. the color that they read). Again, performance is measured as the difference in reaction times (RTs) between incongruent and congruent trials. For both tasks, the expectation is that bilinguals have better inhibitory control and thus will perform better than monolinguals on incongruent trials.

However, the type of inhibitory control measured in these tasks may not tap into the same type of inhibitory control that bilinguals engage in on a daily basis. As Green (1998) suggested, both languages are always active but one of them is constantly inhibited. Furthermore, as bilinguals speak one language, they have to constantly choose between the two representations and inhibit one. Thus, rather than having to intermittently inhibit an initial response (as measured on the Simon and Stroop tasks), bilinguals are continually suppressing one language while engaged in other tasks. Perhaps a more sensitive measure of this type of processing is a dual task typically involved in complex working memory (WM) measures.

Working Memory

WM Models

WM refers to a limited capacity system in which information can be temporarily stored and manipulated at the same time. Different models of WM have been proposed throughout the years. One of the most influential models was originally proposed by Baddeley and Hitch (1974) and updated by Baddeley in 2000. According to Baddeley (2000), working memory (WM) is a

multi-component system that is divided into several subsystems. According to the original model, the phonological loop is a short-term store for incoming auditory information, the visuo-spatial sketchpad is a short-term store for spatial information, and the central executive serves as a supervisory control system that is attention limited (Baddeley & Hitch, 1974). The central executive is responsible for controlling and integrating all the information it receives from the subsystems; however, lacks a storage component (Baddeley & Hitch, 1974).

An episodic buffer was added as an additional component to the model (Baddeley, 2000). It presumably receives, combines, and temporarily stores the information from different modalities and retrieving information from episodic LTM (Baddeley, 2000). Thus, WM is a multi-component system that consists of subsystems that receive information from different modalities, a subsystem that combines and stores that information, as well as a subsystem that controls the entire process. All these processes are essential to language comprehension.

Ericsson and Kintsch (1995) offer their own general mechanism of WM that includes a skilled usage of information stored in LTM that they refer to as long-term working memory (LT WM). According to their view, information is stored in stable form in LTM but it can be retrieved by means of retrieval cues maintained in WM. During language comprehension, the text is read and mental representations are constructed. These mental representations serve as the basis for a variety of text-related behaviors such as free recall and priming effects. Therefore, the text itself is not used as input but rather is represented by a series of cues. New information is integrated with previous meanings that are still held in attention and this mental representation of the text serves as a retrieval structure. Thus, during language comprehension, most of the information is stored in LTM (e.g. the multilevel structural representation of the text) but the accessible portions of this structure in LTM are in LT WM (p. 223).

Finally, Cowan (1999) proposes the embedded-processes model. This model assumes that a subset of LTM is active at any moment and that a small portion of this activated information is currently the focus of attention. Thus, working memory is not viewed as a separate system; rather working memory representations are a subset of representations in LTM. In terms of language comprehension, information that is not currently the focus of attention (i.e., the words currently being spoken or read) is still kept active and accessible in LTM. LTM can also be used as relevant information may be retrieved from it.

Although each of these WM models proposes different mechanisms for connecting information in WM with information in LTM, they all agree that at any given moment there is a subset of information that will be active and can be stored and manipulated at the same time. In a similar vein, bilinguals have only one language active at a time while the other language is inhibited. While bilinguals may know information in both L1 and L2, knowledge about one of these languages will have to be suppressed when in monolingual mode. For instance, bilinguals manipulate information in L1 while at the same time inhibiting information in L2. Therefore, tasks that tap into WM capacity could be more similar to what bilinguals experience on a daily basis as compared to tasks that require a more simple inhibition of responses.

WM Tasks

Several WM tasks have been created (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005; Unsworth, Redick, Heitz, Broadway, & Engle, 2009). Such measures as operation span (OSPAN), reading span (RSPAN), rotation span (RotSpan), and counting span (CSPAN) are among the most popular ones still used today. Most researchers agree that WM should be viewed as a system that allows for storage and manipulation of the information (Baddeley, 2000;

Cowan, 1999; Ericsson and Kintsch, 1995). Thus, the general idea behind most measures of WM is a way to tap into the dual processing nature of WM (i.e., storage and manipulation).

For example, the OSPAN task requires participants to judge whether the solution to a mathematical problem presented on the computer screen is correct or not while simultaneously trying to remember letters that are presented after each math problem. Participants may see (6 – 8/2 = 2; True or False?) on one screen (the processing component), followed by a single letter A on the next screen (the storage component). Then another math problem will be presented, followed by another letter to be remembered etc. After a certain number of trials, unknown to the participant, they are asked to recall the letters in the correct order. Thus, participants are asked to pay attention while solving the math problem, inhibit this information once they have made the decision, and remember the letters. Different variations of this task are available. For example, the reading span task requires participants to judge the grammaticality of a sentence while remembering either words or numbers, the rotation span requires participants to judge whether a rotated letter is presented correctly or is a mirrored image of the letter while remembering arrows pointing in different directions, and the counting span requires participants to count colored shapes among a field of distracters that were either the same shape or the same color and recall the numbers in order after a random number of trials.

Executive Functioning and Inhibition

Such dual tasks have been shown to predict performance on a large number of measures involving attentional control and inhibition, fluid intelligence, and executive functions (Conway et al., 2005). Executive functioning involves processing goal-directed behavior or the control of complex cognition (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). One of the main roles of executive function is to help "filter" incoming information. Similarly to this, most

complex WM tasks are also designed around the idea of resolving conflict from distracting cues, switching efficiently between types of trials, and maintaining rules in WM. For example, to-be-remembered targets in the CSPAN tasks are presented among distracting cues of different colors whereas words must be remembered while judging the grammaticality of sentences during the RSPAN task.

Executive function is at the center of most models of WM. For example, both Baddeley (2000) and Cowan (1999) include what they call a central executive in their models that plays a role of a supervisor by directing attention (Cowan, 1999) and controlling the processing (Baddeley, 2000; Cowan, 1999). McCabe et al. (2010) found strong evidence that WM and EF measure a common underlying construct (there was a very strong correlation between the two, r = .97).

One way in which executive functioning relates to complex WM tasks is the role it plays in helping inhibit irrelevant information. Focusing only on a certain part of a display or certain aspects of a mental representation requires control and so does inhibiting the irrelevant details. Together, the process of control is an important part of attention while depending largely on inhibition (Bialystok, Martin, & Viswanathan, 2005, p. 105). In fact, individual differences in WM span explain how well individuals can stay on task and inhibit distracting information (Kane et al, 2001).

Miyake et al. (2000) proposed a model of executive function. They used latent variable analysis to study the three subcomponents of executive function: shifting, updating, and inhibition. The components were moderately correlated but contributed independently to the variety of executive tasks used in the study (e.g. the Stroop task was proposed as a measure of inhibition). All three of these processes should be engaged when bilinguals juggle the two

languages: bilinguals switch from L1 to L2 or L2 to L1, the information is updated as they are communicating (e.g. noticing such cues as whether the listener knows L2 as well or not), and one of the languages has to be inhibited as discussed above (Gollan & Ferreira, 2009; Fink and Goldrick, 2015).

Many studies have examined the relationship between WM and inhibition (Luo, Craik, Moreno, Bialystok, 2013; Baddeley, 2003; Qualls & Harris, 2003; Kane, Bleckley, Conway, and Engle, 2001). They have shown that the ability to inhibit potentially irrelevant information is dependent on working memory capacity measured by complex WM tasks (Kane et al., 2001).

Further, many studies have shown that executive function declines with age (Salthouse, 1994; Zacks and Hasher, 1994; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003; Bialystok, Poarch, Luo, & Craik, 2014). For example, Bialystok et al. (2005) reports sharp differences in performance between younger adults (in their 20s) and older adults (typically above 60). Verhaeghen et al. (2014) conducted a meta-analysis to assess aging and dual-task performance and reported a significant age-related deficit in dual-task performance in terms of accuracy and response times. Adding a second task increased performance by 92 ms for younger adults and by 170ms for older adults. Thus, the cost of adding a dual-task is twice as large for older adults. Such dual tasks tend to require more active processing and greater involvement of executive functioning (Luo et al., 2012).

WM and Bilingualism

Thus, both of the areas of bilingualism and WM research put a strong emphasis on executive functioning and inhibitory control. Yet, only a handful of studies to date looked at the connection between the established complex WM measures and bilingualism. Ratiu and Azuma (2015) used the OSPAN task, which is a verbal measure of WM, and a symmetry span task,

which is a visuospatial measure. Bilinguals performed worse than monolinguals on the verbal OSPAN task but there was no difference between the two groups on a symmetry span task. Interestingly, Luo, Craik, Moreno, and Bialystok (2013) have showed a similar result that bilinguals performed worse on verbal WM tasks (the word span and the alpha span tasks) but an opposite result that bilinguals outperformed monolinguals on spatial WM tasks (the forward and backward Corsi blocks tests). As discussed above, bilinguals do tend to perform worse on verbal vocabulary tasks. However, the conflicting results for performance on the visuospatial measures are interesting. One possible explanation could be that Ratiu and Azuma (2015) used young adults only while Luo et al. (2012) used both young and older adults – they found that bilinguals in both age groups outperformed monolinguals on spatial tasks. Another possible explanation is that they used different WM measures and controlled for different demographic variables: Ratiu and Azuma (2015) accounted for age and level of education whereas Luo et al. (2013) accounted for vocabulary scores, years of education, and nonverbal intelligence. Such conflicting results deserve more attention.

Current Research

Based on the above discussion, the following lines of research will be address in the current study.

1. Does language mode affect bilinguals' performance?

Language mode can be a very important variable that should be considered in the bilingualism advantage literature. By manipulating whether participants are in a mono- or bilingual mode at the time they perform the task, we could expect to see different results on a variety of tasks.

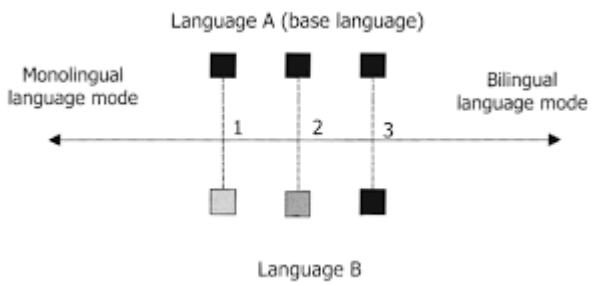

Figure 1. Language mode (Grosjean, 1998; 2011).

Figure 1 is a graphical presentation of language mode according to Grosjean (1998; 2011). In all positions, the bilingual speaker is using language A which is the language that the speaker uses most often. In position 1, or monolingual mode, language A is completely active while language B is inhibited. Position 1 happens when communication is between a bilingual and monolingual listener, or the topic, situation, purpose of the interaction require only one language to be spoken. Position 2 is the intermediate mode. Language A is still the most active language but language B is now partially activated. Bilinguals may find themselves in this position if the person who they are interacting with is bilingual as well but does not want to use the other language (language B in this case) or is less fluent in that language. Finally, position 3 is the bilingual mode. Both languages are active, though language B is slightly less active than language A as it is not the language of communication at that moment. Bilinguals can find themselves in this position when they are communicating with other bilinguals who know the same two (or more) languages.

Therefore, the activation levels for each language are assumed to vary depending on the language mode. Accounting for language mode is important for the bilingualism advantage debate because, depending on whether participants are in a mono- or bilingual mode, the inhibitory control mechanism will be engaged to a different extent. If fully inhibiting a language in monolingual mode requires more resources than does allowing both languages to be active in

bilingual mode, then we may observe the bilingual advantage only in bilingual mode. However, if juggling two languages in bilingual mode is more taxing than fully suppressing one language, we may observe the bilingual advantage only in monolingual mode.

2. What is the relationship between performance on complex WM measures and bilingualism?

Complex WM tasks may more accurately assess the type of executive control used by bilinguals on a daily basis, specifically their ability to inhibit irrelevant information on a continual basis. Yet, only a couple of studies have evaluated the bilingual advantage on complex WM tasks, and these results are conflicting. The current research question will attempt to resolve these discrepancies.

Finally, one of the problems mentioned by Paap et al. (2015) was the fact that in most studies, bilinguals and monolinguals participate in a single task, which yields a single measure. For example, Colzato et al. (2008) evaluated the bilingual advantage in three different studies. While a bilingual advantage effect was found in two out of the three studies, each study used a single measure and a new sample. Unsworth et al. (2005) proposed that a single task may not truly capture the underlying construct but instead it is better to use multiple measures of the same construct. Thus, we propose to use several measures of WM and create a composite score for the analyses because the composite score will be a better representation of participants' WM ability.

Chapter 2 - Pretest

According to Grosjean (2011), language mode needs to be controlled in bilingualism studies; however, there is no established way of leading bilingual participants to either the bilingual or monolingual points of the language mode continuum. Grosjean (1998; 2011) claims that it is very easy to lead participants into a bilingual mode, thus, it is possible that all studies conducted to date unintentionally evaluated participants in the bilingual mode. Therefore, a pretest was conducted to evaluate whether language mode could be successfully manipulated.

Furthermore, a new demographic and fluency questionnaire was developed. The questionnaire was adapted from Rai, Loschky, and Harris (2015) by omitting some questions and adding several other questions that were important to the current study. Further, a new language fluency scale was added, which was adapted from Paap and Greenberg's (2013) 7-point language proficiency scale. The questionnaire is presented in Appendix A in English and in Appendix B in Spanish (discussed further).

A modified version of a picture-word interference task (MPWI; Piocuda, 2015) was used in the pretest. The picture-word interference task (PWI) is often used to study language control and inhibition (Costa & Santesteban, 2004; Jared & Kroll, 2001; Meuter & Allport, 1999). During a standard experiment, a series of word-picture pairs is presented to participants. A presented word can be congruent or incongruent with the picture and participants are asked to identify the picture while ignoring the word. Research has shown that the language in which the word is presented in as well as the language in which participants are required to respond in can affect bilingual participants' reaction times (De Groot, 2011).

The entire pretest was run in either a monolingual mode (only L1 or L2) or in a bilingual mode (using both L1 and L2) and the following hypotheses were assessed:

Bilingual Advantage Hypotheses:

H1a (Hypothesis 1a): Language mode will affect participants' performance on the MPWI task, such that bilingual participants in monolingual mode will be more efficient than monolingual participants as evident by faster reaction times (RTs) [$B_M > M$].

H1ab: Language mode will affect participants' performance on the MPWI task, such that bilingual participants in monolingual mode will be as efficient as monolingual participants as evident by no significant difference in reaction times (RTs) [$B_M = M$].

H1b: Language mode will affect participants' performance on the MPWI task, such that bilingual participants in the bilingual mode will be less efficient than monolingual participants as evident by slower RTs [$B_B < M$].

Language Mode Hypotheses:

H2a: Language mode will affect participants' performance on MPWI, such that there will be a significant difference within bilingual participants' RTs between the monolingual and bilingual modes. Bilingual participants in a bilingual mode are expected to have slower RTs as compared to bilingual participants in a monolingual mode [$B_M > B_B$].

H2b: Language mode will have no effect on participants' performance on the MPWI task, such that there will be no significant difference between the bilingual participants' performance between the bilingual and the monolingual modes [$B_M = B_B$].

H2c: Language mode will affect participants' performance on MPWI, such that there will be a significant difference within bilingual participants' RTs between the monolingual and bilingual modes. Bilingual participants in a bilingual mode are expected to have faster RTs as compared to bilingual participants in a monolingual mode [$B_M < B_B$].

Method

Participants

A total of 60 participants completed the pretest. Bilingual and monolingual participants were recruited through the online survey platform Qualtrics. To become a Qualtrics participant, participants have to complete an extensive questionnaire answering questions not only about their age and gender but also questions on whether they speak any languages other than English. This allowed us to know beforehand whether participants were monolingual or bilingual (and, in our case, knew Spanish). Spanish was the L2 of choice in our case because, according to U.S. Census Bureau (2010), Spanish saw the greatest increase of languages spoken at home between 1980 and 2007, from about 11 million people to almost 34.5 million.

Participants were divided into three groups. Group 1 (M, monolinguals) included only monolingual participants who spoke English only. Groups 2 and 3 included bilingual participants who spoke English and Spanish. The first group completed an entire study in English. The second group (B_B, bilinguals in bilingual mode) completed the study in English and Spanish. The third group (B_M, bilinguals in monolingual mode) completed the majority of the study in Spanish and the last 20 trials of the last task in English and Spanish (discussed below). All participants received an email invitation to participate in an online study; however, those in Groups 1 and 2 received an invitation in English whereas those in Group 3 received the same invitation in Spanish.

Tasks

Participants completed a total of 3 tasks. For Task 1, participants filled out an extensive demographics questionnaire. The questionnaire is presented in Appendix A in English and Appendix B in Spanish. For Task 2, participants read four short paragraphs and answered three

short questions that followed each paragraph (story materials have been adopted from Piocuda, 2015). The language in which the paragraphs and questions were presented varied by group. Group M read all four paragraphs and answered the following questions in English only. Group B_B read half of the paragraphs and answered half of the questions in English and the other half of the paragraphs and questions in Spanish. Group B_M completed the entire task in Spanish. All four paragraphs with questions are presented in Appendix C in English and in Appendix D in Spanish.

The third and final task was a modified picture-word interference task (MPWI). Participants were required to match a picture with a word for a total of 40 trials. A word was congruent with the picture on half of the trials and incongruent with the picture on the other half of the trials. Words were divided into two sets of 20. The language in which the words were presented also varied by Group. All words were presented in English only for Group M. Half of the words were presented in English and half in Spanish for Group B_B; the presentation of words was randomized. The words were presented in Spanish only for the first 20 trials for Group B_M and in English and Spanish for the last 20 trials. This within subject manipulation was done in an attempt to observe participants in Group B_M in both monolingual (Set 1) and bilingual (Set 2) modes and see whether any difference can be observed. The same congruent and incongruent word-picture pairs were presented to all groups; however, the order in which the pairs were presented was randomized for each participant. The words are presented in Appendix E. Finally, participants were presented with a debriefing statement and researcher's contact information. All instructions were presented in English for Group M and Group B_B and in Spanish only for Group B_M. All Spanish materials were translated by a native Spanish speaker.

Table 1

Pretest Demographics

	n	Gender	Age (μ)	EOF	SOF	EL	EW	ER	ES	SL	SW	SR	SS
Group M	19	71%F	$45_{b,c}$	6.00_{c}	x	5.68	5.68	5.05	5.90	x	x	x	x
Group B_B	20	68%F	32_{a}	5.75_{c}	5.30	5.85_{c}	5.90_{c}	5.95_{c}	5.85_{c}	5.05	4.95	4.95	5.40
Group B_M	21	43%F	32_{a}	$4.95_{a,b}$	5.10	5.10_{b}	5.00_{b}	5.05_{b}	5.10_{b}	5.29	4.52	4.81	5.33
F			13.887	8.945		3.968	3.287	5.039	3.804				
p			<.001	<.001	n.s.	.024	.045	.010	.028	n.s.	n.s.	n.s.	n.s.

Note. EOF English Overall Fluency, SOF Spanish Overall Fluency, EL English Listening, EW English Writing, ER English Reading, ES English Speaking, SL Spanish listening, SW Spanish writing, SR Spanish Reading, SS Spanish speaking. Subscripts denote significant group differences (*a* = Group M, *b* = Group B_B, *c* = Group B_M).

Results

Demographics

The demographics for the three groups are presented in Table 1. There were 19 participants in Group M (μ_{age} = 45, 71% female), 20 participants in Group B_B (μ_{age} = 32, 68% female), and 21 participants in Group B_M (μ_{age} = 32, 43% female). There were no significant differences among groups in parental education. However, there was a significant age difference among the three groups, $F(2, 57) = 13.887$, $p < .001$, with Group M being significantly older than Group B_B and Group B_M, $t(18) = 10.693$, $p < .001$ and $t(18) = 10.082$, $p < .001$, respectively. Group B_B and Group B_M did not differ significantly in age, $t(19) = -.905$, $p = .377$.

Further, there was a significant difference in Overall English fluency, $F(2, 57) = 8.945$, $p < .001$, such that Group B_M was significantly less fluent in English than Group M and Group B_B. No other comparisons differed. A one-way ANOVA indicated that there were differences among the group means in English Listening, $F(2, 57) = 3.968$, $p = .024$, English writing, $F(2, 57) = 3.287$, $p = .045$, English reading, $F(2, 57) = 5.039$, $p = .010$, and English speaking, $F(2, 57) = 3.804$, $p = .028$. Despite random assignment of the two bilingual groups, Bonferonni post-hoc comparisons indicated that Group B_B was significantly better than Group B_M in each of these categories. There were no significant differences in Spanish abilities between Groups B_B and B_M. Given these pre-existing group differences, these variables will be accounted for as covariates in the experimental analyses.

Reaction Times on MPWI Task

Composite variables for each word/picture for each language were created by averaging the means across all trials for each language (e.g. English congruent trial, English-Spanish

incongruent trials etc.). Reaction time (RT) was the dependent variable. 1% of RT data was trimmed on both ends and, thus, excluded from the analysis.

Analyses on response accuracy revealed that overall participants made very few errors that did not significantly differ by group, such that Group M made no errors, Group B_B made 14 errors (1.6% of all trials), and Group B_M made 18 errors (2.1% of all trials). These incorrect responses were excluded from the RT analyses.

Word/image pairs have been divided into two sets. This was done to compare the RT for Group B_M to see whether there will be a difference in RT when the group switches from a monolingual mode (all Spanish) to a bilingual mode (English and Spanish). Table 2 shows RT data for Sets 1 and 2 for each group in each of the conditions: congruent and incongruent.

Table 2

Mean Reaction Times for Each Condition of the MWPI Task in Seconds

	Set 1			Set 2			Overall
	CG Set1	IG Set1	All Set1	CG Set2	IG Set2	All Set2	All
Group M	2.123	2.143	2.149	1.870	1.955	1.914	1.974
	(.66)	(.67)	(.68)	(.66)	(.62)	(.63)	(.59)
Group B_B	2.098	2.168	2.138	2.372	2.529	2.453	2.265
	(.83)	(.91)	(.87)	(.98)	(.98)	(.95)	(.89)
Group B_M	1.88	1.933	1.908	1.955	2.049	2.004	
	(.45)	(.61)	(.45)	(.66)	(.76)	(.63)	

Note. CG – congruent, IG – incongruent. Standard deviations are in parenthesis.

Overall RT analyses

A 3 (Group: M vs. B_B vs. B_M) x 2 (Set: Set 1 vs. Set 2) mixed analysis of covariance was conducted to compare overall RT, adjusting for Age and Overall English Fluency (Figure 2). Neither the main effect of Group, $F(1,44) = 1.07$, $p = 0.353$, nor the main effect of Set was significant, $F(1,57) = 0.41$, $p = 0.525$, but the Group x Set interaction was significant, $F(2,57) =$

8.77, $p = 0.0005$. Note here that the lack of group differences between B_B and B_M provide evidence for Hypothesis 2b. Also since Group B_M participants were in a monolingual mode until the end of Set 1, their RTs for Set 1 were compared with Group M RTs from Set 1. There were no significant differences ($p = .813$), indicating that bilingual participants in monolingual mode were as efficient as monolingual participants, supporting Hypotheses H1ab.

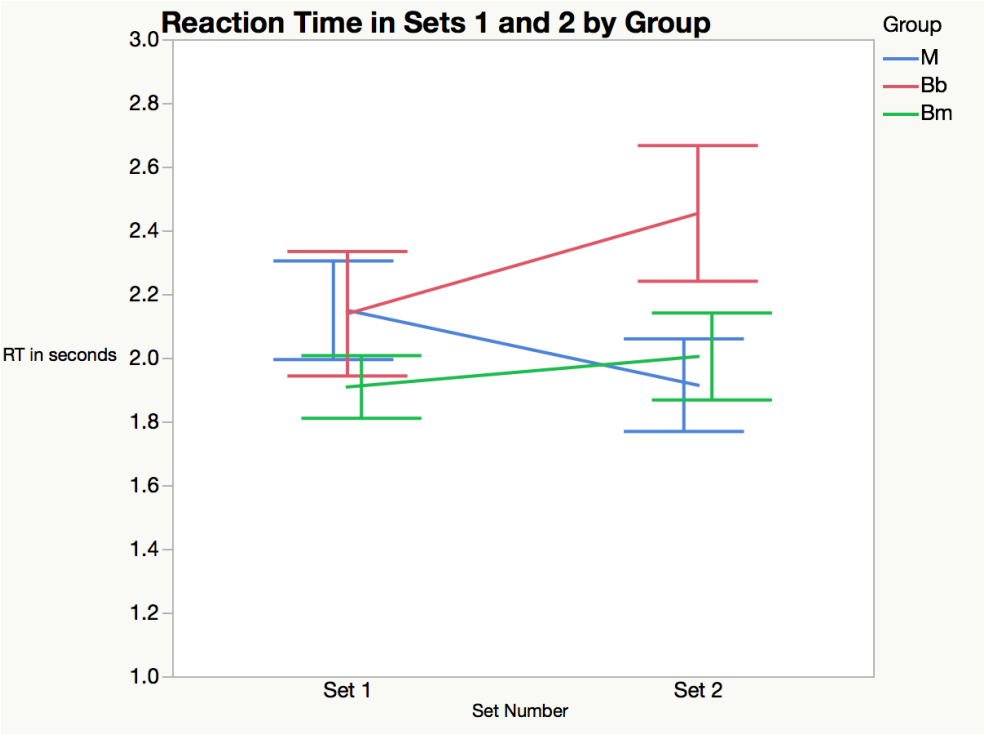

Figure 2. Reaction time in Sets 1 and 2 by Group. Error bars represent 1 standard error from the mean.

To unpack the significant interaction, planned contrasts were conducted to compare RTs within each group for Set 1 vs. Set 2. These contrasts revealed that Group M responded significantly faster in Set 2 ($M = 1.914$ s) as compared to Set 1 ($M = 2.149$ s), $p = .009$, Group B_B responded significantly slower in Set 2 ($M = 2.453$ s) as compared to Set 1 ($M = 2.138$ s), $p = .002$, and the RTs for Group B_M did not change significantly across sets (see Figure 2). Finally, a planned contrast comparing RT in Set 2 for Group M and Group B_B was marginally significant,

p = .053, indicating that monolinguals were faster than bilinguals in bilingual mode providing evidence for Hypotheses H1b.

Considering that there were no significant group differences in Set 1 but there were in Set 2, perhaps there might be downstream cognitive effects of language mode that do not occur immediately when the individual first transitions into monolingual or bilingual mode. In other words, participants might need to speak a single language (monolingual mode) or two languages (bilingual mode) for the entire duration of the task in order for language mode to "take effect." This same reasoning could potentially also explain why Group B_M's reaction times remained fairly stable across Sets 1 and 2. That is, these participants were in monolingual mode for Set 1 and bilingual mode for Set 2 and, therefore, may not have been in either mode long enough to see any effects on RT.

Congruent vs. incongruent analyses

A one-way within groups ANOVA indicated that there was no significant difference between the congruent condition overall RTs and incongruent condition overall RTs for Group M, monolinguals, (p = .611), Group B_B, bilinguals in the bilingual mode (p = .780), or Group B_M, bilinguals in monolingual mode (p = .210). This result indicates that participants responded equally fast to stimuli regardless of whether the picture-word pairs were congruent or not. This task likely was too easy for all participants, which is also supported by the very high accuracy rates reported above.

Discussion

Overall, monolinguals were significantly faster than bilinguals in bilingual mode during Set 2, which supports Hypothesis H1b. At the same time, bilinguals in monolingual mode seem to be as efficient as monolinguals, which supports Hypothesis H1ab. These results indicate that,

on the one hand, being in bilingual mode and constantly switching between the two languages may be more taxing and may require utilizing more resources, resulting in slower RTs. On the other hand, a bilingual being in monolingual mode is as efficient as being monolingual and results in RTs similar to those of monolingual participants. Also, when comparing overall RTs, bilinguals in monolingual mode performed as efficiently as bilinguals in bilingual mode, which supports Hypothesis H2b. However, considering that bilingual participants in monolingual mode switched from monolingual mode in Set 1 to bilingual mode in Set 2, they may not have been in either mode long enough to see the difference in overall RTs between these two groups. Nonetheless, as discussed above, we have shown that bilinguals in bilingual mode and bilinguals in monolingual mode perform differently when compared to monolingual participants. Therefore, our pretest results provided first evidence that language mode is a variable that can be experimentally manipulated. Now that we have demonstrated that priming bilingual participants to be in a bilingual or monolingual mode affects their performance, we continue to the main study of our dissertation.

Chapter 3 - Main Study

The pretest evaluated a simple way of priming participants to either be on the mono- or bilingual ends of the language mode spectrum and effectively changed RT performance on the MWPI task. As mentioned in the introduction, though, the type of inhibitory control measured by certain tasks may not tap onto the same type of inhibitory control that bilinguals engage in on a daily basis. The MWPI only required bilingual participants to make a simple timed decision while the language in which the stimuli were presented in was manipulated; therefore, it is possible that language mode may have even larger effects on more complex tasks that resemble the type of inhibitory control used in day-to-day tasks.

The main objective of the Main Study was to investigate the relationship between bilingualism and performance on complex WM tasks while priming participants to be in a bilingual or monolingual mode. As mentioned above, the dual task nature of measures such as OSPAN and RotSpan (i.e., processing some stimuli while storing other stimuli) may more closely resemble the bilingual experience of using two languages. That is, bilinguals can never fully "turn off" the second language, thus always choosing to speak L1 while still having the other L2 active. However, the degree of L2 activation can vary from situation to situation, which is what the language mode manipulation attempted to capture. The Main Study manipulated language mode and assessed whether it had any effect on bilingual participants' performance on various measures of cognitions such as OSPAN, RotSpan, and another inhibition task that is commonly used in bilingualism research, the Simon task.

These specific tasks were chosen in an attempt to (1) identify WM span tasks that assess an ecologically valid form of inhibition and (2) replicate previous work, which is something Paap and Greenberg (2013) called bilingualism researchers to do. The WM tasks were chosen to

replicate Ratiu and Azuma (2015), who were one of the few recent studies who used a complex WM measure, the OSPAN task, in bilingualism research. The Simon task was chosen because it is one of the most commonly used tasks in bilingualism research. As mentioned in the introduction, results on the Simon task have varied. There is some evidence of a bilingual advantage (Bialystok et al., 2004) and other evidence of no bilingual advantage (Paap and Greenberg, 2013). The design of the current study allowed us to evaluate a novel effect of language mode on cognition while also allowing us to build in two potential replications. Such a robust design is important in light of the "reproducibility crisis" currently plaguing the field of psychology and science as a whole.

Another concern raised by Paap et al. (2015) was the fact that the majority of studies conducted up until now used a single measure with a single group of participants. To address this concern, the proposed study administered not one but three measures of complex WM performance to the same group of participants. In addition to OSPAN and Rotspan, Counting span (CSPAN) task was used in the Main Study (Unsworth et al., 2009). The CSPAN task was used during Part I in an attempt to equate pre-existing working memory differences across groups. OSPAN and RotSpan are two types of different WM measures that were both used in Part II. The OSPAN is a verbal measure of WM since participants have to actively process information in the phonological loop while the RotSpan is a measure of spatial WM because participants are required to actively process information in the visuospatial sketchpad. OSPAN, Rotspan, and their composite score were used to evaluate the effect of language mode. As mentioned above, the composite WM score should be a more accurate measure of WM ability as it captures common variance shared between all of the tasks and removes variance associated with domain specific skills (i.e., mathematic and visuospatial ability).

In addition to the main outcome measures of working memory and executive function, we also included a measure of both language fluency and language proficiency. As mentioned in the introduction, different research labs use different measures of language fluency and/or proficiency. We included a self-report measure of language fluency and an objective measure of language proficiency that have been both previously used in research. This allowed us to compare participants' self-reported language fluency to their observed behavior.

Finally, we addressed the issue of covert versus overt recruitment. Participants were invited to participate in two seemingly unrelated studies (described in detail in the Method section). On the one hand, this allowed us to ask all the demographics and language fluency questions in the first part of the Main study. On the other hand, this also allowed us to invite participants to enroll in the second part of the study without explicitly telling them that it was a language study and monolingual were compared to bilingual participants. This was especially important for our monolingual mode condition when bilingual participants completed the entire study in English only. They were not aware that their knowledge of two languages was an important variable to us, which helped keep them in monolingual mode without explicitly eliciting bilingual mode.

The following hypotheses were proposed regarding bilingualism and working memory performance:

Bilingual (Dis)Advantage Hypotheses:

H1: There will be a significant difference between WM tasks' scores of all bilinguals and monolinguals, such that all bilinguals will outperform monolinguals [B > M].

H2: There will be a significant difference between WM tasks' scores of all bilinguals and monolinguals, such that monolinguals will outperform bilinguals [B < M].

H3: There will be no significant difference between WM tasks' scores of all bilinguals and monolinguals [B = M].

The first three hypotheses assess bilingual and monolingual participants' overall WM performance on the complex WM tasks, not taking language mode into account. Interestingly, if H1 is supported, it would indicate that bilinguals outperform monolinguals due to the dual nature of the tasks as described above. If H3 is supported, it would indicate that there is no bilingual advantage. However, such a result will indicate no bilingual *disadvantage*. However, if monolinguals outperform bilinguals, supporting H2, it would show a bilingual disadvantage, unless these differences are explained by language mode manipulation.

Language Mode Hypotheses:

H4: Language mode will affect bilingual participants' performance on WM tasks, such that bilingual participants in monolingual mode will outperform bilingual participants in bilingual mode [$B_M > B_B$].

H4a: Language mode will affect bilingual participants' performance on WM tasks, such that bilingual participants in bilingual mode will outperform bilingual participants in monolingual mode [$B_B > B_M$].

H5: Language mode will have no effect on bilingual participants' performance on WM tasks, such that there will be no significant difference between the bilingual participants' performance in bilingual and monolingual modes [$B_M = B_B$].

Hypotheses H4, H4a, and H5 assess whether there is an effect of language mode on WM performance in bilingual participants. If H4 is supported, it would indicate that fully suppressing one of the languages allows bilinguals to perform more efficiently on WM tasks. Such a result may indicate that the inhibitory control mechanism is most active in monolingual mode, thus

resulting in bilinguals' better performance on dual tasks that require inhibiting irrelevant information. On the other hand, H4a could be supported, which would indicate that fully suppressing one language in monolingual mode could be very taxing, resulting in a less efficient performance on WM tasks. At the same time, bilinguals' better performance in a bilingual mode may indicate that being in bilingual mode resembles bilinguals' daily experience of juggling two languages the most. Depending on whether H4 or H4a is supported, it could affect future bilingual research, such that these results would shed light on whether language mode shall be manipulated when comparing bilinguals to monolinguals. Finally, if H5 is supported, it could indicate that language mode did not have an effect on bilingual participants' performance on complex WM tasks. Such a result could also indicate that complex WM tasks may not be the most sensitive tasks to tap into bilinguals' everyday use of both languages.

Monolingual Mode hypotheses:

The following hypotheses will compare WM performance of monolingual participants to bilingual participants who are in monolingual mode.

H6a**:** In monolingual mode, bilingual participants will outperform monolinguals on the WM tasks [$B_M > M$].

H6b: In monolingual mode, monolingual participants will outperform bilingual participants on WM tasks [$B_M < M$].

H6c: There will be no significant difference between bilingual and monolingual participants' WM tasks' scores [$B_M = M$].

Based on Green's (1998) theory, inhibitory control is needed to completely suppress a language. Thus, the inhibitory control mechanism should be most active when bilinguals are in the monolingual mode. As a result, bilinguals are expected to perform better on the dual task

processing that is required of them while performing on WM measures, supporting H6a. On the other hand, completely inhibiting one language could be very taxing, leaving fewer resources for the WM task, which would support H6b. In this case, monolinguals will outperform bilinguals because they can utilize all of the resources for the WM task, whereas bilinguals have to inhibit the language while performing WM tasks. If H6c is supported, it could indicate that while only one language is active, bilinguals perform similarly to monolinguals and no bilingual advantage is observed. At the same time, if H6c is supported, it could also indicate that there is no bilingual disadvantage.

Bilingual Mode Hypotheses:

The following hypotheses will compare WM performance for monolinguals to bilinguals in bilingual mode.

H7a**:** Bilingual participants in bilingual mode will outperform monolinguals on WM tasks [$B_B > M$].

H7b**:** Monolingual participants will outperform bilingual participants in bilingual mode on WM tasks [$B_B < M$].

H7c: There will be no significant difference between WM tasks' scores between monolingual participants and bilingual participants in bilingual mode [$B_B = M$].

If H7a is supported, it could indicate that even in the bilingual mode, bilinguals may outperform monolinguals due to the nature of the task. As discussed above, such dual task processing as required by the complex WM measures may capture bilinguals' use of both languages in their everyday lives, thus contributing to bilinguals' better performance on complex WM measures as compared to monolinguals' performance. If H7b is supported, it could indicate that being in bilingual mode and constantly juggling two languages could leave bilinguals with

few resources left to use on the WM tasks. If H7c is supported, it could indicate that having two languages active does not negatively affect bilinguals' performance on the WM tasks, such that bilinguals perform similarly to monolingual participants. While this could indicate that there is no bilingual advantage, it could also support that there is no bilingual disadvantage.

Method

Participants

A power analysis conducted in G*Power 3.1 (effect size from overall RT differences in the pre-test, f = .373; alpha = .05), indicated that a total sample size of 117, or 39 participants per group, were needed to obtain a significant effect of language mode. A total of 180 participants (60 monolinguals and 120 bilinguals) were recruited for the Main Study Part I (see Figure 3). Participants were recruited through the online survey Qualtrics. Participants were invited to participate in the online survey via email in a manner similar to how they were invited to participate in pretest. However, bilingual participants were Russian-English speakers as compared to Spanish-English speakers in pretest. Both the monolingual and the bilingual groups completed the entirety of part I in English. Participants were recruited for Part II through Qualtrics as well. All participants who completed Part I of the Main Study were then invited to participate in Part II via email, similar to the manner in which participants were invited to participate in the pretest. Part II took place approximately 4 to 7 days after Part I.

A total of 108 participants completed Part II (34 monolinguals and 74 bilinguals, 43% and 38% attrition rate, respectively). Those participants who returned for Part II were divided into three groups similar to pretest. Group M included monolingual participants who spoke English only. Groups B_B and B_M included bilingual participants who spoke fluent English and Russian. Group M and Group B_M completed an entire study in English, whereas Group B_B

completed the study in both English and Russian. Participants who returned for Part II completed the CLOZE task, the Simon task, as well as two complex WM span measures: the OSPAN and the Rotspan.

Materials

Demographics Questionnaire. All participants completed the Demographics questionnaire in Part I in English (see Appendix F). Participants were asked to record their age, sex, parental education, their own education, SES, as well as answer several questions related to English and Russian fluency, including overall language fluency in these languages.

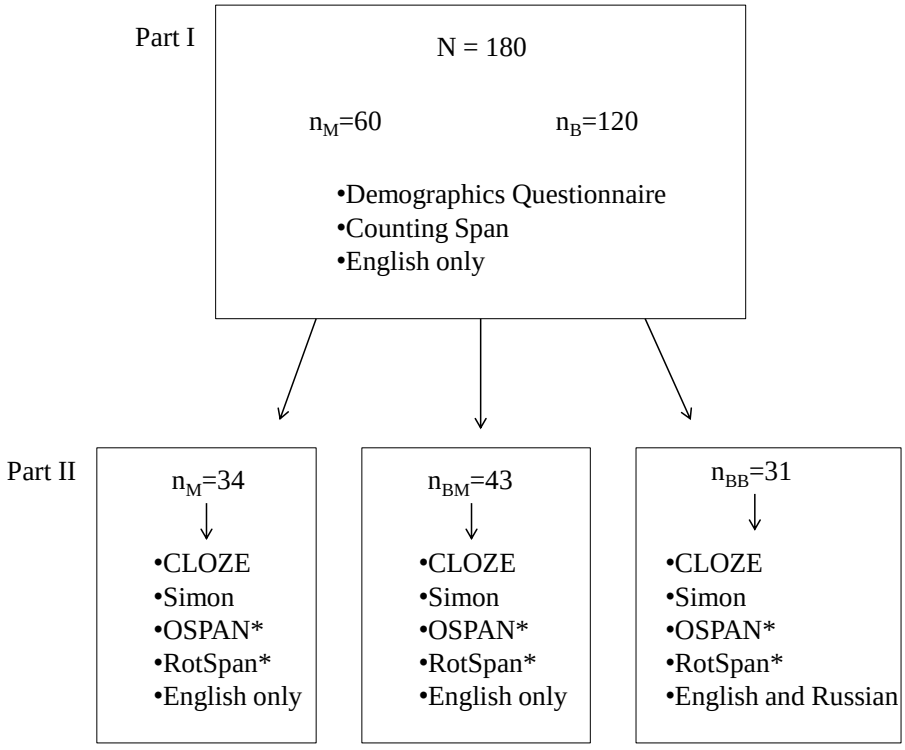

Figure 3. Main Study Method. *OSPAN and RotSpan were counterbalanced. M = monolingual, B = Bilingual, BM = Bilinguals in monolingual mode, BB = Bilinguals in bilingual mode.

CLOZE task. CLOZE task is a measure of language proficiency (Oller, 1972). The CLOZE task consisted of three paragraphs with five words omitted in each text. Each text had five sentences with one word omitted from each sentence. Participants were given five word choices and were asked to choose the word that best fit while also ensuring the sentence remained grammatically correct. Performance was scored as the number of correct answers. Our monolingual participants and bilingual participants in monolingual mode completed the entire CLOZE task in English. However, our bilingual participants in bilingual mode completed the task in English and Russian. The three paragraphs and the answer choices were presented in English; however, the instructions on top of each page were presented in English and Russian. The three paragraphs and the answer choices are presented in Appendix G (http://www.testyourenglish.net/english-online/menu/cloze-tests.html).

Simon task. In the Simon task, participants were presented with either a red or a blue square to the right or to the left of the central fixation (Figure 4). Participants were asked to press the left button as quickly as possible each time they saw a blue square and to press the right button as quickly as possible each time they saw the red square, regardless of their location in regards to the fixation cross. Congruent trials were when the location of the target was on the same side as the correct response (e.g. a blue square on the left, Figure 4a). Incongruent trials were when the location of the target was on the opposite side (e.g. a blue square on the right, Figure 4b). Each Simon block consisted of 20 congruent and 20 incongruent trials presented in random order. Participants completed a practice Simon block of 8 trials before starting the experimental trials. Again, the monolinguals participants and the bilinguals in monolingual mode completed the entire task in English only. For the bilingual participants in bilingual mode, the

instructions at the beginning of the task were presented in English and Russian, as well as the words LEFT and RIGHT were randomly presented in either English or Russian.

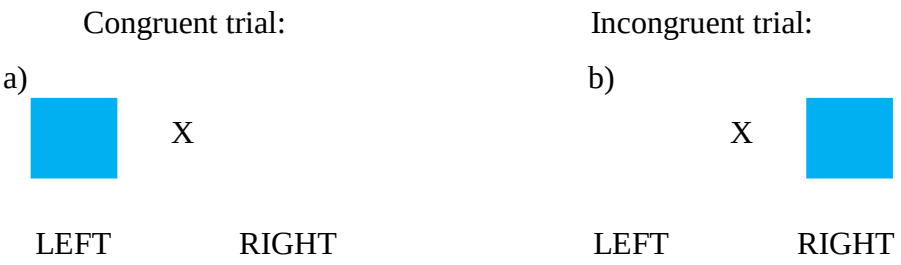

Figure 4. Example of a congruent and an incongruent trial on the Simon task.

Counting Span (CSPAN) task. CSPAN was the first and only complex WM task that participants completed in Part I, and therefore, the entire task was completed in English for all three groups. In this task participants were presented with an array of objects (for an example trial, see Figure 5) and asked to count the number of dark blue circles among the colored distractors by clicking on each of them and remember the total number of those dark blue circles for a later memory test. Once they had clicked on each of the dark blue circles, a new array of objects was presented and once again they were asked to count all of the dark blue circles by clicking on them. After a varying number of trials, participants were asked to recall the numbers in the correct order. Set sizes varied from two to six arrays, and there were a total of 13 sets. The partial unit scoring method was used for all WM tasks (Conway et al, 2005). Using this scoring method, if a participant recalled 3 out of 4 numbers correctly on Trial 1 of the CSPAN task, s/he received a score of 0.75 for Trial 1. Then if on Trial 2, 4 out of 6 numbers were correctly recalled, s/he received a score of .67. These trial-by-trial proportional scores were then averaged across all trials to create an overall CSPAN score for each participant.

Figure 5. Example of a CSPAN trial.

OSPAN task. The OSPAN task (Unsworth et al., 2009) consisted of three parts (see Figure 6 for example trial). Participants were presented with a math equation and asked to judge whether or not it was solved correctly (e.g., 7 + 4/2 = 10; True or False?). Afterwards, participants were presented with a letter that they had to remember. These equation-letter trials were repeated until a recall screen appeared. At this point, participants were instructed to recall all the letters in the correct order after a random number of trials. Set sizes ranged from three to six math equation-letter pairs for a total of 12 sets (Kane et al., 2004).Monolingual participants and bilingual participants in monolingual mode completed the entire task in English only. Bilingual participants in bilingual mode completed the task in English and Russian. The instructions at the beginning of the OSPAN task as well as the instructions on the recall screen were presented in English and Russian. Again, the partial unit scoring method was used to calculate performance.

Rotation Span task. Participants also completed a rotation span task (RotSpan; Kane et al., 2004), which is a visuospatial task. The RotSpan is similar to OSPAN in that it is a dual task consisting of a distractor and memory component. An example trial is presented in Figure 6. The

distractor task in the RotSpan required participants to judge whether a rotated letter is presented correctly or is a mirrored image of the letter. Each letter was followed by arrows of either short or long length and pointing in one of eight different directions. For the memory component, participants had to remember the direction the arrow was pointing as well as the length of the arrow. Set sizes ranged from two to five letter-arrow sequences per trial, and there were a total of 12 trials (Kane et al., 2004). Similar to OSPAN, bilingual participants in bilingual mode saw instructions at the beginning of the task as well as on the recall screen in both English and Russian, whereas bilinguals in monolingual mode and monolingual participants completed the entire task in English only.

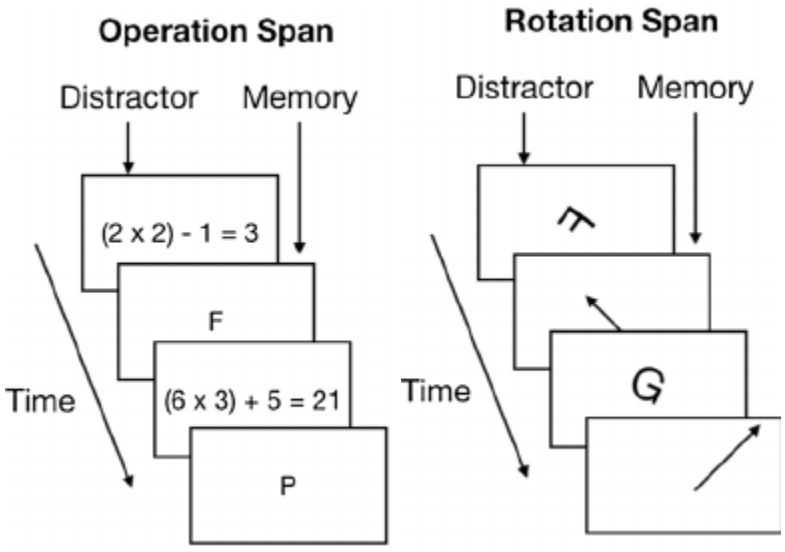

Figure 6. Examples of OSPAN and RotSpan trials (Foster, Shipstead, Harrison, Hicks, Redick, & Engle, 2014).

Procedure

Participants completed the informed consent, the demographics questionnaire, and the CSPAN task in Part I. Both the bilingual and the monolingual participants completed Part I

entirely in English. Participants signed another informed consent (in English) before starting Part II. The CLOZE task was the first task to be completed in Part II, followed by the Simon task. Immediately after completing the CLOZE and the Simon tasks, participants completed the OSPAN task and the Rotspan task. The order of the WM tasks was counterbalanced with half of the participants in each group completing OSPAN first and half of the participants completing RotSpan first. Monolinguals and bilinguals in monolingual mode completed the entire Part II in English. Bilinguals in bilingual mode completed Part II in English and Russian.

Results

Demographics

The Main Study demographics are presented in Table 3. A total of 108 participants returned to complete Part II: 34 participants in Group M (μ_{age} = 53, 32% female), 31 participants in Group B_B (μ_{age} = 51, 41% female), and 43 participants in Group B_M (μ_{age} = 50, 66% female). The groups did not significantly differ in age (p = .503), parental education (p = .262), parental income (p = .648), or participants' income (p = .794); however, there was a significant difference in participants' own education, F (2, 105) = 8.853, p < .001. Monolingual participants had significantly fewer years of education as compared to bilingual participants in monolingual mode (p = .003) and bilingual participants in bilingual mode (p = .001), but the two bilingual groups did not differ (p = .469). To account for this pre-existing difference, years of education will be included as a covariate in the following analyses.

Table 3. *Main Study Demographics*

Group	n	Age	Gender	Education	Parental Education	Income	Parental Income
Group M	34	53	32%F	14.9	16.8	4.2	3.7
Group B_B	31	51	41%F	17.2	17.6	4	3.2
Group B_M	43	50	66%F	16.8	17.1	4.2	3.2

Note. Education and Parental Education are in mean number of years, category 3 in Income and Parental Income represents earnings between $25,000 and $49,999, category 4 represents earnings between $50,000 and $99,000.

The Language Fluency data are presented in Table 4. The three groups did not significantly differ on any of the English language fluency measures: English listening, $p = .152$, English speaking, $p = .139$, English reading, $p = .177$, English writing, $p = .218$. Further, the two bilingual groups did not significantly differ on any of the Russian language fluency measures: Russian listening $p = .507$, Russian speaking, $p = .476$, Russian reading, $p = .445$, and Russian writing, $p = .974$. There were no significant differences in overall English fluency among the three groups ($p = .148$) or in overall Russian fluency between the two bilingual groups ($p = .461$).

Table 4. *Main Study Language Fluency**

	EOF	ROF	EL	ES	ER	EW	RL	RS	RR	RW
Group M	5.8	x	5.8	5.8	5.8	5.8	x	x	x	x
Group B_B	5.6	5.23	5.6	5.5	5.7	5.6	5.4	5.2	5.03	4.9
Group B_M	5.6	5.4	5.6	5.6	5.7	5.6	5.5	5.4	5.3	4.9

Note. Only data for participants who participated in both Part I and Part II are presented here. EOF English Overall Fluency, ROF Russian Overall Fluency, EL English Listening, EW English Writing, ER English Reading, ES English Speaking, RL Russian listening, RW Russian writing, RR Russian Reading, RS Russian speaking.

CLOZE Task

The CLOZE task performance is plotted in Figure 7. This task was mainly used to check for language proficiency as well as to prime the bilingual participants to be in either a bilingual or monolingual modes. While all three groups completed the task in English, the bilinguals in bilingual mode read instructions in English and Russian as opposed to reading instructions in English only. Overall, CLOZE performance was high with very little variability, even amongst bilinguals (Group M: M = 14.44; SD = .91; Group B_M: M = 14.37; SD = 1.02; Group B_B: M = 14.10; SD or SE = 1.35). An analysis of covariance (ANCOVA) was performed to evaluate the effect of group (Groups M vs. B_M vs. B_B) on CLOZE task performance while controlling for years of education. Results indicated that performance on this task did not significantly differ among all three groups (p = .451), which was expected, because the three groups did not differ in self-reported language proficiency (Table 4).

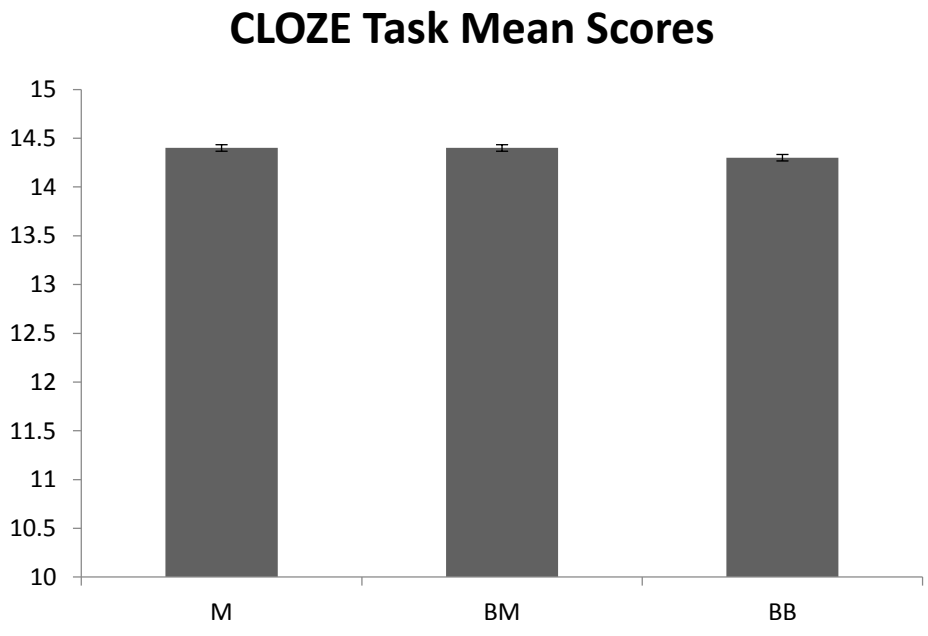

Figure 7. Average scores on the CLOZE Task plotted by monolinguals (M), bilinguals in monolingual mode (BM), and bilinguals in bilingual mode (BB) on the x-axis. The range of possible scores was 0-15 (y-axis); error bars with standard error are displayed.

Simon Task

Performance on the congruent and incongruent trials on the Simon task is presented in Table 5. Error rates were very low and did not differ by group, but the main dependent variable in this analysis is the *Simon effect*, which was the difference in RTs in the congruent and incongruent conditions. Similar to prior research (Bialystok et al., 2004; Paap and Greenberg, 2013), only correct responses were used when calculating the effect. An ANCOVA, adjusting for years of education, indicated that there were no significant differences among the three groups on the Simon effect (p = .693), which replicates the findings obtained by Paap and Greenberg (2013). The magnitude of the effect was typical for the Simon task (Lu & Proctor, 1995).

Table 5. *Simon task results*

Group	Congruent RT	Incongruent RT	Simon Effect	Total Number of Errors
M	.762 (.16)	.882 (.17)	+.121 (.11)	4.00%
B_B	.789 (.23)	.919 (.27)	+.130 (.12)	3.75%
B_M	.734 (.19)	.842 (.21)	+.108 (.10)	3.75%

Note. Standard deviations are in parentheses.

WM Tasks

Prior to running the main WM analyses, performance on the individual tasks was checked for completion and accuracy. Based on guidelines used in previous research (Turner & Engle, 1989; Conway et al., 2005), participants who were less than 80% accurate on the distractor task (e.g., CSPAN: counting shapes; OSPAN: math problems; RotSpan: regular vs. mirrored image decision) were excluded in order to guarantee that participants were engaged in both the distractor and memory components. Other participants were excluded from analyses if they did not complete a WM span task. These participants included 8 monolingual participants: 1 did not

complete the CSPAN, 3 had less than 80% accuracy on the RotSpan distractor task, and 4 did not complete the RotSpan task. Further, 13 bilinguals were also removed from further analyses: 2 did not finish the CSPAN, 1 was less than 80% accurate on the OSPAN distractor task, 1 did not finish OSPAN, 6 were less than 80% accurate on the RotSpan distractor task, and 3 did not finish the RotSpan. Participants likely did not complete the WM tasks due to fatigue because they were the final tasks of Part I (CSPAN) and Part II (OSPAN or RotSpan).

Based on a strong correlation scores on the OSPAN and the RotSpan (r = .418; Table 6), a composite WM score was created. To do so, scores on both tasks were averaged to create one composite WM score per participant. Therefore, each participant who completed both the OSPAN and the RotSpan has scores on the individual span tasks as well as a composite WM score. Individual WM tasks' scores are presented in Appendix H. The range of scores was typical for these types of WM tasks (Conway et al., 2005).

Table 6. *Zero-order correlations amongst all of the cognitive measures*

	CSPAN	OSPAN	RotSpan	CLOZE	Simon Effect	EOF
CSPAN	1					
OSPAN	.221*	1				
RotSpan	.291*	.418**	1			
CLOZE	.187	.065	.076	1		
Simon Effect	-.055	.004	.162	.032	1	
English Fluency	-.043	.203*	.080	-.048	.148	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Overall Bilingual (Dis)Advantage Analyses

The first set of analyses evaluated the bilingual advantage debate in the literature; thus, all monolingual participants were compared to all bilingual participants regardless of language

mode group. Group means for each WM task are presented in Figure 8 (for individual data see Appendix H). Four separate ANCOVAs were conducted to evaluate the effect of group (monolinguals vs. bilinguals) on each of the three individual complex WM tasks as well as the composite WM score, adjusting for participants' education. There was no significant main effect of group on CSPAN scores (monolinguals = .928, bilinguals = .922, p = .922), OSPAN scores (monolinguals = .889, bilinguals = .912, p = .330), or RotSpan scores (monolinguals = .598, bilinguals = .596, p = .862). Given that there were no significant differences on the individual tasks, it was no surprise that there was also no significant difference between the two groups on the composite WM score (F (1, 87) = .281, p = .597, η_p^2 = .003). These results provide initial support to H3 [B = M], stating that there was no significant difference between all bilinguals and all monolinguals on the WM measures.

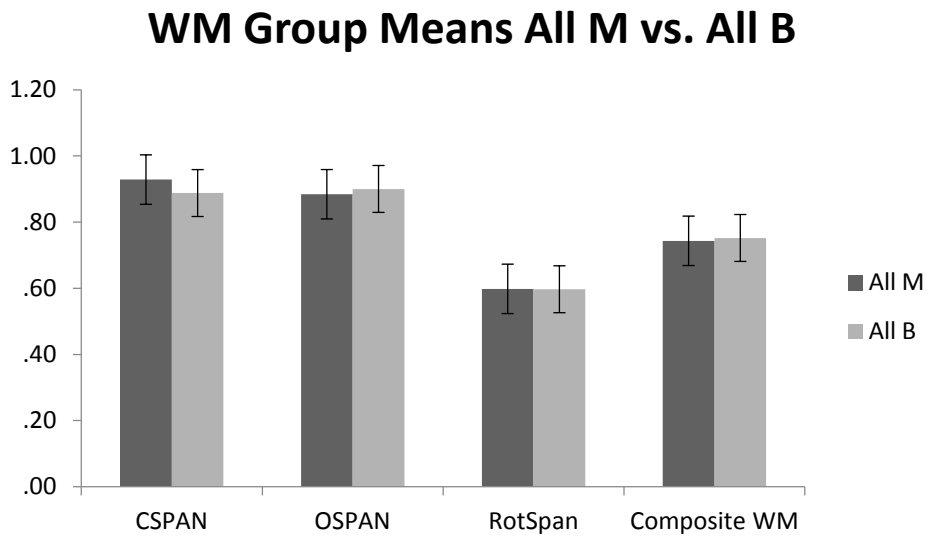

Figure 8. Group means for the three complex WM tasks as well as the composite WM score are presented. Dark bars represent all monolingual participants (All M), light grey bars represent all bilingual participants (All B); error bars with standard error are displayed.

WM Tasks and Language Mode

In the second set of analyses, WM performance was evaluated as a function of language mode. In these analyses, only performance on the OSPAN and RotSpan, as well as their composite score, were evaluated because participants completed them after the manipulation of language mode. (CSPAN performance was not included in the composite WM score because it should not be affected by language mode because it was in Part I, which was conducted completely in English.) Three separate ANCOVAs were conducted to compare group performance (Groups M vs. B_M vs. B_B) on both of the individual complex WM tasks as well as their composite score, adjusting for participants' education. WM group means are presented in Figure 9.

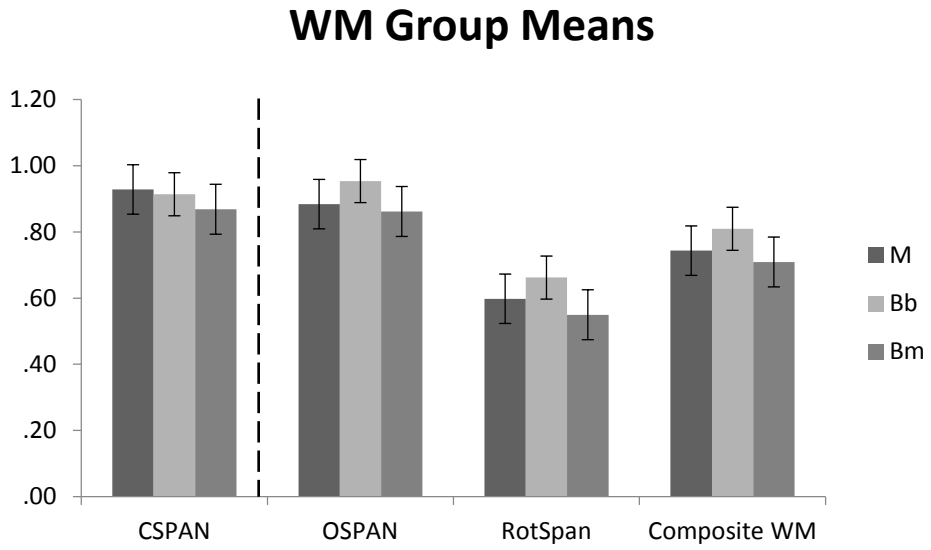

Figure 9. WM Tasks' Group Means; error bars with standard error are displayed.
Note. Participants completed CSPAN in Part I; therefore, CSPAN was not used to create Composite WM score.

OSPAN. After priming participants into either a bilingual or monolingual language mode, there was a significant main effect of group on OSPAN scores, F (2, 102) = 6.710, p = .002, η_p^2 = .12. Planned pairwise comparisons revealed that bilingual participants in bilingual

mode (M = .954, SD = .06) had significantly higher OSPAN scores than monolingual participants (M = .884, SD = .12), p = .018, Cohen's d = .74, and significantly higher OSPAN scores than bilingual participants in monolingual mode (M = .862, SD = .13), p = .005, d = .91. There was no significant difference between monolingual participants and bilingual participants in monolingual mode on OSPAN scores (p = .818). This provides support for H4a [$B_B > B_M$] and H7a [$B_B > M$], as well as H6c [$B_M = M$].

RotSpan. There was also a significant main effect of group on RotSpan scores, F (2, 87) = 4.821, p = .01, η_p^2 = .10. Planned pairwise comparisons revealed that bilingual participants in bilingual mode (M = .662, SD = .14) had significantly higher RotSpan scores as compared to bilingual participants in monolingual mode (M = .549, SD = .14), p = .003, d = .81, and marginally higher scores than monolingual participants (M = .598, SD = .15), p = .076, d = .44. There were no significant differences between monolingual participants and bilingual participants in monolingual mode (p = .284). Once again, this provides partial support to H4a [$B_B > B_M$], H7a [$B_B > M$], and H6c [$B_M = M$].

Composite WM Score. An ANCOVA was also conducted to evaluate the effect of language mode group on WM composite performance, adjusting for education. Again, there was a significant main effect of group on the composite WM scores, F (2, 86) = 7.544, p = .001, η_p^2 = .15. Pairwise comparisons indicated that bilingual participants in bilingual mode (M = .810, SD = .08) had significantly higher composite WM scores than bilingual participants in monolingual mode (M = .709, SD = .11), p < .001, d = .90, as well as significantly higher composite WM scores than monolingual participants (M = .743, SD = .11), p = .012, d = .69. There was no significant difference between bilingual participants in monolingual mode and monolingual participants on the composite WM score (p = .322). Thus, as with the individual

WM span tasks, once language mode is accounted for, these composite results provide support for H7a [$B_B > M$], H4a [$B_B > B_M$], and H6c [$B_M = M$].

Main Study Discussion

Is there a bilingual advantage?

The main goal of this study was to evaluate whether language mode has an effect on bilinguals' performance on cognitive measures such as complex WM tasks while accounting for a variety of demographic variables. The first set of proposed hypotheses evaluated the long-debated question of whether there is bilingual advantage. As mentioned in the introduction, research has shown that bilinguals tend to perform better than monolinguals on a number of cognitive measures such as the Stroop task, the Simon task, and task switching (Bialystok, 1988; Bialystok, Martin, & Viswanathan, 2005; Bialystok & Craik, 2010; Bialystok, Luk, & Craik, 2012; Alladi et al., 2013; Bak et al., 2014; Costa et al., 2009; Gold, Kim, Johnson, Kriscio, & Smith, 2013). However, recent research found no bilingual advantage and even some trends toward a bilingual disadvantage (deBruin, Bak, & Della Sala, 2015; Paap & Greenberg, 2013; Paap, Johnson, & Sawi, 2015). Therefore, we compared all bilingual participants to all monolingual participants regardless of language mode in the first set of analyses.

Results indicated no significant differences between the two groups on either the Simon task or any of the complex WM measures, supporting H3 [B = M]. These results are in line with results obtained by Paap and Greenberg (2013, 2015). Although we found no evidence of a bilingual advantage, we also found no evidence of a bilingual disadvantage. These null results, however, can be explained when we compare bilinguals' and monolinguals' cognitive performance based on language mode.

Does language mode affect bilinguals' performance on WM tasks?

In the next set of analyses, we separated bilinguals into two groups – those in monolingual mode and those in bilingual mode – and then compared each group to the monolinguals. Across several tasks including the OSPAN, RotSpan, and the composite WM score, bilingual participants in monolingual mode performed similarly to monolingual participants, supporting H6c [$B_M = M$], whereas bilingual participants in bilingual mode outperformed both monolingual participants, supporting H7a [$B_B > M$], and bilinguals in monolingual mode, supporting H4a [$B_B > B_M$].

If we assume that people in monolingual mode were fully suppressing one language, then the current results suggest that attentional resources needed to fully suppress L1 impairs performance on WM measures. The strongest evidence is that bilinguals in bilingual mode outperformed those in monolingual mode. Having two simultaneously active languages (i.e., bilingual mode) is more beneficial because perhaps more attentional resources are available to complete complex WM tasks rather than having them engaged in L1 inhibition.

Most importantly, results from the Main study indicated that language mode is a variable that has to be accounted for: there were no significant differences when we compared all bilinguals to all monolinguals; however, the differences appeared once language mode was accounted for. In other words, while we found no overall bilingual advantage, we instead found a *bilingual mode advantage* such that bilingual participants in bilingual mode outperformed both monolinguals and other bilinguals who were in monolingual mode. Implications of these results will be discussed in detail in the General Discussion.

Chapter 4 - General Discussion

The main objective of this dissertation was to study the possible effects of bilingualism on cognition while manipulating language mode. Our pretest provided initial evidence that language mode produces differences in bilingual participants' performance on a simple cognitive task like MPWI. A similar language mode manipulation was used in the Main study while testing bilingual and monolingual participants' performance on different cognitive measures such as the complex WM tasks (CSPAN, OSPAN, and RotSpan) and the Simon task while accounting for a number of demographic variables.

Interestingly, there were no significant differences between the three groups on the Simon task, even after we accounted for language mode, which partially replicates findings by Paap and Greenberg (2013, 2015). This begs the question, which tasks better represent bilinguals' daily experience of switching from one language to another, while having both languages active? We propose that the cognitive processing involved in complex WM tasks is more similar to how bilinguals process the two languages on a daily basis than many of the criterion tasks commonly used in the field. All three complex WM tasks contained a distractor task (i.e. "irrelevant information") and a to-be remembered task (i.e. "relevant information"). One of the main roles of executive functioning is to inhibit irrelevant information (McCabe et al., 2010), which is very important for successful performance on the complex WM tasks used in the Main study. Bilinguals are often required to choose between two languages: they need to inhibit one language to a certain degree (i.e. "irrelevant" information) and speak their second language (i.e. "relevant" information). Such processing is different from what participants are required to do in simpler tasks such as the Simon task on which participants are only required to inhibit a prepotent response from time to time. Bilinguals may be able to better inhibit irrelevant

information and focus attention on the relevant, to-be-remembered information given their experience with continuous language suppression. Therefore, complex WM tasks may better capture this type of processing, which could explain why bilinguals in bilingual mode performed better than monolingual participants on the WM tasks but not the Simon task.

Furthermore, another important difference between the Simon task and the WM tasks is their dependent measure. The Simon task assesses performance in terms of reaction time (RT), whereas the WM tasks assess performance in terms of memory accuracy. Results from this dissertation indicate that bilinguals in bilingual mode may be more accurate in the long run (e.g., as measured by memory accuracy on the WM tasks) even though they might be slower during the process (e.g., as measured by RTs on the Simon task). While the difference did not reach statistical significance, bilinguals in bilingual mode had slower RTs on the Simon task as compared to the monolingual participants and the bilingual participants in monolingual mode (Table 5). These results converge with those obtained on the MPWI task in the pretest. Again, bilingual participants in bilingual mode responded slower than monolingual participants (a marginally significant difference). Further, all bilingual participants responded slower in Set 2 as compared to in Set 1. The MPWI task is a simple RT task that is fairly similar to the Simon task in that participants must make decisions across congruent and incongruent trials. Thus, there was a *bilingual mode advantage* on measures of memory accuracy such as the complex WM tasks and a *bilingual disadvantage* on tasks that are simpler in nature but use RT as a dependent variable. Having to juggle the two languages may cause bilinguals to be slower to provide a response, but may help them remember information more accurately because more attentional resources are available to inhibit the irrelevant stimuli while encoding the information on a WM span task. Further research is needed to evaluate whether the effects observed in the current

study are due to the complex dual task nature of WM tasks, due to using accuracy as the dependent measure, or a combination of the two.

Why is having two languages active simultaneously more beneficial to WM performance? Green (1998) proposes that inhibitory control is required to suppress one of the languages when a bilingual is in monolingual mode. According to the current results, when bilinguals have to fully suppress one language, they perform similarly to monolingual participants on WM measures. Thus, it may require the use of more inhibition resources to fully inhibit one language and, as a result, there may be fewer resources left to complete the complex WM span tasks. At the same time, juggling two languages may be less taxing. Highly fluent bilinguals are constantly switching from one language to another; thus, language switching (as in bilingual mode) may be less resource demanding than fully inhibiting one of the languages (as in monolingual mode).

Findings from task-switching literature also support such an explanation. Meuter and Allport (1999) showed that switching into the dominant language on easier tasks was more costly than switching into the nondominant language. One of the main explanations for such counterintuitive asymmetry comes from Green's (1998) inhibition theory discussed above: more resources are required to inhibit the dominant language. At the same time, Gollan and Ferreira (2009) demonstrated that when allowed to voluntarily switch between languages, switch costs were not greater for dominant language. Similarly, our bilingual participants in monolingual mode had to inhibit their native L1 (Russian), which typically is a bilingual's dominant language (although not always) while our bilinguals in bilingual mode were freely switching between the two languages (i.e. Russian and English words were presented in random order). Therefore, more

inhibitory control was required to fully inhibit one L in monolingual mode while fewer resources were used in a bilingual mode.

Given this reasoning, it makes sense that participants in bilingual mode outperformed those in monolingual mode. Our complex WM tasks required participants to inhibit some information while attending to and memorizing a different set of information. Since bilinguals in monolingual mode may be using up many available attentional resources on the single task of fully inhibiting L1, they may not have had enough resources left to inhibit another set of information (irrelevant information in the WM tasks). At the same time, juggling the two languages in bilingual mode may be less resource demanding and leave enough resources (as compared to bilinguals in monolingual mode) to be more successful at WM tasks.

These findings are especially important given the current debate in the field. Language mode could potentially explain why some studies find a bilingual advantage and why others have not. Established research labs that have evaluated bilingualism for years have consistently found bilingual advantage. However, as a result, participants might have certain expectations about language research when coming into these labs that might automatically shift them to the bilingual end of the language mode continuum. In other cases, participants may have no expectations that the research study involves their ability to speak several languages and, as a result, these participants might find themselves on the monolingual end of the language mode continuum. In the current study, the bilingual advantage was only observed once language mode was manipulated, and while we cannot be certain of which end of the language continuum participants in the different labs were in, language mode could potentially explain the discrepancies in the field.

Most importantly, our results indicate that language mode is an important variable that must be considered in bilingualism research. That is, no significant differences were observed when all monolinguals were compared to all bilinguals on the Simon task (similar to recent research by Paap and Greenberg, 2013; 2015) as well as on any of the WM measures. There were also no pre-existing differences in WM performance, as evident from the results on the CSPAN that they completed in Part I. However, the differences were observed on both WM tasks (OSPAN and RotSpan) in Part II, once language mode was manipulated and accounted for in the statistical analyses. Notably, the CSPAN and OSPAN are both verbal WM span tasks; therefore, we have more confidence that our bilingual mode advantage was not due to aspects of the criterion tasks but instead due to language mode.

Interestingly, overall, our bilinguals in bilingual mode performed better than monolinguals and bilinguals in monolingual mode. On the other hand, bilinguals in monolingual mode performed similarly to monolingual participants. These findings suggest that the influence of participants' daily bilingual experience on cognition is more trait-like whereas the influence of language mode on cognition is more state-like. That is, the bilingual advantage observed in previous work seems to be more stable and trait-like, such that most bilinguals tend to outperform monolinguals on various cognitive tasks based on their experience speaking two languages. However, results from the current study indicate that this trait-like effect is moderated by language mode, which is a temporary state that can shift depending on internal and external factors such as communicating with other bilinguals (or monolinguals), participating in a bilingual study, completing a task using two languages etc.

As mentioned earlier, a daily bilingual experience that is consistently inhibiting one language could induce strong executive abilities (Bialystok et al., 2008; Luo et al., 2013), and

complex WM tasks involve a strong executive control component. If bilingualism is indeed associated with a more enhanced executive function, we could expect a superior performance in bilinguals on WM tasks. At the same time, Shipstead, Harrison, and Engle (2015, p. 1863) defined WM *capacity* as "the cognitive system in which memory and attention interact to produce complex cognition." Capacity is referred to the extent to which resources are available in order to be able to control attention to maintain relevant information. In other words, capacity goes beyond just a storage space (Bialystok, 2017, Engle and Kane, 20004). This view applies well to our results: bilinguals in monolingual mode may constantly deplete their inhibition resources while bilinguals in bilingual mode may have more resources left to successfully complete a complex WM task.

Strengths and Limitations

Accounting for language mode was one of the most important goals of this dissertation. However, accounting for a number of other variables was also important. Several other issues that are often present in bilingualism work were addressed in the current experiments. For instance, to address the issue of covert vs. overt recruitment, the Main Study consisted of two parts, although the connection between the two parts was unbeknownst to the participants. Participants completed all the demographics and language fluency questionnaire in Part I, as well as one measure of WM (CSPAN). Participants completed the rest of the tasks in Part II. Breaking the Main study in two parts allowed us to ensure participants did not know that the study was evaluating language. This was especially important for our bilingual participants in monolingual mode, since according to Grosjean (2011), simply mentioning bilingualism could put participants in bilingual mode.

Another common issue in the field is only using one outcome measure on a single group of participants. In the current study, participants completed several tasks including three complex WM tasks and the Simon task. This allowed us to compare participants' performance on established measures used in previous bilingualism research (i.e. the Simon task) as well as look at their performance on complex WM measures that are less common in bilingualism research. As mentioned above, our results support findings by Paap and Greenberg (2013) that found no bilingual advantage on the Simon task, and may even explain the conflicting results reported by Ratiu and Azuma (2015) and Luo et al. (2012). While we have initially found no bilingual advantage on the verbal OSPAN task, similar to the results obtained by Ratiu and Azuma (2015), the differences between the bilinguals and monolinguals appeared once we have accounted for language mode. We also found the same effects on the visuospatial task, the RotSpan, but only after accounting for language mode, which supports findings by Luo et al. (2012).

Next, several demographic variables were accounted for in the current study, including language fluency and proficiency, income, education, parental income and education, and age. We adopted the language fluency questionnaire used in Paap and Greenberg (2013). To date, various studies use different measures of language fluency, many of them created by the researchers themselves. While self-report measures of language fluency have been shown to be reliable in previous research (Grosjean, 1982), the use of a standard measure would allow for better comparisons across studies and to design better replications. This was one reason why the questionnaire from Paap and Greenberg (2013) was used in the current study. Their language fluency questionnaire is accessible, the questions and response options (ranging from 1 [beginner] to 6 [fluent]) are easy for participants to comprehend, and it could be easily adapted for future studies. The language fluency and demographics questionnaire can be found in

Appendix A. It is important to mention that the significant differences observed in this sample were found even after accounting for these demographic variables.

Furthermore, two different languages were used in our studies: Spanish and Russian. Interestingly, Spanish was the L2 for our bilingual participants in pretest but Russian was the L1 for the participants in Main study. Therefore, by asking bilinguals in monolingual mode to complete the Main study in English only, we have primed them to suppress their L1 (Russian) similarly to how bilinguals in monolingual mode in pretest also suppressed their L1, even though in that case it was Spanish. Importantly, we have shown the language mode effect is robust in that it influenced performance on various outcome measures in the Pretest and the Main study with two different languages.

Finally, Qualtrics was used as the recruitment and data collection tool. Most researchers in the field, both supporting a bilingual advantage (Bialystok, 2009; Bialystok et al. 2014) and refuting the idea (Paap and Greenberg, 2013; deBruin et al., 2015), tend to agree that young college students may be at their peak cognitive performance and thus, using this cohort may mask any true effects of bilingualism. Researchers argue that the benefits of bilingualism may only appear later in life when cognitive processes typically decline (Bialystok et al., 2005; Costa et al., 2009; Paap and Greenberg, 2013). Therefore, while the goal of the pretest and the Main study was not to necessarily recruit older adults, the samples recruited from Qualtrics in both studies were much more diverse groups in terms of age and income than the typical samples of undergraduate students (Paap & Greenberg, 2013; Ratiu & Azuma, 2015). In fact the average age in the main study was 51 years and the average income across groups was between $50,000 and $99,000, which is a much more representative sample of all bilinguals than are college students.

One possible limitation of the current experiments is lack of power. This could potentially explain the marginally significant difference between monolinguals and bilinguals in bilingual mode observed in our pretest. There was no a priori effect size for the influence of language mode on WM performance, so for the Main Study, the initial goal was 39 participants per group. We expected some amount of attrition; therefore, we recruited 180 participants (60 per group) for Part I. The attrition rate was approximately 43% for the monolinguals and 38% for the bilinguals, leaving us with between 31-43 participants per group. However, low power seems to be less of an issue in the Main Study because despite the attrition rates, we observed large effects (Cohen's *d* ranging from .44 to .91) for language mode on WM performance.

Although it was described as a strength above, another possible limitation of the current study is online data collection. Qualtrics provided a more representative sample, but it may have influenced some of the outcome data. While this should not have much of an effect, if any, on the accuracy performance such as on the complex WM tasks, variations in browser speeds could have potentially affected response time data on the Simon task. However, using online recruitment platforms such as Qualtrics and mTurk is becoming more popular and research has repeatedly demonstrated that using such platforms can provide reliable RT data (e.g., Enochson & Culbertson, 2014; Barnhoorn, Haasnoot, Bocanegra, & Steenbergen, 2014).

Future Directions

Our results indicated that language mode is an informative variable that must be accounted for in bilingualism research. Priming bilingual participants towards either a bilingual or a monolingual mode will ensure robustness and consistency in the field. This study provided initial evidence that language mode influences cognitive behavior, but many questions remain. For instance, how easy it is to guide participants into a bilingual or monolingual mode? How

easy it is for participants to shift between the two modes? At what point does language mode stops affecting participants' performance? Does language mode similarly affect performance during L2 suppression?

Regarding the last question, our research could be extended to studies evaluating fluent bilinguals who complete tasks in their first language. Bilingual participants in both our pretest and the Main study completed the tasks in their L2 (Spanish in pre-test; English in Main study). It was methodologically important in the current study for both the monolinguals and the bilinguals in monolingual mode to complete the tasks in the same language (English), but it would be interesting to evaluate whether there are any differences if bilingual participants complete the cognitive tasks in their L1 while suppressing L2.

In similar vein, the language mode manipulation could also be extended to studies in *non-fluent* bilinguals. This could prove to be especially interesting. Non-fluent bilinguals may need to exhibit different levels of inhibitory control when they are in different language modes as compared to fluent bilinguals. For example, greater inhibitory control might be needed when non-fluent bilinguals are in monolingual mode with their L2 being active since they have greater knowledge of L1. On the other hand, less inhibitory control may be expected when L2 is inhibited. Thus, it is possible that opposite effects from those in the current study could be observed with non-fluent bilinguals performing best in monolingual mode (L2 being suppressed).

Furthermore, most bilinguals will differentiate between dominant and non-dominant languages. As mentioned above, bilinguals' native L may indeed be their dominant L, however it may also become their non-dominant L as they use their L2 on an everyday basis. Thus, future

research can evaluate how bilinguals in monolingual mode perform in their dominant or non-dominant LL.

It is important to note that, according to Grosjean (1998; 2002), there are three types of language mode: monolingual, bilingual, and intermediate. As mentioned in the introduction, intermediate language mode refers to a state of activation of both languages but with one language being activated to a higher degree than the other language. While we did our best to prime our participants to have both English and Russian languages active and be fully in the bilingual mode, we cannot be completely certain whether participants were in full bilingual mode or in intermediate mode. This is an interesting question that deserves more attention in future research as well.

Finally, the current language mode results should be further extended to an aging population. Several cognitive abilities are known to decline with age (Salthouse, 1994; Zacks and Hasher, 1994; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003; Luo et al., 2013; Bialystok et al., 2014). Currently, every 70 seconds someone in the U.S. develops Alzheimer's disease (AD). A two-year delay in the onset of AD could reduce the prevalence in the U.S. by 1.94 million after 50 years and significantly reduce cost and spending (Alzheimer's Association, 2009). There is growing evidence that various environmental factors such as active lifestyle, physical activity, and social engagement may help postpone the onset of AD (Bialystok et al., 2007; Scarmeas & Stern, 2007), and recent research has proposed that bilingualism also protects against such cognitive decline and perhaps even dementia (Bialystok, Craik & Freedman, 2007; Craik, Bialystok &Freedman, 2010). Specifically, this work found that lifelong bilinguals were diagnosed with dementia approximately 4-5 years later than their monolingual counterparts, who were matched on cognitive functioning and the degree of clinical severity.

Furthermore, Kave, Eyal, Shorek, and Cohen-Mansfield (2008) had participants (m_{age} = 83 years old) complete Katzman et al.'s (1983) cognitive-screening test and the MMSE (as described in Kave et al., 2008) three times over the course of 12 years (n_1 = 814, n_2 = 457, n_3 = 115). Results showed that the number of languages spoken was a significant predictor of cognitive test scores beyond age, gender, years of education and other demographic variables. Nonetheless, some conducted with older adults have not find a bilingual advantage (Kousaie and Phillips, 2012) – and perhaps the null results were because language mode was not accounted for. And, to date, no study has evaluated complex WM performance in older bilinguals. While the current sample was on average much older than the typical college student samples, unfortunately, we were unable to evaluate age-related differences of language mode on cognition. Therefore, we suggest conducting the methods from the Main study to a sample of older adults, using complex WM tasks and manipulating language mode.

Conclusion

Joint activation of the two languages requires a language selection mechanism to ensure that bilinguals speak one or both languages fluently (Bialystok, 2017). Bilinguals' experience using such a mechanism has been shown to affect their performance on various cognitive tasks. As mentioned above, some research labs have consistently shown bilingual advantage on such tasks as the Simon and the Stroop tasks, whereas others have found no such advantage using the same tasks. The current study evaluated whether language mode may account for the discrepancies in bilingualism research and indicated that measures with better ecological validity should be used to evaluate the potential bilingual advantage.

Language mode can be defined as a state of language activation and language processing mechanisms (Grosjean, 2008). Bilinguals can find themselves at either the monolingual or the

bilingual end of the language mode continuum throughout their daily experiences. According to Grosjean, simple factors such as speaking to a bilingual or a monolingual person, reading a monolingual book or participating in a bilingualism study result in a shift to either a mono- or bilingual mode. We have shown that bilingual advantage is not observed unless language mode is accounted for. There were no significant differences in participants' performance on a complex WM task (CSPAN) before we manipulated language mode. However, once bilingual participants were primed into either the monolingual or the bilingual modes, bilinguals in bilingual mode outperformed both monolinguals and bilinguals in monolingual mode on two complex WM tasks (OSPAN and RotSpan). We have also shown the importance of accounting for demographics variables as well as the use of cognitive tasks that better reflect bilinguals' daily experience using the two languages.

Thus, language mode is a variable that must be accounted for in bilingualism research as it affects bilinguals' performance on complex cognitive measures such as complex WM tasks. Further, the current work shed light on the hotly debated issue of the existence of a bilingual advantage, while accounting for many existing and new variables. Most importantly, we have shown that there is evidence of a *bilingual mode* advantage.

References

Alladi, S., Bak, T. H., Duggirala, V., Surampudi, B., Shailaja, M., Shukla, A. K., et al. (2013). Bilingualism delays age at onset of dementia, independent of education and immigration status. *Neurology, 81*(22), 1938-1944. doi: 10.1212/01.wnl.0000436620.33155.a4

Alzheimer's Association (2009). Alzheimer's disease facts and figures. *Alzheimer's and Dementia, 5*, 234-270. doi:10.1016/j.jalz.2009.03.001

Bak, T., H, Nissan, J. J., Allerhand, M. M., & I. J. Deary, (2014). Does bilingualism influence cognitive aging? *Annals of Neurology, 75*(), 959-963. doi: 10.1002/ana.24158

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (Vol. 8, pp. 47 – 82). New York: Academic Press.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417-423. Retrieved from http://nbu.bg/cogs/events/2002/materials/Markus/ep_bufer.pdf

Baddeley, A. D. (2003). Working memory and language: an overview. *Journal of Communication Disorders, 36*(3), 189-208. doi:10.1016/S0021-9924(03)00019-4

Barnhoorn, J. S., Haasnoot, E., Bocanegra, B. R., & van Steenbergen, H. (2015). QRTEngine: An easy solution for running online reaction time experiments using Qualtrics. *Behavior research methods, 47*(4), 918-929. doi: 10.3758/s13428-014-0530-7

Berinsky, A. J., Huber, G. A., & Lenz, G. S. (2011). Using mechanical turk as a subject recruitment tool for experimental research. Retrieved from http://www.mit.edu/~glenz/Mechanical_Turk.pdf

Bialystok, E. (1988). Levels of bilingualism and levels of linguistic awareness. *Developmental Psychology, 24*(4), 560-567. Retrieved from http://search.proquest.com.er.lib.k-state.edu/docview/614290434/fulltextPDF/MC5995778DF421BPQ/1?accountid=11789

Bialystok, E., Martin, M. M., & Viswanathan, M. (2005). Bilingualism across the lifespan: The rise and fall of inhibitory control. *International Journal of Bilingualism, 9*(1), 103-119. doi: 10.1177/13670069050090010701

Bialystok, E., Craik, F. I. M., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia, 45*, 459-464. doi:10.1016/j.neuropsychologia.2006.10.009

Bialystok, E., Craik, F. I. M., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*(4), 859-873. doi: 10.1037/0278-7393.34.4.859

Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition, 12*(1), 3-11. doi:10.1017/S1366728908003477

Bialystok, E., & Craik, F. I. M., (2010). Cognitive and linguistic processing in the bilingual mind. *Current Directions in Psychological Science, 19*(1), 19-23. doi: 10.1177/0963721409358571

Bialystok, E., Craik, F. I. M., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends Cogn Sci*, *16*(4), 240-250. doi: 10.1016/j.tics.2012.03.001

Bialystok, E., Poarch, G., Luo, L., & Craik, F. I. M. (2014). Effects of bilingualism and aging on executive function and working memory. *Psychology and Aging, 29*(3), 696-705. doi: http://dx.doi.org/10.1037/a0037254

Colzato, L. S., Bajo, M. T., Wildenberg, W., Paolieri, D., Nieuwenhuis, S., Heil, W., & Hommel, B. (2008). How does bilingualism improve executive control? A comparison of active and reactive inhibition mechanisms. *Journal of Experimental Psychology, 34(2).* doi: 10.1037/0278-7393.34.2.302

Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wihelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin &Review, 12*(5). doi: 10.3758/BF03196772

Cowan, N. (1999). An embedded-processes model of working memory. In Miyake, A., Shah, P. (Eds.), *Models of Working Memory: Mechanisms f Active Maintenance and Executive Control* (pp 62-101). Cambridge, UK: Cambridge University Press.

Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition, 113*(2), 135-149. doi: 10.1016/j.cognition.2009.08.001

Costa, A. & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language, 50*, 491-511. doi: https://doi.org/10.1016/j.jml.2004.02.002

de Bruin, A., Treccani, B., & Della Sala, S. (2015). Cognitive advantage in bilingualism: an example of publication bias. *Psychological Science, 26*(1), 99-107. doi**:** 10.1177/09 56797614557866

deBruin, A., Bak, T. H., & Sala, S. D. (2015). Examining the effects of active versus inactive bilingualism on executive control in a carefully matched non-immigrant sample. *Journal of Memory and Language, 85*(1), 15 – 26. doi: 10.1016/j-jml.2015.07.001

De Groot, A. M. (2011). *Language and cognition in bilinguals and multilinguals: An introduction*. New York, NY: Psychology Press.

Del Vecchio, A., & Guerrero, M. (1995). *Handbook of English language proficiency tests*. Evaluation Assistance Center-Western Region, New Mexico Highlands University.

Engle, R. W., & Kane, M. J. (2004). Executive attention, working memory capacity, and a two factor theory of cognitive control. *Psychology of learning and motivation*, *44*, 145-200.

Enochson, K., & Culbertson, J. (2014). Collectng psycholinguistic response time data using Amazon Mechanical Turk. *PLoSONE10*(3):e0116946. doi:10.1371/journal.pone.0116946

Ericsson, K. A., & Kintsch, W. (1995). Long-term Working Memory. *Psychological Review, 102*(2), 211 - 245. doi: http://dx.doi.org/10.1037/0033-295X.102.2.211

Fink, A., & Goldrick, M. (2015). Pervasive benefits of preparation in language switching. *Psychonomic Bulletin & Review, 22*(3), 808 – 814. doi: 10.3758/s13423-014-0739-6

Foster, J. L., Shipstead, Z., Harrison, T. L., Hicks, K., Redick, T. S., & Engle, R. W. (2014). Shortened complex span tasks can reliably measure working memory capacity. *Memory and Cognition, 43*(2), 226 – 236. doi: 10.3758/s13421-014-0461-7

Gollan, T. H., & Ferreira, V. S. (2009). Should I stay or should I switch? A cost-benefit analysis of language switching in young and aging bilinguals. *Journal of Experimental Psychology, 35*(3), 640-665. doi: 10.1037/a0014981

Gold, B. T., Kim, C., Johnson, N. F., Kriscio, R, J., & Smith, C. D. (2013). Lifelong bilingualism maintains neural efficiency for cognitive control in aging. *Journal of Neuroscience, 33*(2), 387-396. doi: 10.1523/jneurosci.3837-12.201.3

Gollan, T. H., & Ferreira, V. S. (2009). Should I stay or should I switch? A cost-benefit analysis of language switching in young and aging bilinguals. *Journal of Experimental Psychology, 35*(3), 640-665. doi: 10.1037/a0014981

Goodenough, F. L. (1926). Racial differences in the intelligence of school children. *Journal of Experimental Psychology, 9*(5), 388-397

Green, D. W. (1998), Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1*(02), 67-81. doi: http://dx.doi.org/10.1017

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology, 25*(5), 515-530. doi: 10.1080/20445911.2013.796377

Grosjean, F. (1982). *Life with Two Languages: an Introduction to Bilingualism.* Cambridge, Massachusetts: Harvard University Press.

Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition, 1*(02), 131-149. doi: http://doi.org/10.1017/S136672899800025X

Grosjean, F. (2008). *Studying Bilinguals*. New York, NY: Oxford University Press Inc.

Grosjean, F. (2011). An attempt to isolate, and then differentiate, transfer and interference. *International Journal of Bilingualism, 16*(1), 11 – 21. doi:10.1177/1367006911403210

Housen, A., Kuiken, F., & Vedder, I. (Eds.). (2012). *Dimensions of L2 performance and proficiency: Complexity, accuracy and fluency in SLA* (Vol. 32, pp. 1 - 17). Amsterdam, PA: John Benjamins Publishing.

Jared, D. & Kroll. J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language, 44,* 2-31. doi: https://doi.org/10.1006/jmla.2000.2747

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General, 133*(2), 189–217. doi: http://dx.doi.org/10.1037/0096-3445.133.2.189

Kave, G., Eyal, N., Shorek, A., & Cohen-Mansfield, J. (2008). Multilingualism and cognitive state in the oldest old. *Psychology and Aging, 32(*1), 70-78. doi: 10.1037/0882-7974.23.1.70

Kousaie, S., & Phillips, N. A. (2012). Conflict monitoring and resolution: Are two languages better than one? Evidence from reaction time and even-related brain potentials. *Brain Research, 1446*, 71-90. doi: 10.1016/j.brainres.2012.01.052

Lu, C. H., & Proctor, R. W. (1995). The influence of irrelevant location information on performance: A review of the Simon and spatial Stroop effects. *Psychonomic bulletin & review*, *2*(2), 174-207.

Luo, L., Luk, G., & Bialystok, E. (2010). Effect of language proficiency and executive control on verbal fluency performance in bilinguals. *Cognition, 114*(1), 29-41. doi: 10.1016/j.cognition.2009.08.014

Luo, L., Craik, F. I. M., Moreno, S., & Bialystok, E. (2013). Bilingualism interacts with domain in a working memory task: Evidence from aging. *Psychology and Aging, 28*(1), 28-34. doi: 10.1037/a0030875

Luo, L., Craik, F. I. M., Moreno, S., & Bialystok, E. (2013). Bilingualism interacts with domain in a working memory task: Evidence from aging. *Psychology and Aging, 28*(1), 28-34. doi: 10.1037/a0030875

Macnamara, J., & Kushnir, S. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behavior, 10,* 480-487. doi: 10.1016/S0022-5371(71)80018-X

Marian, V., & Spivey, M. (2003). Competing activation in bilingual language processing: Within-and between-language competition. *Bilingualism: Language and Cognition*, *6*(2), 97-115. DOI: 10.1017/S1366728903001068

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive psychology*, *41*(1), 49-100. doi: 10.1006/cogp.1999.0734

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7*, 134-140. doi: 10.1016/S1364-6613(03)00028-7

Meuter, R. F., & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language, 40*(1), 25-40. doi: 10.1006/jmla.1998.2602

Oller, J. W., Jr. (1972). Scoring methods and difficulty levels for cloze tests of proficiency in English as a second language. *The Modern Language Journal*, *56*(3), 151-158. doi: 10.2307/324037

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*(2), 232 – 258. doi: 10.1016/j.cogpsych.2012.12.002

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex, 69*, 265 – 278. doi: 10.1016/j.cortex.2015.04.014

Peal, E., & Lambert, W. (1962). The relation of bilingualism to intelligence. *Psychological Monographs, 76*(546), 1-23. doi: http://dx.doi.org/10.1037/h0093840

Piocuda, J. E. (2015). *Intermediate bilingual comprehension via target Language priming with a short passage of discourse* (Master's thesis).Retrieved from K-Rex http://hdl.handle.net/2097/20564

Prior, A., & MacWhinney, B. (2010). A bilingual advantage in task switching. *Bilngualism: Language and Cognition, 13*(2), 253-262. doi: 10.1017/S1366728909990526

Rai, M. K., Loschky, L. C., & Harris, R. J. (2015).The effects of stress on reading: A comparison of first-language versus intermediate second-language reading comprehension. *Journal of Educational Psychology, 107*(2), 348 – 363. doi: 10.1037/a0037591

Ratiu, I., & Azuma, T. (2015). Working memory capacity: Is there bilingual advantage? *Journal of Cognitive Psychology, 27*(1), 1-11. doi: 10.1080/20445911.2014.976226

Salthouse, T. A. (1994). The aging of working memory. *Neuropsychology, 8*(4), 535-543. doi: 10.1037/0894-4105.8.4.535

Scarmeas, N. & Stern, Y. (2003). Cognitive reserve and lifestyle. *Journal of Clinical and Experimental Neuropsychology, 25*. 625-633. doi: 10.1076/jcen.25.5.625.14576

Shipstead, Z., Harrison, T. L., & Engle, R. W. (2015). Working memory capacity and the scope and control of attention. *Attention, Perception, & Psychophysics, 77*(6), 1863-1880.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*(2), 127-154. doi: 10.1016/0749-596X(89)90040-5

Unsworth, N., Redick, T. S., Heitz, R. P., Broadway, J. M., & Engle, W. (2009). Complex working memory span tasks and higher-order cognition: A latent-variable analyses of the relationship between processing and storage. *Memory, 17* (6), 635-654. doi:10.1080/ 09658210902998047

Vega-Mendoza, M., West, H., Sorace, A., & Bak, T. H. (2015). The impact of late, non-balance bilingualism on cognitive performance. *Cognition, 137*, 40-46. doi: 10.1016/j.cognition.2014.12.008

Verhaeghen, P., Steitz, D. W., Sliwinski, M. J., & Cerella, J. (2003). Aging and dual-task performance: A meta-analysis. *Psychology and Aging, 18*(3), 443 – 460. doi: 10.1037/0882 – 7974.18.3.443

Zacks. R. T., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T.H. Carr (Eds.). Inhibitory processes in attention, memory, and language (pp. 241-264). San Diego, CA: Academic Press.

Appendix A - Language Fluency and Demographics Questionnaire

ENGLISH

Age: _____ years

Place of birth (city, state/province, country):_____

Nationality (e.g., U.S., Mexican, Canadian): _____

Gender:_____

What is the highest level of education achieved by your parents (name the highest one)?

_____

How old were you when you moved to the U.S. **if** you were born outside the U.S.? _____

How much did you earn, before taxes and other deductions, during the past 12 months?
_____Less than $5,000
_____$5,000 through $24,999
_____$25,000 through $49,999
_____$50,000 through $99,999
_____$100,000 and greater
_____Don't know
_____No response

How much did your parents earn, before taxes and other deductions, during the past 12 months?
_____Less than $5,000
_____$5,000 through $24,999
_____$25,000 through $49,999
_____$50,000 through $99,999
_____$100,000 and greater
_____Don't know
_____No response

A. Is English your **native language** (i.e., the very first language you learned)? Y N
If not, what is your native language? _____

B. Please list all the languages you speak, understand, are formally studying, or have studied in the past:_____

Circle one:

C. Do you currently have any family or close friends who are fluent in a language other than English? Y N
If so, do you speak with them in that language? Y N
If so, how often? _____hours per… day week month year

Answer the next questions using the following 1 to 6 scale:

1. Beginner know some words and basic grammar
2. Advanced beginner: can converse with a native speaker only on some topics and with quite a bit of difficulty
3. Intermediate: can converse with a native speaker on most everyday topics, but with some difficulty
4. Advanced intermediate: can converse with little difficulty with a native speaker on most everyday topics, but with less fluency than a native speaker
5. Near fluency: almost as good as a typical native speaker on both everyday topics and specialized topics I know about
6. Fluent: as good as a typical native speaker

D. How would you rate your current **listening** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **speaking** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **reading** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **writing** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

E. Do you know Spanish?:_____

How would you rate your current **listening** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **speaking** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **reading** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **writing** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

Answer the last 2 questions using the following 1 to 6 scale:

1. Beginner know some words and basic grammar
2. Advanced beginner: can converse with a native speaker only on some topics and with quite a bit of difficulty
3. Intermediate: can converse with a native speaker on most everyday topics, but with some difficulty
4. Advanced intermediate: can converse with little difficulty with a native speaker on most everyday topics, but with less fluency than a native speaker

5. Near fluency: almost as good as a typical native speaker on both everyday topics and specialized topics I know about
6. Fluent: as good as a typical native speaker

How would you rate your English language fluency?

1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your Spanish language fluency?

1 (beginner) 2 3 4 5 6 (fluent)

Appendix B - Language Fluency and Demographics Questionnaire

SPANISH

Edad: _____ años

Lugar de nacimiento (ciudad, estado/provincia, país):_____
Género:_____

¿Cuál es el nivel educativo más alto alcanzado por el progenitor (padre/madre) más educado?
_____

¿Qué edad tenía cuando se mudó a los Estados Unidos si usted nació fuera de los EE.UU?
_____

¿Cuánto ganó usted, antes de impuestos y otras deducciones, durante los últimos 12 meses?
_____Menos de $5,000
_____entre $5,000 y $24,999
_____entre $25,000 y $49,999
_____entre $50,000 y $99,999
_____ $100,000 y más
_____No sabe
_____No responde

¿Cuánto ganaron sus padres, antes de impuestos y otras deducciones, durante los últimos 12 meses?
_____Menos de $5,000
_____entre $5,000 y $24,999
_____entre $25,000 y $49,999
_____entre $50,000 y $99,999
_____ $100,000 y más
_____No sabe
_____No responde

A. ¿Es inglés su **idioma nativo** (es decir, el primer lenguaje que aprendió)? Y N
Si no, ¿Cuál es su idioma nativo? _____

B. Por favor, mencione todos los idiomas que habla, entiende, está estudiando formalmente o ha estudiado en el pasado: _____

Seleccione uno:

C. ¿Actualmente tiene algún familiar o amigos cercanos que hablan con fluidez un idioma diferente al inglés?
Y N
Si es así, ¿usted habla con ellos en ese idioma? Y N
Si es así, ¿con qué frecuencia? _____horas… al día a la semana al mes al año

D. Responda las siguientes preguntas usando una escala del 1 al 6:

1. Principiante: sabe algunas palabras y la gramática básica
2. Principiante avanzado: puede conversar con un hablante nativo solamente en algunos temas y con mucha dificultad
3. Intermedio: puede conversar con un hablante nativo en la mayoría de temas cotidianos, pero con un poco de dificultad
4. Avanzado intermedio: puede hablar con poca dificultad con un hablante nativo en la mayoría de temas cotidianos, pero con menos fluidez que un hablante nativo.
5. Cercano a la fluidez: casi tan bueno como un hablante nativo típico tanto en temas cotidianos como en temas especializados que conoce
6. Con fluidez: tan bueno como un hablante nativo típico

¿Cómo calificaría su actual comprensión auditiva en inglés?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual habilidad de hablar en inglés?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual comprensión de lectura en inglés?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual redacción y escritura en inglés?
1 (principiante) 2 3 4 5 6 (fluidez)

E. ¿Sabe español?:_____

¿Cómo calificaría su actual comprensión auditiva en español?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual habilidad de hablar en español?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual comprensión de lectura en español?
1 (principiante) 2 3 4 5 6 (fluidez)

¿Cómo calificaría su actual redacción y escritura en español?
1 (principiante) 2 3 4 5 6 (fluidez)

F. Answer the last 2 questions using the following 1 to 6 scale:

1. Principiante: sabe algunas palabras y la gramática básica
2. Principiante avanzado: puede conversar con un hablante nativo solamente en algunos temas y con mucha dificultad
3. Intermedio: puede conversar con un hablante nativo en la mayoría de temas cotidianos, pero con un poco de dificultad
4. Avanzado intermedio: puede hablar con poca dificultad con un hablante nativo en la mayoría de temas cotidianos, pero con menos fluidez que un hablante nativo.

5. Cercano a la fluidez: casi tan bueno como un hablante nativo típico tanto en temas cotidianos como en temas especializados que conoce
6. Con fluidez: tan bueno como un hablante nativo típico

¿**En general** cómo calificaría su fluidez en inglés?

1 (principiante) 2 3 4 5 6 (fluidez)

¿**En general** cómo calificaría su fluidez en español?

1 (principiante) 2 3 4 5 6 (fluidez)

Appendix C - Stories and Questions in English

Story #1

Susan had been saving up for a brand new bicycle. Her parents gave her $5 a week for completing her chores. The new bicycle that Susan wanted to buy cost $110, but Susan didn't have enough money. One day, Susan went into her mother's purse and took $10. Her mother noticed that the money was missing from her purse and confronted Susan. At first, Susan had lied to her mother and told her that she did not take the money from her purse. Susan's mother said that if she did not tell her the truth, Susan would be punished and not able to go to her friend Megan's birthday party. Susan confessed to her mother for taking the money. In the end, Susan didn't get her allowance for 3 weeks and was not allowed to go to her friend's birthday party.

1. How much did money did Susan take from her mother's purse?

A) $10
B) $5
C) $15
D) $20

2. What was Susan not allowed to attend because she stole the money?

A) School
B) Pool party
C) Birthday party
D) Sleepover

3. Besides stealing the money, what else was Susan punished for?

A) Cheating on a test
B) Misbehaving
C) Getting upset
D) Lying

Story #2

As Clint and his friends pulled into the amusement park parking lot, he was extremely nervous and his heart began to beat fast. After paying the admission price of $29.95, they finally got into the park and were surrounded by all sorts of rides. Clint's friends urged him to ride one ride with them, and after much thought, Clint said he would. Clint's friend Tony picked the fastest and tallest ride in the whole park for them to ride: Speed Mountain. His friends told him not to worry and that it would be fun. Next in line for the ride, they got in the seats and strapped in. As soon as they strapped themselves in, the coaster took off. Clint screamed and yelled and wanted to get off the coaster, but soon after, he was enjoying the coaster! As soon as the coaster ride ended, Clint was running off trying to decide which coaster to ride next.

1. How much did it cost to get into the amusement park?

A) $40.95
B) $25.50
C) $29.95
D) $95.25

2. What type of ride did Clint's friend choose?

A) The longest
B) The fastest
C) The newest
D) The one nearest the gate

3) How many times has Clint been to an amusement park before?

A) 7
B) 0
C) 2
D) 6

Story #3

John was driving on I-70 to Kansas City for the job interview of a lifetime. He had recently applied for a research position at a new company and had received a call back for an interview. John made sure that he had left early just to ensure that he would make it to Kansas City on time. John was typically someone who would wait to the last minute to do something. Yet he wasn't going to wait until the last minute to leave his house and wanted to be prompt and present for the interview. Halfway there, John heard a loud "POP!" and instantly began to swerve. John regained control of his truck and pulled over to the side of the road and knew his worst fear had come true.

1) Where was John's interview?

A) Kansas City
B) Topeka
C) Dodge City
D) Lawrence

2) What job position did John apply for?

A) Manager
B) Research team
C) Truck Driver
D) Librarian

3) What did the loud "POP" suggest to John?

A) Something wrong with engine
B) Flat tire
C) Hit an animal
D) Something fell off his truck

Story #4

Edward was somewhat of a loner. He liked to go fishing at the lake by himself and bring a cooler full of snacks to enjoy with his dog. One day, Edward decided to try night fishing and got to the lake at 9 p.m., rather than his usual 5 a.m. Despite his best efforts to get some vision by keeping his car lights on behind him, he could hardly see. As he was eating a turkey sandwich, he heard his dog barking at his fishing line. Edward ran over to his pole and gave a good pull. He couldn't see what was going on, but he suspected it was a real big fish! Finally on the last pull Edward fell backwards and a baby crocodile came crawling out of the water with the hook in his mouth!

1) What time did Edward usually go fishing?

A) 9 a.m.
B) 5 p.m.
C) 11 a.m.
D) 5 a.m.

2) What kind of sandwich was Edward eating?

A) Ham
B) Turkey
C) BLT
D) Bologna

3) What did the dog barking suggest to Edward?

A) The dog was frightened
B) Someone was coming
C) There was something on the fishing line
D) The dog was in the water

Appendix D - Stories and Questions in Spanish

Story #1

Susan había estado ahorrando para comprar una bicicleta nueva. Sus padres le dieron $5 a la semana por completar sus tareas. La nueva bicicleta que Susan quería comprar tiene un costo de $110, pero Susan no tenía suficiente dinero. Un día, Susan tomo $10 de la bolsa de su madre. Esta se dio cuenta de que faltaba dinero en su bolso y confrontó a Susan. Susan le mintió y dijo que ella no tomó el dinero de su bolso. La madre de Susan, dijo que si ella no le decía la verdad, sería castigada y no podría ir a la fiesta de cumpleaños de su amiga Megan. Despues de todo, Susan le confesó a su madre que ella tomo el dinero. Al final, Susan no recibió su mesada durante 3 semanas mas no le permitieron ir a la fiesta de cumpleaños de su amiga.

1. ¿Cuánto dinero tomo Susan de la bolsa de la madre?

A) $10
B) $5
C) $15
D) $20

2. ¿Cuáles serian las consecuencias para Susan si su madre se enteraba que ella robo el dinero?

A) No podría ir a la escuela
B) Perdería la fiesta en la piscina
C) Seria castigada mas no podría ir a la fiesta de cumpleaños de su amiga
D) Podría dormir en la casa de su compañera

3. Por haber robado el dinero, ¿Cuál fue otra consecuencia que tuvo Susan?

A) No recibió su mesada
B) Pudo ir a la fiesta
C) Pudo comprar su bicicleta
D) Completo su tarea

Story #2 (Spanish)

Clint se sentía muy nervioso mientras se estacionaban en el parque de diversiones con sus amigos. Su corazón latía muy rápido pues esta sería su primera vez en un parque de diversiones. Después de pagar la entrada de $29.95, al fin entraron al parque y fueron rodeados por toda clase de atracciones. Los amigos de Clint le insistieron que tratara una de las atracciones con ellos y Clint acepto. Tony, el amigo de Clint escogió la más rápida del parque entero para que se montaran: "Montaña velocidad o Montaña Rusa." Sus amigos le dijeron que no se preocupara porque sería muy divertido. Después de hacer la fila, por fin llego su turno y pudieron entrar a esta atracción. Clint gritaba y gritaba porque quería salirse de la montaña. Pero, después de un rato termino disfrutándola! Tan pronto como el paseo de la montaña terminó, Clint corría de la emoción y preguntaba a sus amigos cual sería la próxima atracción!

1. ¿Cuánto cuesta entrar en el parque de diversiones?

A) $40.95
B) $25.50
C) $29.95
D) $95.25

2. ¿Qué tipo de atracción Clint experimento?

A) El más largo
B) El más rápido
C) El más reciente
D) El más cercano a la puerta

3. ¿Cuántas veces ha ido Clint a un parque de diversiones?

A) 7
B) 0
C) 1
D) 6

Story #3

Recientemente John había aplicado para un puesto de investigador en una empresa nueva y había recibido una llamada para una entrevista. Usualmente, el esperaba al último minuto para hacer sus cosas. Sin embargo, esta vez John se aseguro de salir temprano para llegar a tiempo y se fue manejando por la I-70 con destino a la cuidad de Kansas para una entrevista de trabajo que solamente viene una vez en la vida. A mitad del camino, Juan oyó un fuerte sonido "POP" y al instante comenzó a desviarse. John recuperó el control de su camioneta y se detuvo a un lado de la carretera y sabía que su peor temor se había hecho realidad.

1) ¿Dónde era la entrevista de John?

A) La cuidad de Kansas
B) Topeka
C) La ciudad de Dodge
D) Lawrence

2) ¿Qué puesto de trabajo solicito John?

A) Profesor
B) Equipo de investigación
C) Camionero
D) Dentista

3) ¿Qué implica el fuerte "POP" para John?

A) No llegaría a tiempo a la entrevista y perdería la oportunidad
B) Se le poncho un neumático
C) Golpear a un animal
D) Algo se cayó de la camioneta

Story #4

Edward era algo así como un solitario. Le gustaba ir solo a pescar en el lago y llevaba una nevera llena de aperitivos para disfrutar con su perro. Un día, Edward decidió irse de pesca por la noche y llego al lago a las 9 p.m. en lugar de su habitual 5 de la mañana. Al estar tan oscuro prendió las luces de su coche para poder ver mejor. Pero a pesar de sus mejores esfuerzos por conseguir un poco de visión le fue imposible pues apenas podía ver. Cuando se estaba comiendo un sándwich de pavo, el oyó que su perro comenzó a ladrar. Este se encontraba cerca de la línea de pesca. Edward corrió hacia a su línea y le dio un buen tirón. No podia ver lo que estaba pasando, pero él sospechaba que era un pez grande! Finalmente en el último tirón Edward cayó hacia atrás y un cocodrilo bebé llegó arrastrándose fuera del agua con el anzuelo en la boca!

1) ¿A qué hora suele Edward ir a pescar?

A) 9 a.m.
B) 5 p.m.
C) 11 a.m.
D) 5 a.m.

2) ¿Qué tipo de sándwich comió Edward?

A) Jamón
B) Pavo
C) BLT
D) Bolonia

3) ¿Qué sugirió el ladrido del perro a Edward?

A) El perro se asustó
B) Alguien se acercaba
C) Había algo en la línea de la pesca
D) El perro estaba en el agua

Appendix E - Words Used in Pretest*

Words Used in Pretest*	
Anchor*	Ancla*
Arrow	Flecha
Banana*	Plátano*
Basket	Canasta
Coat*	Abrigo*
Clock	Reloj
Drum*	Tambor*
Finger	Dedo
Gun*	Pistola*
House	Casa
Key*	Clave*
Lamp	Lampara
Lightbulb*	Bombilla*
Moon	Luna
Pencil*	Lápiz*
Ruler	Regla
Squirrel*	Ardillo*
Snail	Caracol
Table*	Mesa*
Wheel	Rueda
Ave. # Letters: 5.2	5.7

Note: * indicates words used in Incongruent condition

Axe	Hacha
Bird*	Pájaro*
Butterfly	Mariposa
Chain*	Cadena*
Candle	Vela
Door*	Puerta*
Fox	Zorro
Glove*	Guante*
Horse	Caballo
Hanger*	Percha*
Kite	Cometa
Ladder*	Escalera*
Mouse	Ratón
Owl*	Búho*
Potato	Patata
Ring*	Anillo*
Shoe	Zapato
Sheep*	Oveja*
Turtle	Tortuga
Window*	Ventana*
Ave. # Letters: 4.95	5.95

Appendix F - Language Fluency and Demographics Questionnaire

Used in Main Study ENGLISH

Age: _____ years

Place of birth (city, state/province, country):_____

Nationality (e.g., U.S., Mexican, Canadian): _____

Gender:_____

What is the highest level of education achieved by your parents (name the highest one)?

_____No schooling completed
_____Elementary school to 8th grade
_____Some high school, no diploma
_____High school graduate, diploma or the equivalent (for example GED)
_____Associate degree
_____Bachelor's degree
_____Master's degree
_____Professional degree
_____Doctorate degree

What is the highest level of education achieved by YOU (name the highest one)?

_____No schooling completed
_____Elementary school to 8th grade
_____Some high school, no diploma
_____High school graduate, diploma or the equivalent (for example GED)
_____Associate degree
_____Bachelor's degree
_____Master's degree
_____Professional degree
_____Doctorate degree

How old were you when you moved to the U.S. **if** you were born outside the U.S.? _____

How much did you earn, before taxes and other deductions, during the past 12 months?
_____Less than $5,000
_____$5,000 through $24,999
_____$25,000 through $49,999
_____$50,000 through $99,999
_____$100,000 and greater
_____Don't know
_____No response

How much did your parents earn, before taxes and other deductions, during the past 12 months?
_____Less than $5,000
_____$5,000 through $24,999
_____$25,000 through $49,999
_____$50,000 through $99,999
_____$100,000 and greater
_____Don't know
_____No response

A. Is English your **native language** (i.e., the very first language you learned)? Y N
If not, what is your native language? _____

B. Please list all the languages you speak, understand, are formally studying, or have studied in the past:_____

Circle one:

C. Do you currently have any family or close friends who are fluent in a language other than English? Y N
If so, do you speak with them in that language? Y N
If so, how often? _____hours per… day week month year

Answer the next questions using the following 1 to 6 scale:

1. Beginner know some words and basic grammar
2. Advanced beginner: can converse with a native speaker only on some topics and with quite a bit of difficulty
3. Intermediate: can converse with a native speaker on most everyday topics, but with some difficulty
4. Advanced intermediate: can converse with little difficulty with a native speaker on most everyday topics, but with less fluency than a native speaker
5. Near fluency: almost as good as a typical native speaker on both everyday topics and specialized topics I know about
6. Fluent: as good as a typical native speaker

D. How would you rate your current **listening** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **speaking** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **reading** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **writing** skills in English?
1 (beginner) 2 3 4 5 6 (fluent)

E. Do you know Spanish?:_____

How would you rate your current **listening** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **speaking** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **reading** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your current **writing** skills in Spanish?
1 (beginner) 2 3 4 5 6 (fluent)

Answer the last 2 questions using the following 1 to 6 scale:

1. Beginner know some words and basic grammar
2. Advanced beginner: can converse with a native speaker only on some topics and with quite a bit of difficulty
3. Intermediate: can converse with a native speaker on most everyday topics, but with some difficulty
4. Advanced intermediate: can converse with little difficulty with a native speaker on most everyday topics, but with less fluency than a native speaker
5. Near fluency: almost as good as a typical native speaker on both everyday topics and specialized topics I know about
6. Fluent: as good as a typical native speaker

How would you rate your English language fluency?
1 (beginner) 2 3 4 5 6 (fluent)

How would you rate your Spanish language fluency?
1 (beginner) 2 3 4 5 6 (fluent)

Appendix G - CLOZE Task Texts

CLOZE Task Texts

1. Can we see **(1) .....** the earth is a globe? Yes, we can, when we watch a ship that sails out to sea. If we watch closely, we see that the ship begins **(2) ..... .** The bottom of the ship disappears first, and then the ship seems to sink lower and lower, **(3) .....** we can only see the top of the ship, and then we see nothing at all. What is hiding the ship from us? It is the earth. Stick a pin most of the way into an orange, and **(4) .....** turn the orange away from you. You will see the pin disappear, **(5) .....** a ship does on the earth.

1. A. if
B. where
C. that
D. whether
E. when

2. A. being disappeared
B. to be disappeared
C. to have disappeared
D. to disappear
E. having disappeared

3. A. until
B. since
C. after
D. by the time
E. unless

4. A. reluctantly
B. accidentally
C. slowly
D. passionately
E. carefully

5. A. the same
B. alike
C. just as
D. by the way
E. similar to

1. C
2. D
3. A
4. C
5. C

2. After months of colder weather, the days get longer, the buds **(1) .....** in the trees, birds sing, and the world **(2) .....** a green dress. Spring passes **(3) .....**summer. Everyone knows that summer will not **(4) ..... .** The power of all the wisest men and women in the world cannot keep it for us. The corn becomes ripe, the leaves turn brown and then drop to the ground, **(5) .....** the world changes its green dress for a dress of autumn colors.

1. A. fall off
B. take up
C. put off
D. come out
E. bring down

2. A. looks after
B. puts on
C. carries on
D. comes around
E. deals with

3. A. into
B. by
C. from
D. on
E. out of

4. A. forego
B. evaluate
C. succumb
D. last
E. evolve

5. A. yet
B. therefore
C. since
D. whereas
E. and

1. D
2. B
3. A
4. D
5. E

3. The postal service is the government agency (1) ----- handles the mail. Its job is (2) ----- letters and packages to people and businesses all over the world. Its goal is to see that your mail gets to its destination (3) ----- possible. People (4) ----- the postal service to deliver important letters and even valuables, (5) ----- time and to the right person.

1. A. the fact that
B. whether
C. of which
D. that
E. in that

2. A. being delivered
B. to be delivered
C. to have delivered
D. having delivered
E. to deliver

3. A. less quickly
B. too quickly
C. so quickly that
D. as quickly as
E. the most quickly

4. A. back out
B. check out
C. come in
D. figure out
E. rely on

5. A. to
B. for
C. at
D. on
E. over

1. D
2. E
3. D
4. E
5. D

Appendix H - WM Tasks' Scores

Table 7

WM Tasks' Scores

Participant #	Group	CSPAN	OSPAN	RotSpan	Composite WM Score
1	0	.84	.77	.47	.62
2	0	.96	.94	.54	.74
3	0	.94	.91	.69	.80
4	0	.94	.92		
5	0	.55	.61	.49	.55
6	0	.97	1.00	.54	.77
7	0	.96	.92	.47	.69
8	0	.95	.75		
9	0		.73		
10	0	.88	1.00	.47	.73
11	0	.96	1.00	.43	.72
12	0	.92	.82	.63	.73
13	0	.95	.90		
14	0	.97	.97	.69	.83
15	0	.94	1.00	.70	.85
16	0	.95	.88	.41	.64
17	0	.97	.96	.49	.72
18	0	.96	.96	.80	.88
19	0	.95	.75	.44	.60
20	0	.90	1.00	.64	.82
21	0	.97	.98	.80	.89
22	0	.88	.73	.43	.58
23	0	.91	.61	.43	.52
24	0	.96	.88	.65	.76
25	0	.92	.82	.82	.82
26	0	.88	.98		
27	0	.96	.88	.65	.76
28	0	.97	1.00	.48	.74
29	0	.88	.75	.48	.62
30	0	.93	.96	.79	.88
31	0	.97	.77	.79	.78
32	0	.99	.91	.49	.70
33	0	.97	1.00	.77	.88
34	0	.96	1.00	.88	.94
1	1	.70	.93	.70	.82
2	1	.97	1.00	.90	.95
3	1	.92	.83		
4	1	.96			
5	1	.97	1.00	.80	.90

6	1	.90	1.00	.52	.76
7	1	.97	1.00	.88	.94
8	1	.93	1.00	.74	.87
9	1	.96	.97	.88	.93
10	1	.96	.88	.58	.73
11	1	.87	.94	.62	.78
12	1	.97	1.00	.58	.79
13	1		.98		
14	1	.94	1.00	.70	.85
15	1	.97	.90	.79	.85
16	1	.97	.93	.70	.81
17	1	.96	1.00	.55	.78
18	1	.92	.98	.51	.75
19	1	.95	1.00	.67	.84
20	1	.90	1.00	.70	.85
21	1	.93	1.00	.63	.82
22	1	.94	.83	.59	.71
23	1	.89	.85	.70	.77
24	1	.97	1.00	.59	.79
25	1	.94	.84	.41	.63
26	1	.96	1.00	.86	.93
27	1	.96	.93	.47	.70
28	1	.96	.97	.66	.81
29	1	.48	.94		
30	1	.80	.98		
31	1	.88	.94	.47	.70
1	2	.78	.72	.52	.62
2	2	.79	.94	.54	.74
3	2		.83	.48	.65
4	2	.94	1.00	.94	.97
5	2	.95	.85	.41	.63
6	2	.96	.78	.46	.62
7	2	.97	.97	.67	.82
8	2	.97	.96	.52	.74
9	2	.93	.90	.77	.83
10	2	.84	.66	.40	.53
11	2	.94	.83	.41	.62
12	2	.90	.93	.58	.76
13	2	.12	.67		
14	2	.87	.83		
15	2	.87	.92	.36	.64
16	2	.85	.92	.54	.73
17	2	.97	.92	.72	.82
18	2	.77	.83	.40	.62
19	2	.96	.97	.70	.83
20	2	.97	.92	.51	.71

21	2	.96	.62		
22	2	.94	.96	.66	.81
23	2	.95	.92	.70	.81
24	2	.94	.80		
25	2	.88	.77		
26	2	.80	.47	.45	.46
27	2	.86	.80	.45	.63
28	2	.96	.92	.60	.76
29	2	.77	1.00	.43	.72
30	2	.94	.62	.58	.60
31	2	.95	.96	.57	.76
32	2	.99	.92	.41	.66
33	2	.97	.98	.43	.71
34	2		1.00		
35	2	.96	.93	.54	.73
36	2	.99	1.00	.80	.90
37	2	.97	.93	.45	.69
38	2	.93	.74	.41	.57
39	2	.97	1.00	.67	.84
40	2	.88	.70	.46	.58
41	2			.79	
42	2	.77	.86		
43	2	.88	.97	.46	.71

Note. 0 = Monolingual participants; 1 = bilingual participants in bilingual mode; 2 = bilingual participants in monolingual mode; partial unit scoring method used.