

THE EFFECTS OF BILINGUALISM ON CONTROLLED AND AUTOMATIC
PROCESSING DURING LEXICAL
ACCESS

by

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ABSTRACT

The effects of bilingualism on individuals' controlled and automatic visual word processing during a semantic task were examined. Proficient bilinguals, intermediate bilinguals and monolinguals were presented with a semantic priming task where semantic relatedness of prime and target words was manipulated. Lexical stimuli were also manipulated in terms of the strength of association with their category meaning and their meaningfulness. Half of the lexical stimuli were presented at short SOA (automatic condition) and half – at long SOA (controlled condition). The results indicated that there was a strong category effect demonstrated by all language groups in both automatic and controlled conditions (strongly related words were processed faster than weakly related words).

Monolinguals were found to outperform intermediate but not proficient bilinguals on controlled lexical task. Monolinguals also demonstrated a facilitation effect on automatic lexical task that was matched by proficient bilinguals but not intermediate bilinguals

Consistent with the previous research was the finding that bilinguals' superior L2 skills tend to facilitate their L2 information processing.

DEDICATION

This thesis is dedicated to everyone who helped me and guided me through the trials and tribulations of creating this manuscript.

LIST OF ABBREVIATIONS AND SYMBOLS

<i>df</i>	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
<i>F</i>	Fisher's <i>F</i> ratio: A ration of two variances
<i>M</i>	Mean: the sum of a set of measurements divided by the number of measurements in the set
ms	Milliseconds
<i>p</i>	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
<i>r</i>	Statistical power
<i>t</i>	Computed value of <i>t</i> test
<	Less than
=	Equal to

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CHAPTER 1

INTRODUCTION

Bilingualism is a widespread phenomenon that interests researchers from various fields of study, including linguistics, cognitive psychology, developmental psychology and neuroscience. Different models and explanations have been proposed that could account for the mental processes that underlie bilinguals' use of their two language systems (e.g., Francis, 2005; Gollan & Brown, 2006; Paradis & Lebrun, 1983). The debate of whether bilinguals have a common semantic system or separate systems for their native language (L1) and second language (L2) is discussed below. However, the cognitive literature is not limited to the discussion of the linguistic aspects of bilingualism; some researchers are more interested in studying the effects of bilingualism on such cognitive processes as executive control processing, mental flexibility, cognitive development, and so on.

According to Francis (2005), cognitive research on bilingualism falls at the intersection of psychology and linguistics. Language is a tool that is used for communication purposes as well as practical purposes, such as, say, solving a problem, and as a tool it can affect the task it is applied to. Based on the existing research in the area of bilingualism and cognition, it is logical to expect to see a reciprocal relation between language and cognitive processes that are involved in any given activity: not only is the language affected by mental processes but it affects these processes as well.

In the sections that follow, research on the relationship of bilingualism with various cognitive processes will be described. These processes include executive control processing; cross-linguistic information processing; and processing L2 orthographic features and morphology.

Effects of Bilingualism on Cognitive Processing

Vygotsky (1962) described the nature of the relation between language and thought and the beneficial influence that bilingualism has on the cognitive functioning of a bilingual individual. He maintained that learning a second language enables bilinguals to enhance their understanding of their native language and adopt an abstract, generalized approach to language as they become more deliberate in using words as tools of their thought. He also compared learning a second language to learning algebra after acquiring the knowledge of arithmetic. The knowledge of arithmetic liberates the mind from concrete figures and takes it to a higher level of generalization when a person learns algebra. In the same way, when bilingual individuals learn a second language, the knowledge of their native language liberates their mind from the dependence on concrete linguistic forms and enables it to access the arbitrary properties of the language. It also enables bilingual individuals to see their native language as one particular system among many other systems, which ultimately leads them to realize that they are engaged in linguistic operations when they speak a foreign language. This metalinguistic awareness implies development of abstract thinking, which is important for solving various cognitive tasks.

Mohanty and Babu's (1983) experiment compared bilingual and monolingual students of different ages on metalinguistic ability using a modified version of the

Metalinguistic Ability Test (Osherson & Markman, 1975). The test measures three aspects of metalinguistic ability: the understanding of the arbitrariness of language; meaning and referent relationship; and the nonphysical nature of words. The measure for the understanding of the arbitrariness of language is used to determine whether participants understand that there is an arbitrary relationship between a word and its referent (e.g., can we call the sun the *moon*?). The meaning and referent relationship measure assesses participants' understanding that the meaning of a linguistic symbol such as a word is independent of the state of the object to which it refers (e.g. will the meaning of the word change if the object it refers to no longer exists?). The last measure, the nonphysical nature of words, assesses participants' awareness that words do not share the physical characteristics of the object they stand for (e.g., is the word *book* made of paper?). Bilinguals' metalinguistic ability scores in Mohanty and Babus' (1983) study were significantly higher than the monolinguals' ones.

Studies of divergent thinking that used bilingual and monolingual participants provide evidence that bilinguals have a language asset (Carringer, 1974; Okoh, 1980; Price-Williams & Ramirez, 1977). For instance, Okoh's (1980) study that used 289 bilingual and monolingual students from Nigeria and Wales demonstrated that bilingual participants scored significantly higher than monolinguals on tests of verbal creativity. No difference was found between the groups in the nonverbal creativity tests. Participants in the two groups were matched on verbal intelligence. The verbal creativity tests consisted of Word Meanings (listing all possible uses for a given word) and Uses of Objects (listing all possible uses for various objects). The figural tasks from the Torrance Tests of Creative Thinking were used as a measure of nonverbal creativity. The author

attributed bilingual advantage in verbal creativity to the fact that a bilingual person “has two linguistic vantage windows or corridors to the world of phenomena... and therefore would have an advantage over the monoglot in that aspect (divergent style) of cognitive functioning sometimes labeled “creativity”, since he would presumably have a greater repertoire of cognitive cues, signs, meanings, and relationships to draw upon” (Okoh, 1980, p. 163).

Carringer (1974) examined the relationship of bilingualism and creative thinking abilities using a group of Spanish-English proficient bilinguals and Spanish monolinguals. Ninety-six high school students from the American school and the Prayera School in Torreón, Coahuila, Mexico were used in the study. Four subtests from the Torrance Tests of Creative Thinking were administered to both groups as a measure of participants’ creative skills. The test has both verbal and nonverbal (figural) tasks. Each task is scored based on the fluency, flexibility, and originality of participants’ ideas. In Carringer’s (1974) study bilingual students scored significantly higher than monolinguals on the dependent measures of figural fluency, figural originality, verbal flexibility, and verbal originality.

Vygotsky (1962) emphasized another important advantage of bilingualism: two different processes are involved in learning one’s native language and a foreign language. If both languages are not acquired simultaneously then bilinguals learn a foreign language at a time when most word meanings have already been developed in their native language and they merely need to translate them into a foreign language. The use of the semantics of the native language as a foundation for developing a second language implies that bilinguals develop cognitive processes that are different from those of

monolinguals. These additional processes could underlie the greater intellectual flexibility of bilinguals reported by many researchers (e.g., Lambert, 1977; Lemmon & Goggin, 1989; Peal & Lambert, 1962). Peal and Lambert's (1962) study, which used French-English bilinguals, demonstrated that bilingualism had a positive effect on cognitive functioning and the magnitude of the effect was dependent on the degree of the bilingual abilities of individual participants. The goal of this study was not merely to compare the IQ scores of mono- and bilingual participants but to compare a wide variety of cognitive abilities using both verbal and nonverbal tasks. It turned out that bilinguals performed significantly better than monolinguals on both types of intelligence tasks. One particular area in which bilinguals were better than monolinguals was mental manipulation and reorganization of visual patterns. Concept formation tasks, which required mental flexibility, were also an area of strength of bilingual participants. Summarizing more than a decade of research on bilingualism, Lambert (1977) emphasized the cognitive advantage that bilinguals have in the domain of cognitive flexibility.

Bilingual Performance on Controlled Tasks

Studies of cross-linguistic information processing rely on theories that include the distinction between controlled and automatic information processing (Posner & Snyder, 1975). Controlled information processing is generally believed to require certain control mechanisms. It involves decision making and is supposed to be vulnerable to interference from external sources. Automatic information processing, on the other hand, does not require attentional resources and occurs without higher level monitoring.

Recent research indicates that bilingualism may create an advantage in controlled processing (Bialystok et al., 2004; Bialystok et al., 2008). Bialystok et al.'s (2004) study was conducted to determine whether bilingualism attenuates the negative effects of aging on cognitive control of older adults. Forty bilingual and monolingual middle-aged (age 30-54) and older adults (age 60-88) participated in this research study. In each age group, half the participants were monolingual English speakers living in Canada and half were Tamil-English bilinguals living in India. The bilingual participants spoke two languages fluently and used both languages on a daily basis throughout their lives. In three consecutive studies, Bialystok et al. (2004) had monolingual and bilingual adults perform versions of the Simon task as a measure of cognitive control.

The Simon task is based on stimulus-response compatibility and it “assesses the extent to which the prepotent association to irrelevant spatial information affects participants’ response to task-relevant nonspatial information” (Bialystok et al., 2004, p. 291). This task is relatively content free and is used with participants of all ages. It allows the researchers to study cognitive processes that are believed to occur differently in bilinguals and monolinguals, such as attentional control. During the Simon task, colored patches are presented to the right or left of the screen, above right or left response keys. A participant may be instructed to press a left response key if the patch is red and press the right one if the patch is green. The patch may be presented above the appropriate key (congruent response) or above the inappropriate key (incongruent response). Incongruent responses are generally associated with longer response times than congruent ones (the so-called Simon effect) and a smaller Simon effect usually indicates better cognitive control (Lu et al., 1995).

Both middle-aged and older bilingual adults in Bialystok et al. (2004) experiment responded faster and made fewer errors than the monolingual groups. The “older” group of bilingual and monolingual participants in this study revealed a greater bilingual advantage than the “younger” group, indicating that the bilingual advantage in executive functioning becomes even greater with age.

A smaller Simon effect in bilinguals - as compared to that of monolinguals - has been attributed to a more efficient attentional control that bilinguals would have to develop to selectively use (or suppress) one of their two language systems.

Yang (2007) conducted a study to find out whether Korean-English bilingual children were any different from Korean and English monolingual children in terms of executive attention. Bilingual participants in the study demonstrated a positive effect of bilingualism on cognitive measures that were used as tests of executive attention and in some tasks it was clearly separable from a cultural effect.

Bilingual participants have been also found to outperform monolinguals in rule switching on the dimensional change card sort task (Bialystok & Martin, 2004). Bialystok and Martin’s (2004) experiment emphasized two types of cognitive processes which are called *analysis of representations* and *control of attention*. Analysis is described as “the process of constructing mental representations that are increasingly capable of recording information that is detailed, explicit and abstract” (Bialystok & Martin, 2004, p. 325). When mental representations are analyzed, knowledge can be organized around abstract categories and details that are retrieved independently of their context. As people develop, their mental representations become increasingly explicit, organized, and abstract, allowing access to detailed knowledge.

The second cognitive process, control of attention, is described as a process by which attention is selectively directed to specific aspects of a representation. This process becomes especially important during problem solving, when a person deals with a misleading situation. Problem solving is associated with the necessity to focus on relevant information and inhibit the irrelevant. The selective attention is considered to be more difficult when some salient or habitual response contradicts the optimal one, when one response must be ignored and the other one selected. In such situations, inhibition becomes an essential component of control.

In their 2004 study, Bialystok and Martin used the dimensional change card sort task (Zelazo, Frye, & Rapus, 1996) to test whether bilingual children would differ from monolingual children in both types of cognitive processes (analysis of representations and control of attention). The task requires children to sort a set of cards by one dimension and then to resort the same cards by a different dimension. Two compartments are provided for the sorted cards, and each compartment is marked by a target stimulus. For instance, the set of cards can contain cards that are either blue squares or red circles. The target stimuli on the sorting compartments would be a red square and a blue circle. First, participants are told to sort by one dimension (pre-switch phase), for example, color, and put all the blue cards into the box indicated by a blue circle and all the red cards into the box indicated by a red square. In the post-switch phase, participants are asked to sort cards by shape, so each card must now be re-assigned to the opposite box. The square cards must be put into the box indicated by the red square (instead of the blue circle) and the circle cards - into the box indicated by the blue circle. When this task is administered to children, they tend to persist in sorting the cards according to the first

dimension (color) and continue to put the blue squares into the box indicated by the blue circle.

Chinese-English bilingual children and English monolingual children in Bialystok and Martin's (2004) study were matched on age, working memory capacity and general intelligence. Children in the bilingual group showed advantage over the monolinguals in the card sort task, they solved the card sort problem more easily and were found to be better on conceptual inhibition.

One of the purposes of Bialystok and Martin's (2004) study was to find out why the dimensional change card sort task is difficult for children to solve. Based on the results of the study, the researchers concluded that the source of the difficulty is in conceptual inhibition, the ability to inhibit attention to a mental representation and ignore misleading cues so that a new representation can be constructed. The new representation is the basis for sorting in the post-switch phase of the task. The dimensional change card sort task requires children to represent a target stimulus by referring to one particular feature of the stimulus, then to ignore that feature and re-represent the same stimulus in a different way. The ability to ignore the feature that was used for stimulus identification in the pre-switch phase becomes crucial at this point. Children who are able to reinterpret the target stimulus for the post-switch phase and ignore its perceptual properties that were crucial to the pre-switch phase tend to do well on this task.

The positive effect of bilingualism on cognitive development and, more specifically, on the controlled processing in bilingual individuals thus supports Bialystok's suggestion that the conflicting nature of the coexistence of two language systems in a single mind should require the development of a mechanism for the

resolution of any conflicting situations. And if such mechanism exists, its function could extend beyond purely linguistic phenomena.

Green (1998) suggested that the same mechanism could be responsible in bilinguals for attending to one of their languages and for controlling all other processes that require attention or inhibition.

Neuroimaging Evidence during the Simon Task

Neuroimaging studies support this view by demonstrating the importance of Broca's area - that traditionally has been associated with language production - for the resolution of conflicting situations during lexical processing (Bialystok et al., 2005; Novick et al., 2005). Bilingual speakers have been found to have this area more activated than monolinguals during the Simon task, which suggests that this area should be important for the resolution of both verbal and nonverbal conflicts in bilinguals.

Detrimental Effects Associated with Bilingualism

Recent research on the effects of bilingualism on cognitive performance revealed not only the facilitating nature of such effects, but some detrimental effects as well. For instance, bilingualism has been found to be associated with the increased tendency to have a tip-of-the-tongue state (Gollan & Acenas, 2004) and naming difficulties whether it is a picture naming task (Roberts, Garcia, Desrochers, & Hernandez, 2002) or word identification through noise (Rogers, Lister, Febo, Besing, & Abrams, 2006). In Gollan and Acenas's (2004) study, the researchers induced tip-of-the-tongue states (TOTs) for English words in English monolinguals and Spanish-English bilinguals. Picture stimuli with cognate (e.g., *scorpion*, which is *escorpión* in Spanish) and noncognate (e.g., *octopus*, which is *pulpo* in Spanish) names were used to elicit TOTs. Bilinguals in this

study had more TOTs than did monolinguals when they had to retrieve noncognate words from their memory. This finding indicates that, relative to monolinguals, bilinguals are less able to activate word representations specific to each language.

It is easier to establish a link between bilingualism and rapid word retrieval than between bilingualism and executive processing because bilinguals' linguistic skills are tested during rapid word retrieval tasks, so it would be natural to assume that these skills should be affected by their bilingual ability. However, when bilinguals are tested on nonverbal skills such as executive control processing, results can be only remotely related to bilingualism per se. So far, research has not revealed the exact mechanisms that are at work in the relation between bilingualism and executive control processing, so it is not clear whether this relation has a direct or indirect nature. It is possible that a mediating factor exists that facilitates bilinguals' performance on executive control tasks. In fact, research on working memory in bilinguals has consistently produced mixed results (Bialystok et al., 2004; Fernandes et al., 2007; Bialystok et al., 2008) and working memory has traditionally been treated as one of the essential components of the executive processing (Bialystok et al., 2008).

Based on results of experiments described above, Bialystok et al. (2008) posit that a detrimental effect of bilingualism is only found when bilinguals have to perform automatic linguistic tasks that require a rapid retrieval of specific lexical items and that this deficit in performance does not spread to other forms of linguistic or conceptual processing.

Bilingual Performance on Automatic Tasks

Learning a second language and reading in it is a very complex activity and it makes heavy demands on cognitive processing, though with time and practice bilinguals approach automatic processing shown by monolinguals (e.g., Favreau & Segalowitz, 1983, Frenck-Mestre & Prince, 1997). Slowing of performance in a second language is an indication of controlled information processing, whereas decreased latencies are generally associated with automatic processing.

Favreau and Segalowitz (1983) used English-French and French-English unequal-reading-rate bilinguals and equal-reading-rate bilinguals in their study that was a bilingual version of Neely's (1977) experiment. In his (1977) experiment, Neely manipulated participants' expectations about the semantic relatedness of prime and target words. He told participants to expect to see either a semantically related target word after seeing a prime word (e.g., *bird - robin* (nonshift condition)) or, in a different condition, to expect an unrelated word (e.g., *body - window*; *building - head* (shift condition)) and then he manipulated target words by occasionally exposing participants to unexpected targets when they expected to see a related word (e.g., *bird-door*) or exposing them to a semantically related word when an unrelated word would be expected (e.g., *body-arm*). There were five different types of prime-target trials in the study: *bird-robin* (nonshift-expected-related condition); *bird-arm* (nonshift-unexpected-unrelated condition); *body-door* (shift-unexpected-unrelated); *body-sparrow* (shift-unexpected-unrelated); *body-heart* (shift-unexpected-related). The stimulus onset asynchrony (SOA) between the prime and the target letter strings varied between 250 ms and 2000 ms.

The lexical decision task that was used in Neely's (1977) experiment was found to produce a semantic facilitation effect that has an automatic rather than a controlled nature and lead to a facilitation of reaction times to expected words and an inhibition of reaction times to unexpected words. The automatic nature of the semantic facilitation effect was demonstrated when participants showed a facilitation effect to unexpected but semantically related words at the 250 ms SOA and an inhibition effect to unexpected but related words (e.g., *body-heart*) at the 2000 ms SOA.

Favreau and Segalowitz (1983) modified and replicated this study to test bilinguals' semantic processing in their native and second languages. The researchers found that only equal-reading-rate bilinguals (bilinguals with equal levels of comprehension and equal reading rates in L1 and L2) showed automatic priming within their second language, less proficient bilinguals who could comprehend their L1 and L2 equally well but were slower L2 readers only had automatic processing in their native language and not in L2.

Favreau and Segalowitz's (1983) study demonstrated that unequal-reading-rate bilinguals did not have any facilitation for target words that were unexpected but related, whereas more proficient bilinguals did. However, unequal-reading-rate bilinguals were found to have automatic priming activation in their L2 when targets were related and expected. Thus, creating and upsetting unequal-reading-rate bilinguals' expectations about target words disrupted their automatic processing of L2.

The authors commented on a few factors that are at play when bilinguals process information in a nonnative language, such as a reduced sensitivity to orthographic, syntactic, and semantic redundancies of L2 and a longer fixation time of eye movement

that is needed to process printed information. These factors may partially explain bilinguals' poorer automatic processing of L2 as compared to L1 because automaticity is commonly associated with speed of information processing and responding. It is typical for bilingual studies that examine automatic lexical processing to use SOAs of 100 ms and less to prevent participants from effortful conscious processing of lexical stimuli.

One reason for unequal-reading-rate bilinguals' performance in Favreau and Segalowitz's (1983) study was the fact that these bilinguals were not schooled in their L2 as long as equal-reading-rate bilinguals, which possibly could account for their reduced automatic processing in L2. The authors commented on the relation between automaticity and extended practice with linguistic stimuli. Frequency of exposure to L2 words could be directly related to the development of automatic processing of such words.

Bilingual Spreading Activation

Yet another automatic process that can be implicated in bilinguals' cognitive functioning and hinder their performance on automatic tasks is the so-called spreading activation. It is an influential model that is traditionally used to account for individuals' semantic processing (Anderson, 1983a; Rumelhart & McClelland, 1982) and can be described as "a complex association network in which specific memories are distributed in conceptual space with related concepts that are linked by associations" (Samani et al., 1997). Specific concepts in this association network are thought to be represented as nodes that are linked together by means of the associative pathways. Activation of certain concepts (nodes) in the network should thus lead to the spreading of activation along the associative pathways to all related concepts that are stored in one's memory. This model can explain how individuals access related concepts (with varying degree of the strength

of relation among them) during semantic processing. It has been shown that the nature of this process is automatic rather than controlled (Balota & Lorch, 1986); however it is not clear whether bilinguals have an automatic or controlled cross-linguistic activation (Frenck & Pynte, 1987). In their (1986) experiment, Balota and Lorch used a lexical decision task and a pronunciation task to investigate whether activation automatically spreads beyond directly associated concepts within the memory network. The lexical decision task was completed at different SOAs between the prime and the targets words. 32 subjects received a 250 ms prime target SOA and another 32 subjects – 500 ms prime target SOA. The lexical stimuli consisted of a set of 56-word triads. Four conditions were used in the experiment: related, mediated, neutral, and unrelated. In each triad, the first and second words (lion-tiger) were directly related and the second and third words (tiger-stripes) were directly related, but the first and third words (lion-stripes) were associated only indirectly by their relations to the second word. Participants were presented with pairs of stimuli on many trials and were asked to indicate by pressing a key whether the second word in each pair was a word or a nonword. The lexical decision results yielded facilitation of directly related priming conditions (e.g., lion-tiger and tiger-stripes) but not in the mediated condition (e.g., lion-stripes). This supported the single-step activation model, however the results of a lexical decision task could not be generalized to a variety of cognitive processes. Therefore, a pronunciation experiment was conducted in which 56 subjects were presented with lexical stimuli that were similar to the ones used in the lexical decision experiment. The length of the SOA was manipulated in this experiment as well. In the pronunciation experiment, participants were asked to pronounce the second word in each pair as quickly as possible without mispronouncing it. Their

responses were recorded and reaction times were compared across different conditions of the experiment (related, mediated, neutral, unrelated). The results of this experiment yielded facilitation of both directly related and mediated priming conditions. This finding supported the notion that activation spreads beyond directly related concepts in semantic memory and is a multi-step process. The authors suggested that the nature of the lexical decision task could mask the appearance of a mediated priming effect. Facilitation effects were observed for the mediated pairs at both SOAs, which indicated it had an automatic nature.

Language Representation in a Bilingual Mind

Francis (2005), holds that bilingual semantic representation has been of interest to psychologists because of the fundamental cognitive question of redundancy versus efficiency of language representation. She posits that understanding the nature of language representation will enable the researchers to understand how two languages are used competently within a single mind.

Research has tried to reveal the nature of language representation in a bilingual mind and find evidence either in favor of an independent lexical organization (with L1 and L2 having separate lexicons) or an interdependent lexical organization (with L1 and L2 having a common lexicon). An interdependent bilingual mental lexicon is supposed to be represented by word representations that are common for each particular word and its translation equivalent in both L1 and L2, whereas an independent bilingual mental lexicon is supposed to be represented by word representations that are characteristic of one language only and which does not share word representations with the other language.

Various cross-linguistic tasks have been used to find out whether bilinguals have a common or separate stores for their languages, some of these tasks rely on the efficiency of bilinguals' within-language and cross-language spreading activation. Some bilingual lexical studies have shown that more similar lexical items (e.g., cognates versus noncognates) are more likely to be stored as a single lexical unit and the more different ones – as separate lexical units in a language system (de Groot & Nas, 1991; Hummel, 1993).

Research studies that focused on the semantic priming of lexical decision have demonstrated that lexical decisions are faster when a word is immediately preceded by a semantic associate than when it is immediately preceded by an unrelated word or presented in isolation. Some bilingual studies, such as Frenck and Pynte's (1987) study have shown that the advantage for a related prime remains even when the related prime is in a different language than the target word. This means that processing of a linguistic item by a bilingual can be facilitated when the bilingual sees a related item in the other language. Thus, the existing evidence seems to favor the interdependent model of language representation in bilinguals.

Effects of L1 on L2 Performance

Most cross-linguistic reading researchers emphasize factors that seem to be crucial for effective performance in bilinguals' L2 and that are obviously implicated in reading and visual word recognition, namely orthographic and phonological differences between languages (e.g., Akamatsu, 1999; Wade-Woolley & Geva, 1994).

Akamatsu (1999) compared bilinguals whose L1 was alphabetic (e.g., Iranians , Persians) and those whose L1 was nonalphabetic (e.g., Chinese, Japanese) on an

automatic word recognition task in English, which was a second language for the bilinguals in the study. The main interest was finding out how orthographic characteristics of bilinguals' L1 could affect their performance on a word recognition task completed in English. Lexical stimuli in Akamatsu's (1999) study were English words that were somewhat distorted (e.g., cAsE aLtErNaTiOn). The results of the study indicated that bilinguals whose L1 was alphabetic tended to be less affected by visual distortions of the English words because they could still rely on the spelling patterns of words (though words' word-shape cues were lost for them). The magnitude of the case alternation effect was significantly larger for bilinguals whose L1 was nonalphabetic in nature, these participants could not name English words as efficiently as the first group because their native language had a nonalphabetic orthography. This study demonstrates the importance of the first language orthographic features (and, perhaps, other factors associated with bilinguals' L1) for bilinguals' orthographic coding mechanism (i.e., word recognition mechanism) and their information processing when they use L2. When bilinguals from different linguistic and cultural backgrounds translate English words that are presented to them as letter strings into mental representations of those words, this process involves the computation of the sequences of letter strings (i.e. spellings) that make up those words. Research has shown that for speakers of nonalphabetic languages, such as Japanese, for instance, this process is different in that speakers of nonalphabetic languages deal with logographic, not alphabetic words (e.g., Jackson, Lu & Ju, 1994). Therefore, it is logical to suggest that orthographic characteristics of bilinguals' L1 could have an affect on the speed and accuracy of their word processing in L2. Bilinguals, whose L1 is orthographically similar to L2, such as French and English, for instance,

should have some advantage over bilinguals whose L1 is orthographically different from L2, such as any Slavic language and English, granted they are equally proficient in their L2 (English in this case). This effect could be very subtle as translation of alphabetic words into mental representations happens at the initial stage of word processing and generally is considered to be a rather basic cognitive operation. Besides, results of research studies that compared bilinguals from different linguistic backgrounds have produced mixed results. For instance, Brown and Haynes's (1985) study that used native speakers of Arabic, Spanish, and Japanese languages revealed that Japanese native speakers were faster than Arabic and Spanish speakers when they processed English words. Even though they were not able to pronounce English words (and nonwords) as efficiently as Arabic and Spanish speakers, they were still the fastest in the visual processing of the English words. Contrary to the prediction of the researchers, the group of Spanish native speakers did not outperform the other two groups despite their familiarity with the Roman alphabet.

Akamatsu's (1999) study provides evidence for our understanding of the cognitive processes that underlie bilinguals' word processing in L2, such as their reliance on prior reading experience in a second language and any cross-linguistic effects between their L1 and L2 that may influence their performance, just to name a few. Like the majority of researchers who compare L2 performance of intermediate and proficient bilinguals, Akamatsu explains proficient bilinguals' superior performance during automatic word-recognition processing by the fact that skilled L2 speakers have more "cognitive space" for comprehension when they read L2 words than intermediate bilinguals who need their attentional resources for this task.

However, areas of interest to cross-linguistic reading researchers have not been limited to orthographic differences between languages. In their 1998 study, Wade-Woolley and Geva compared Russian- and English-native speakers on an automatic word naming task and a reading task in Hebrew, participants' L2. The main focus of the experiment was the relation of bilinguals' L2 learning patterns and experience to the acquisition of automatic processing skills in the morphological domain. Morphology, or word formation rules, is yet another important aspect of L2 learning and reading acquisition. Russian and English native speakers were chosen for the study because these languages do not have such complex morphological structures that exist in the Hebrew language. For instance, in Hebrew, some words are formed by affixation of prepositions to nouns, which results in single words that are also full prepositional phrases. In English and Russian, prepositions and nouns in prepositional phrases are autonomous as both languages require the preposition to be separate from its object. This can be illustrated by the following example: the English phrase "in the sea" and its Russian translation /v more/ is translated into Hebrew by a single inflected lexical item /bayam/. Another example is a Hebrew word /layam/ and its English translation "to the sea". However, Hebrew has words that present a challenge even for the native speakers of this language because of the ambiguity of their word form, the complexity of the morphosyntactic phrases expressed by those words (e.g., /kəmot/ "at the death of") or the fact that some Hebrew words may be printed without certain vowels. This difficulty does not exist in the English language. However, English also presents certain challenges to nonnative speakers of this language because it has 26 letters in its alphabet which map onto more than 36 phonemes (Taylor, 1981). It is often difficult for the English reader to determine

the sound of one letter without reference to a second. English accommodates all its phonemes by incorporating certain strategies, such as, for instance, the use of digraphs, in which two letters represent one sound (e.g., *th*). The “silent *e* rule” characteristic of the English language may also be problematic for bilinguals who are not proficient in this language. According to this rule, the phonological realization of a vowel in an English word changes with the word-final addition of the letter *e*, which has no phonological realization in and of itself.

Morphology wise, English, Hebrew and Russian belong to the same group of languages, the so-called *inflecting languages*, because they have words that consist of a single morpheme or many morphemes. The other two groups are the *isolating languages* and the *agglutinating languages*. The isolating languages (e.g., Chinese) have words that consist of one morpheme that can not be reduced to smaller meaningful units and the agglutinating languages (e.g., Turkish) have words that have a base form, to which many morphemes may be attached. Within the group of inflecting languages, various languages differ in regard to their morphological complexity. For instance, Hebrew allows the affixation of prepositions, whereas English and Russian do not.

In Wade-Woolley and Geva’s (1998) study, high frequency Hebrew words of one morpheme (e.g., /para/ “cow”) and three morphemes (e.g., /bakis/ “in the pocket”) were presented to participants during an experiment. The natural morpheme boundaries of words were either preserved or disrupted through the manipulation of font size. Therefore, the researchers used Stroop-like interference effect in their study. Participants were also asked to read a passage from an Israeli newspaper. The study revealed that Russian native speakers were less impaired by the experimental manipulation and

significantly more accurate than the English speakers at text reading, but significantly less accurate and slower than the English group at the naming task. Both groups were significantly slower and less accurate than the native speakers. The interesting finding was that Russian speakers, who made fewer errors than the English speakers when they read the text, were at a disadvantage during the naming task because they could not use the contextual information to guide their understanding of morphosyntactically complex words. The fact that the English speakers were more accurate at the naming task was explained by their extensive exposure to Hebrew print (they were exposed to it from an early age) which made it easier for them to access lexical representations of morphosyntactically complex words. Because of extensive practice, these words became more or less crystallized in their L2 lexicon.

Wade-Wolley and Geva's (1998) study demonstrated that as reading skills of L2 speakers become automatized, accuracy develops before speed and this is true not only for single words but also for morphosyntactically complex words. The fact that English speakers' performance on the naming task was not impaired, but correct naming was slowed by the manipulation of the morpheme boundary supported other findings from bilingual experiments which have shown that Stroop-like interference effects do not appear in the second language until a threshold degree of fluency in L2 has been attained by bilingual speakers. The study has also supported the notion that age of onset of L2 learning, the duration and intensity of formal education in L2, as well as the relative weighting of the oral-written contribution at the various stages of formal education may all play important role in the acquisition of L2 and facilitate bilinguals' access to crystallized orthographic representations necessary for automatic word recognition in L2.

The Non-Selectivity Effect in Visual Word Recognition

The facilitating nature of the contextual information in Wade-Wolley and Geva's (1998) study (demonstrated by the group of Russian native speakers) is worth noting because a number of studies that looked at bilinguals' processing of words out of context (e.g., lexical decision tasks) and in the presence of a sentence context found that context tends to constrain the effects of the so-called *non-selectivity* (Schwartz & Kroll, 2006). The non-selectivity effects were revealed in studies that compared bilinguals' recognition of homonyms and unambiguous words (e.g., Hino & Lupker, 1996; Pexman & Lupker, 1999). Because recognition performance for homonyms was facilitated, it became evident that the multiple representations of homonyms were activated in parallel during lexical access. This led researchers to the realization that lexical access involves the initial activation of numerous lexical competitors within the lexicon. Later, it was found that this effect persists irrespective of task instructions, participants' expectations or knowledge that they will be presented with lexical stimuli from multiple languages (Dijkstra et al., 2000). This finding was important for the long-standing debate in bilingual research that was concerned with the issue of whether the bilingual word recognition process involves the initial activation of word representations from bilinguals' L2 only (if they are doing a lexical task in that language) or whether all words in their lexicon (including L1) are candidates for potential selection. The first view thus supports the *language-selective lexical access* and the second one – the *non-selective lexical access* (Lemhöfer, Dijkstra, Schriefers, Baayen, Grainger, Zwitserlood, 2008). The majority of bilingual studies on word recognition that presented lexical stimuli out of context revealed the initially non-selective access of lexical information across

bilinguals' two languages (e.g., De Groot & Keijzer, 2000; Dijkstra, Timmermans, & Schriefers, 2000).

For researchers who focus on out of context lexical tasks in participants' L2, this phenomenon has an important implication in that the researcher needs to be aware that multiple cross-linguistic lexical competitors become activated during bilinguals' lexical access in L2 and that suppression of the irrelevant information requires a certain effort and may lead to increased latencies during lexical performance. This effect may be especially evident in lexical decision tasks that rely on automatic information processing. It also may concern more proficient bilinguals than the intermediate ones because the latter activate lexical information in their L2 less automatically. However, presence or absence of this effect may depend on the specific language combination (L1 and L2) of bilingual participants.

L1 and L2 Combinations

Although many studies have reported that word recognition in a second language is affected by the native language (its orthographic features, phonology, etc.), few studies have looked at the specific combinations of the various languages. A study by Lemhöfer et al. (2008) used a word identification task on 1,025 monosyllabic English words. The lexical stimuli in this study were presented to native speakers of French, German, and Dutch, who were proficient in English. A large number of within- and between-language variables were used in the study as predictors of bilinguals' performance. Examples of within-language variables used in the study are *word frequency*, *word length*, *concreteness*, and *familiarity* of words. The between-language variables included *orthographic neighborhood variables with respect to L1* and *interlingual cognates and*

homographs. The orthographic neighborhood variables with respect to L1 were included in the study to find out if there was any between-language neighborhood effect. Any occurrence of such an effect would indicate that during the recognition of a word in a second language, word candidates of a native language become active as well and compete for recognition. This effect can be explained by the nonselective model of bilingual lexical access that has been described above.

Results of the regression analysis showed that reaction time patterns for the different groups of bilinguals were very similar and word recognition results obtained for a group of bilinguals with a specific mother tongue could be generalized to other groups as well. The only between-language variable that turned out to be a significant predictor was the cognate status of a word (this finding is supported by the results of many previous experiments), so influence of L1 on L2 word recognition task was found to be very subtle and within-language factors were found to play a more significant role in L2 lexical access. The within-language variables that turned out to be significant predictors of differences between English native speakers and English (L2) speakers were written and spoken frequency of words and morphological family size (i.e. the number of derivations and compounds in which a word occurs). However, it needs to be noted that Lemhöfer et al.'s (2008) study looked at the combination of a limited number of languages that are within the same alphabet and results could be different if other combinations of languages were used.

Bilingual Performance as a Multistage Process

To summarize results of research that investigated L1 influence on L2 reading and naming performance, L1 influence has been reported to occur at the initial stage of L2 information processing. There is considerable evidence that both L1 and L2 are active even when only one language is used, thus bilinguals constantly have access to two competing language systems. The various theories that try to explain how these two systems coexist focus on the relation between these systems in their shared or individual localization in the bilingual brain. However, because bilinguals constantly have to shift attention from one language system to the other when they process information, monitor the context in which information is presented to them and switch between lexical representations in L1 and L2, they develop an attentional mechanism that allows them to be efficient at these tasks. The integration of linguistic and cognitive systems becomes crucial at this point because when the system is fully integrated the task of managing two competing language systems can be handled by general cognitive processes. Research shows that processes such as attention, inhibition, monitoring and switching that are used by bilinguals to use and suppress their L1 and L2 are all components of the executive function. Bilinguals, who rely on these processes to control their two language systems, may develop their executive control processing differently than monolinguals (Bialystok, 2007).

As it has been demonstrated, existing research reveals some bilingual advantage in controlled information processing, which is evident from bilingual executive processing studies, and some bilingual disadvantage in automatic information processing, as revealed through some bilingual lexical studies. However, both lexical and executive

processing studies have produced mixed results depending on the methodology used and the language skills of bilingual participants (Bialystok, 2007; Favreau & Segalowitz, 1983; Frenck-Mestre & Prince, 1997), so clearly more research is needed in this area to reveal the exact nature of this phenomenon. Because of the linguistic nature of bilingualism, the current study was proposed to test bilinguals' automatic and controlled processing in their L2 using a lexical task.

In most bilingual studies where lexical stimuli in two different languages were used (participants' L1 and L2), researchers tried to match lexical items from the different languages on such dimensions as category membership strength and mean frequency of occurrence (e.g., Duyck et al., 2008; Favreau & Segalowitz, 1983; Frenck-Mestre & Prince, 1997). If practice with L2 lexical stimuli has a direct relation with automatic processing in L2, as has been at least indirectly suggested by Favreau and Segalowitz's (1983) study, then one could expect that bilinguals would show an increased automaticity of processing high frequency L2 words and less developed automaticity of processing low frequency L2 words. Likewise, one could expect that they would be better at the automatic processing of L2 words that are strongly associated with their category meaning ("good members of the category") than L2 words that are weakly associated with their category meaning ("bad members of the category"). There are some reports in the bilingual literature about differences in reaction times for processing high and low frequency English words by native speakers of different languages (e.g., Lemhöfer et al.'s 2008 megastudy) but there is a lack of evidence about bilingual processing of English words that differ in strength of association with their category. Bilingual priming studies have revealed the existence of the semantic facilitation effect for proficient

bilinguals (Favreau & Segalowitz, 1983; Frenck-Mestre & Prince, 1997), the priming effect facilitates their L2 processing on lexical decision tasks when primes and targets are semantically related. The semantic facilitation effect that was originally revealed in Neely's (1977) study is related to the automatic spreading activation that has been discussed above. Neely's predictions for the study were based on the assumptions that the automatic spreading activation has an effect only when the prime word and the target word are semantically related and that the automatic spreading activation produces only facilitatory effects and no inhibitory effects (Neely, 1977). To unconfound the facilitatory effects of the automatic spreading activation and the subject's conscious attention to the target word (after seeing the prime word), Neely used in his experiment both related and unrelated prime-target pairs. In the unrelated trials, the subject's attention was directed to the area in lexical memory that contained the target word. Because the present study was a modified replication of Neely's (1977) experiment, related and unrelated trials were used in it as well. The unrelated trials allowed the researcher to investigate the conscious-attention facilitation effect and the related ones – automatic activation facilitation effect. There were twice more related trials than the unrelated ones in the current experiment because the related trials also differed in the strength of association between the prime words and the target words. This, in turn, allowed the researcher to investigate the category effect in the present priming experiment.

Based on results of existing research, it was predicted that a category effect would be found if words' strength of association with their category was manipulated. A word is considered to be strongly associated with its category if it comes to mind easily when an individual thinks of a particular category (e.g., ANIMALS – dog). Weakly associated

words come to mind with some difficulty (e.g., ANIMALS – porcupine). Research studies that collect information about these category norms (e.g., Overschelde et al., 2004) present participants with names of categories and collect data about the ease (or difficulty) with which different words come to peoples' mind. These normative data can be used in a bilingual experimental study that would test for the category effect using a modification of Neely's (1977) experiment.

The Present Study

The present study investigated whether bilingualism has a facilitating effect on controlled lexical decision priming tasks and a detrimental effect on automatic lexical decision priming tasks (in L2) in adult bilingual speakers. Previous research had shown that bilinguals tend to outperform monolinguals on tasks that demand controlled attention and that they are at a disadvantage compared to monolinguals when they work on automatic priming tasks where they have to use their L2. The current research further examined the effect of bilingualism on the cognitive ability of bilinguals in these two domains: performance on controlled versus automatic lexical decision priming tasks. Thus, the primary objective of the present study was to investigate further the nature of the relationship between bilingualism and performance on controlled and automatic lexical decision priming tasks. It was hypothesized that bilingual speakers for whom English is a second language would do better on lexical tasks that would allow them to apply their skills in nonautomatic, conscious information processing than on lexical tasks where they would be deprived of such an opportunity.

To control for the possible effect of culture, bilinguals were selected from a variety of cultures and they were native speakers of different languages. For the purposes

of the present study, bilinguals were considered to be all people who use two languages on a regular basis by their own reports. This definition of a bilingual was proposed by Grosjean (1992).

A secondary objective of the present study was to find out whether monolinguals and both groups of bilinguals (intermediate and proficient) would show a priming effect on the automatic lexical decision priming task for words that are strongly related to their category meaning but not for words that are weakly related to their category meaning and whether this effect would be larger in the group of proficient bilinguals than in the group of intermediate bilinguals. This reasoning was based on the assumption that proficient bilinguals should have had more exposure to L2 words than intermediate bilinguals and that proficient bilinguals should have had more practice with words that are “good” members of their category (i.e., they come to mind easily) than with words that are “bad” members of their category.

The third objective of the present study was to determine whether the level of language proficiency in L2 has an effect on bilinguals’ performance on both controlled and automatic lexical decision priming tasks. It is logical to assume that the more proficient bilinguals are in their L2 the better their performance would be as compared to those who did not attain a high level of language proficiency in a second language. Thus, a positive correlation was expected to be found between bilinguals’ language proficiency and their performance on both types of lexical tasks.

A comparison group of adult English speaking monolinguals was included in the present study. Their performance in the automatic and controlled conditions of the lexical decision priming task was used as a basis for comparison of performance of English

native speakers who have been exposed to English words since birth and that of nonnative English speakers who acquired English later in life.

The prediction was that English monolinguals would outperform intermediate bilinguals on the efficiency of their automatic priming as compared to nonautomatic priming and proficient bilinguals would perform as well as monolinguals because they have had more practice with the English language than the intermediate bilinguals.

Likewise, monolinguals and proficient bilinguals were expected to show a priming effect in the automatic condition for English words that are strongly related to their category as compared to words that are weakly related to their category and intermediate bilinguals were expected to show this effect to a smaller degree than proficient bilinguals.

Finally, it was predicted that the more proficient bilinguals are in the English language the better they would perform in both conditions of the semantic priming task (short SOA and long SOA).

The lexical stimuli for the current study were selected from Overschelde et al.'s (2004) category norms and compared against Kucera and Francis's (1967) ratings of word frequencies. Some category names used in Overschelde et al.'s original study were replaced with shorter versions because they were used as prime words in the present study. Words were considered to be strongly associated with their category meaning if within their category they were produced by more than 50% of people who participated in Overschelde et al.'s (2004) study. Words were considered to be weakly associated with their category meaning if within their category they were produced by less than 50% of people who participated in the study.

All selected words ranged in length between 3 and 10 letters, inclusive.

The Language background questionnaire (Appendix) and the Peabody Picture Vocabulary Test-III were used in the current study to assess bilinguals' language proficiency in English. It allowed the researcher to separate intermediate bilinguals from the proficient ones using a median split.

CHAPTER 2

METHODOLOGY

Design

The present study used a 3 x 2 x 4 mixed factorial design with three independent variables: the language group (monolingual, intermediate bilingual, proficient bilingual); the length of SOA (short (200 ms) and long (1,150 ms) SOA); the type of prime-target pairs in the lexical decision priming task (primes followed by strongly associated words, primes followed by weakly associated words, primes followed by unrelated words, primes followed by nonwords).

The language group was a between-subject variable. All other IVs were within-subject variables.

Participants

A power analysis was done for the present study. An estimate of 40 bilinguals and 20 monolinguals was obtained as a result of this analysis. Participants were recruited for the study by means of flyers and researcher's informal contacts. Monolingual and bilingual participants in the present study were matched on age and education. Monolinguals' and bilinguals' mean age was 41.94 and 39.30 years, respectively. Monolingual participants ranged in age from 20 to 67 years old and bilingual participants ranged in age from 20 to 61 years old. For the monolingual group, the mean number of years in school was 18.84 years and for the bilingual group it was 19 years. In both

groups, the level of participants' education ranged from high school to Ph.D.

Monolingual and bilingual participants were also matched on gender. Monolingual group comprised 42% of males and 58% of females and bilingual group comprised 39% of males and 61% of females.

The language background questionnaire was administered to those bilinguals who informed the researcher that they used their native language and English on a daily basis and that their average daily use of English was about 50% and the average daily use of their native language was also about 50%. Bilingual participants were native speakers of the following languages: Belorussian (2), French (3), German (9), Greek (1), Italian (1), Japanese (2), Korean (1), Latvian (1), Russian (9), Rwandese (1), Spanish (3), Ukrainian (3). The monolingual English participants were all natives of the US and were selected for the study if they indicated that they were not fluent in any other language besides their native language. It was possible that some monolingual participants could have taken language courses in school but this problem was inevitable.

All participants were tested by the same experimenter (the researcher) using the same equipment and the same instructional protocols, except that monolinguals were not asked to complete the language background questionnaire during the recruitment process. Both groups had to complete the Peabody Picture Vocabulary Test-III. Testing was carried out in the psychology department of The University of Alabama. All participants were paid \$15 for their participation in the study.

Measures

Language background questionnaire. This measure was used to get potential participants' self-ratings of their language skills. The questionnaires was distributed and

completed before the study took place, when the experimenter was interviewing bilingual participants. Demographic information was collected by means of this questionnaire as well as information about bilinguals' use of English and their native language, and so forth. The self-rating scales were included in the questionnaire to assess bilingual participants' English language proficiency (Frenck-Mestre & Prince, 1997). Using a 9-point scale, participants rated their language skills in speaking, reading, writing and understanding English. Bilinguals were also asked to indicate in the questionnaire if they spoke any other languages besides their native language and English. The questionnaire was completed in English.

Peabody Picture Vocabulary Test (PPVT-III). The third edition of the Peabody Picture Vocabulary Test that was used in the present study is an individually administered, untimed, norm-referenced, wide-range test that is used with people of various ages across the life span. It contains four training items and 204 test items grouped into 17 sets of 12 items each. The items sets are arranged in order of increasing difficulty. Each item consists of four black-and-white illustrations arranged on a page called a PicturePlate. The task of the test taker is to select the picture that best represents the meaning of a stimulus word presented orally by the examiner. Testing time averages 11 to 12 minutes because most individuals take only five sets, or 60 items, of appropriate difficulty. Item sets that are too easy or too hard are not administered. Most of the scoring, which is rapid and objective, is accomplished while the test is being administered.

The test is designed for persons aged 2½ through 90+ years. It serves two purposes: (1) as an achievement test of receptive (hearing) vocabulary attainment for

standard English; and (2) as a screening test of verbal ability. When used as an achievement test, the PPVT-III indicates the level of a person's vocabulary acquisition. In the present study, it was used to separate participants into intermediate and proficient bilinguals based on their level of English vocabulary acquisition.

Semantic priming task. A semantic priming task was used to test bilinguals' ability in controlled and automatic lexical decision. This task had been patterned after the one used in the original priming experiment performed by Neely (1977) in that there was a manipulation of the semantic relatedness of prime and target words (related prime-target pairs vs. unrelated prime-target pairs). In the instruction that precedes the task, participants were told that primes and targets would be usually related to each other and if, for instance, they saw a prime *FURNITURE*, they should expect to see a related target (e.g., *futon*). This was done to encourage participants to attend to the degree of the semantic relation between the prime and the target words that were presented to them.

Lexical stimuli were also manipulated in terms of the strength of association with their category meaning (primes followed by strongly associated targets vs. primes followed by weakly associated targets) and their meaningfulness (words vs. nonwords as targets, preceded by category names as primes). Prime-target pairs were presented to participants in a random order. The order of presentation of the related condition (strongly and weakly associated lexical stimuli), unrelated condition, nonword condition, and SOA (short and long) were counterbalanced across participants.

The total set of items in the semantic priming task consisted of 280 prime-target pairs, of which there were 60 "strongly associated" prime-target pairs and 60 "weakly associated" prime-target pairs, a total of 120. Each participant saw only 40 strongly

associated and 40 weakly associated prime-target pairs, the remaining 20 pairs from each subset (strongly associated and weakly associated) were used to form the unrelated prime-target pairs. Thus, unrelated prime-target pairs were formed by using pairs from the pool of the related prime-target pairs. There were a total of 40 unrelated prime-target pairs.

Half of the prime-target pairs seen by each participant were presented at a short SOA and half – at a long SOA. Overall, each subject contributed 240 observations to the combination of all variables used in the study.

All target words were seen in the related and the unrelated condition, but they were only seen once by each participant. Each participant saw 80 out of the 120 related prime-target pairs, 40 unrelated prime-target pairs, and 120 prime-nonwords.

Both sets of 60 related prime-target pairs (strongly associated and weakly associated) were broken down into 3 subsets of 20 pairs each. Each participant saw two of these subsets in the related condition and one – in the unrelated condition (see Table 1). In the unrelated condition, the primes and the targets were repaired so primes and targets would not be semantically related to each other.

Table 1.

Presentation of Related and Unrelated Prime-Target Pairs.

“Strongly associated” pairs	“Weakly associated” pairs	Unrelated pairs	Prime-nonword pairs
40	40	40	120

Table below illustrates how these subsets and the prime-nonword pairs were presented to different participants (S = a set of 20 strongly associated prime-target pairs; W = a set of 20 weakly associated prime-target pairs):

Table 2.

Presentation of Different Sets of Prime-Target Pairs to Participants.

Participant	“Strongly associated” pairs	“Weakly associated” pairs	Unrelated pairs	Prime-nonword pairs
1	S1/S2	W1/W2	S3/W3	ALL
2	S2/S3	W2/W3	S1/W1	ALL
3	S1/S3	W1/W3	S2/W2	ALL

As it can be seen from the table, each of the 60 participants recruited for the present study was presented with a specific combination of the “related” and the “unrelated” subsets of prime-target pairs. Each combination was presented 20 times.

The 17 prime words used in the current experiment were selected from category names used in Overschelde et al’s. (2004) study and target words were selected from the norms that are associated with them.

The group of strongly associated words consisted of words that were named by a large percentage of participants (50% and up) who were presented with the names of different categories. Many of these items were named first within their particular category. For instance, within the category of ANIMALS, the word “dog” was named by 98% of participants and 65% of them named it first. Although it is not crucial for the present study that a word would be named first or second, it provides additional evidence that strongly associated words come to mind before other ones within the same category.

The group of weakly associated words, on the other hand, consisted of words that were named by a small percentage of people (below 50%) within a given category and those words were very rarely named first. An example of a weakly associated word within the category of ANIMALS is an "elk", it was named by 6% of people and no one named it first.

The same primes were used in the related (strongly and weakly), unrelated, and the nonword conditions of the experiment. Most prime words were used more than once in each condition of the experiment and they were used with an equal frequency in the related (strongly and weakly) condition and the nonword condition. In the unrelated condition, for each participant 17 original primes were used along with 3 additional primes selected randomly from the pool of 17 original primes. This procedure was repeated twice per participant because each participant was presented two sets of 20 unrelated prime-target pairs.

Target words were used once in the related condition. Each target word that was used in the related condition was repeated once in the unrelated condition, where it was preceded by an unrelated prime. In the unrelated condition, prime words bear no relationship to the target words.

The prime and target words selected for the current experiment bear no substantial physical resemblance to each other. Primes were presented as uppercase letter strings and targets were presented as lowercase letter strings. Both primes and targets were presented in English. The nonwords were derived from English words used in the semantic priming task by changing one or two letters of a word while obeying the phonological and orthographic rules of the English language (Frenck-Mestre & Prince, 1997).

The lexical decision task had been programmed on a desktop computer using the Superlab software. All experimental and practice stimuli consisted of black letters that were presented on the screen of a 12-inch monitor. An X served as a fixation mark. Lexical stimuli and X appeared in the center of the screen when they were displayed.

Procedure

The participants were individually tested during their sessions that did not vary in length for monolinguals and bilinguals. It took approximately an hour for monolinguals and bilinguals to complete the study.

In the beginning of the experiment, all participants performed the semantic priming task.

Upon the completion of the semantic priming task, bilingual participants who were selected based on their self-ratings on the language background questionnaire and monolingual participants did the Peabody Picture Vocabulary Test. Testing was done in a quiet, private room where there were no distractions.

The PPVT-III is a power test rather than a speed test, so examinees had adequate time and were not hurried as they made their selection of the right picture on the PicturePlate. However, the decision making process was not supposed to take more than 15 seconds per item in general.

At the beginning of each session, participants received instructions in English. These instructions introduced them to the Superlab software and the task they were to do. They were told that they would be presented with uppercase and lowercase letter strings. The uppercase letter strings would form words that would represent names of different categories (e.g., FURNITURE) and the lowercase letter strings would form words that

would represent members of those categories (e.g., “dresser”). Participants were told that sometimes the lowercase letter strings would form nonwords. Their task was to make fast and accurate lexical judgments about words that would be presented as lowercase letter strings. They would have to indicate whether they saw a word or a nonword by pressing a key. Participants were told that in most cases category names would be semantically related to words presented immediately after them.

Each trial began with the verbal signal “READY” which was followed by the 1,500 ms fixation mark and then the prime word for 150 ms. Following the onset of the prime, there was either a short (200 ms) or long (1,150 ms) SOA to the onset of the target word, which remained in view until the participants indicated his or her lexical decision by pressing one of the response keys. The intertrial interval was 3 seconds. Reaction times were recorded from the onset of the target to the keypress.

Lexical decisions made at a short SOA were automatic in nature because participants had to make them fast and were not able to use strategic thinking. Decisions made at a long SOA were controlled in nature because participants were able to use their attentional resources and higher level monitoring when working on the task.

Experimental trials were preceded by a block of 20 practice trials. During practice trials, participants received feedback regarding the speed of their responses, but they received no feedback during experimental trials. Experimental trials were presented in two separate blocks, one block with a short SOA following the onset of the prime and the other block – with a long SOA. Participants were able to take a break when they completed the first block and were ready to proceed with the second one.

Only the reaction times to correctly identified targets during experimental trials as well as percentages of correct responses were included in the final data analyses.

CHAPTER 3

RESULTS

Statistical level of probability for the present study was set at alpha level = .05 and statistical power, with the sample of $N = 55$ and a medium effect size, was $1 - \beta = .80$.

The data from 36 of the 42 bilingual and 19 of the 20 monolingual participants were used for the statistical analyses. The other bilingual participants and one monolingual participant were removed from the study based on the low level of accuracy of their responses. The monolingual participant and three bilinguals were removed because they each made less than 80% of correct responses to nonwords, and the three bilingual participants were also removed because they made only 10% correct responses on the unrelated trials.

The overall mean correct reaction time across all participants was 644 ms for short SOA trials and 705 ms for long SOA trials. The mean percentage of correct responses on word trials was 96% and on nonword trials it was 95% across both short and long SOA.

A 3-way repeated measures ANOVA was conducted with participants' mean correct reaction times to compare monolinguals' and bilinguals' performance on strongly related, weakly related and unrelated prime-target pairs that were presented at short and long SOA. Language group was a between-subject variable and the two within-subject variables were strength of target association with the category prime (strong, weak, unrelated) and length of SOA (short and long).

The ANOVA revealed a significant main effect of the language group ($F[1, 53] = 5.41, p = .02$), indicating an overall faster reaction time for monolinguals ($M = 613$ ms) relative to bilinguals ($M = 735$ ms). The ANOVA revealed a significant main effect of the strength of target association with the category prime ($F[1, 53] = 13.67, p < .001$). A Bonferroni post-hoc test was performed to find out the nature of the difference between strongly related, weakly related, and unrelated prime-target pairs. The test revealed that reaction times for strongly related prime-target pairs were significantly faster than those for weakly related ($p = .004$) and unrelated ($p < .001$) pairs, and that there was a nonsignificant difference between reaction times for weakly related pairs and unrelated pairs ($p = .46$). The means for these comparisons are shown in Table 3.

Table 3.

Descriptive Statistics for Strongly Related, Weakly Related and Unrelated Prime-Target Pairs.

Prime-target pair	Mean	Standard deviation
Strongly related	656	166
Weakly related	696	214
Unrelated	727	206

The ANOVA showed also that there was a significant main effect of the length of SOA ($F[1, 53] = 25.59, p < .001$), with reaction times being shorter at the short SOA. The means for short and long SOA trials are shown in Table 4.

Table 4.

Descriptive Statistics for Trials Presented at Short and Long SOA

Trial	Mean	Standard deviation
Short SOA	644	124
Long SOA	705	178

The test revealed a nonsignificant interaction effect between the strength of target association with the category prime and the language group ($F[1, 53] = 1.23, p = .30$); a nonsignificant interaction effect between the length of SOA and the language group ($F[1, 53] = 2.92, p = .09$); and a significant interaction effect between the strength of target association with the category prime and the length of SOA ($F[2, 53] = 7.80, p = .001$). A post-hoc test revealed that at short SOA there was a significant difference between strongly and weakly related prime-target pairs ($p < .001$), a significant difference between strongly related and unrelated prime-target pairs ($p < .001$), and a significant difference between weakly related and unrelated prime-target pairs ($p = .002$). At long SOA, there was a nonsignificant difference between strongly and weakly related prime-target pairs ($p = .11$), a significant difference between strongly related and unrelated prime-target pairs ($p < .001$) and a significant difference between weakly related and unrelated pairs ($p = .005$).

Figure 1 illustrates the difference between participants' performance on strongly related, weakly related and unrelated pairs at short and long SOA.

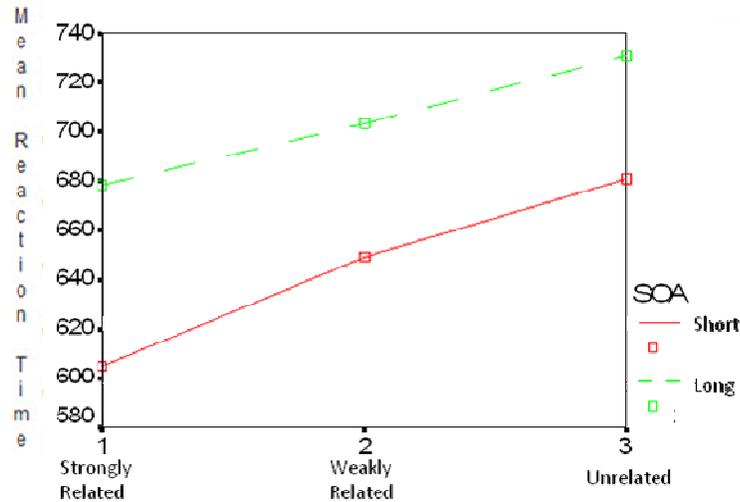


Figure 1. Participants' mean reaction times (ms) on strongly related, weakly related and unrelated trials at short and long SOA.

The test also revealed a nonsignificant 3-way interaction effect between the strength of target association with the category prime, length of SOA and the language group ($F[2, 52] = .37, p = .69$). The means for these comparisons are shown in Table 5.

Table 5.

Descriptive Statistics for Performance on Strongly Related, Weakly Related and Unrelated Prime-Target Pairs at Short and Long SOA for the Two Language Groups.

Prime-Target Pairs	Mean	Standard deviation
Monolinguals at Short SOA		
Strongly Related	561	91
Weakly Related	591	108
Unrelated	618	128
Monolinguals at Long SOA		
Strongly Related	626	106
Weakly Related	627	95
Unrelated	653	112
Bilinguals at Short SOA		
Strongly Related	648	150
Weakly Related	707	183
Unrelated	742	180
Bilinguals at Long SOA		
Strongly Related	730	237
Weakly Related	779	317
Unrelated	808	286

Role of the English Language Proficiency

To find out whether participants' English language proficiency had any influence on their performance during the lexical decision task, an analysis of covariance was conducted. Language group was a between-subject variable and the two within-subject variables were strength of target association with the category prime (strong, weak, unrelated) and the length of SOA (short and long). Monolingual and bilingual participants' scores on the English language receptive vocabulary test (PPVT-III) were used as a covariate in this test.

The analysis of covariance revealed a nonsignificant main effect of the language group ($F[1, 52] = .84, p = .36$) once proficiency was factored out, indicating neither an

overall slower nor faster reaction time for bilinguals ($M = 711$ ms) relative to monolinguals ($M = 659$ ms).

The analysis of covariance revealed a nonsignificant interaction effect between the strength of target association with the category prime and the language group ($F[2, 52] = 1.24, p = .29$); a nonsignificant interaction effect between the length of SOA and PPVT-III ($F[1, 52] = 3.73, p = .06$) and nonsignificant interaction effect between the length of SOA and the language group ($F[1, 52] = .02, p = .88$).

The test also revealed a nonsignificant 3-way interaction effect between the strength of target association with the category prime, length of SOA and PPVT-III ($F[2, 52] = 2.46, p = .09$) and a nonsignificant 3-way interaction effect between the strength of target association with the category prime, length of SOA and the language group ($F[2, 52] = .13, p = .88$). In contrast to the absence of interactions involving the language group, the analysis of covariance revealed a significant interaction effect between the strength of target association with the category prime and the covariate PPVT-III ($F[2, 52] = 4.54, p = .01$). Before conducting post-hoc tests, to elucidate the nature of this interaction, the PPVT-III variable was dichotomized. Based on the median PPVT-III score (median = 189), participants were broken into two groups – those with lower PPVT-III scores ($N = 28$) and those with higher PPVT-III scores ($N = 27$). Those with lower PPVT-III scores had significantly shorter reaction times for strongly related than for weakly related prime-target pairs ($p = .01$), significantly shorter reaction times for strongly related than unrelated prime-target pairs ($p < .001$), and a significant difference between weakly related and unrelated prime-target pairs ($p = .05$). Participants with higher PPVT-III scores showed no significant difference in reaction times for strongly related and weakly

related prime-target pairs ($p = .11$), significantly shorter reaction times for strongly related than unrelated prime-target pairs ($p < .001$), and shorter reaction times for weakly related than unrelated prime-target pairs ($p < .001$).

Figure 2 illustrates the difference between performance on strongly related, weakly related and unrelated pairs for participants with lower and higher PPVT-III scores.

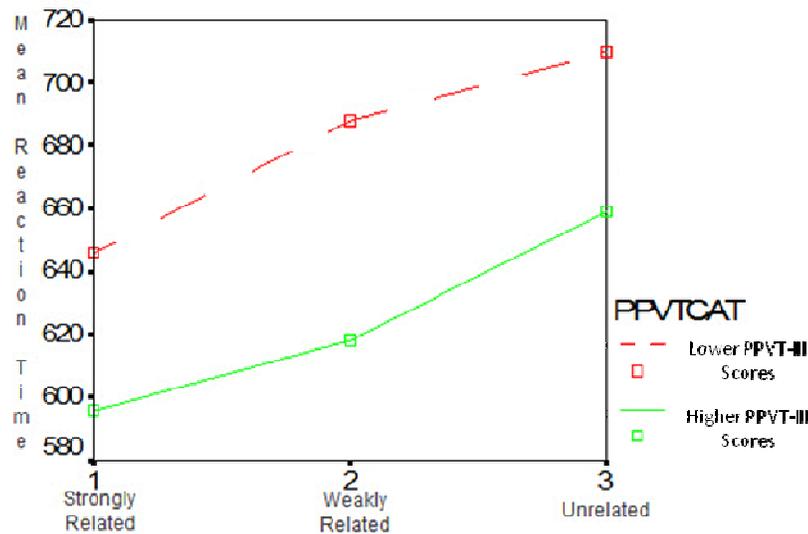


Figure 2. Participants' mean reaction times (ms) on strongly related, weakly related and unrelated trials.

Unlike the ANOVA test that yielded a significant difference between monolinguals and bilinguals, the analysis of covariance did not yield any significant differences between the language groups or any significant interaction effects between the language group and the two within-subject variables that have been of interest for the present study (strength of target association with the category prime and length of SOA). However, a significant interaction effect between the PPVT-III and the strength of target association with the category prime was found as a result of the analysis of covariance performed. This finding indicates that differences between monolingual and bilingual

participants in the present study may be better explained by participants' English language proficiency than bilingualism per se. When PPVT-III was included in the overall model as a covariate, it took variance away from the language group variable and the test yielded nonsignificant differences between monolinguals and bilinguals.

In addition to comparisons between monolinguals and bilinguals, it was of interest to conduct comparisons just within the bilingual group to assess the role of L2 proficiency in a bilingual sample. The prediction for the present study was that relative to monolinguals, proficient bilinguals would demonstrate a larger priming effect than intermediate bilinguals. To compare intermediate and proficient bilinguals' mean reaction times on strongly related, weakly related and unrelated prime-target pairs presented at short SOA, a repeated measures ANOVA was performed with the language group (monolingual, intermediate bilingual or proficient bilingual) as a between-subject variable and strength of target association with the category prime as a within-subject variable. The test revealed a significant main effect of the language group ($F[2, 52] = 5.14, p = .009$) and a significant main effect of the strength of target association with the category prime ($F[2, 52] = 43.59, p < .001$). The test also revealed a nonsignificant interaction effect between the strength of target association with the category prime and the language group ($F[2, 52] = 1.70, p = .15$). The post-hoc test performed to elucidate the nature of the significant main effect of the language group, showed that there was a significant difference between monolinguals and intermediate bilinguals (590 vs. 741 ms, $p = .002$), but no significant difference between monolinguals and proficient bilinguals (590 vs. 651 ms, $p = .21$). There was also a nonsignificant difference between intermediate and proficient bilinguals (741 vs. 651 ms, $p = .07$). The difference between

intermediate and proficient bilinguals, even though it turned out to be nonsignificant, was nevertheless in the direction that was expected based on the present study's predictions. If more subjects were used in the comparison, than there would be more power and this effect, perhaps, would become significant.

The post-hoc test performed to elucidate the nature of the significant main effect of the strength of target association with the category prime, showed that there was a significant difference between strongly related and weakly related pairs (618 vs. 666 ms, $p < .001$), a significant difference between strongly related and unrelated pairs (617 vs. 699 ms, $p < .001$) and a significant difference between weakly related and unrelated pairs (666 vs. 699 ms, $p < .001$). The mean correct reaction times demonstrated by monolinguals, intermediate bilinguals and proficient bilinguals on the strongly related, weakly related and unrelated trials are shown in Table 6.

Table 6.

Descriptive Statistics for Performance on Strongly Related, Weakly Related and Unrelated Prime-Target Pairs for Monolinguals, Intermediate Bilinguals and Proficient Bilinguals.

Prime-Target Pairs	Mean	Standard deviation
Monolinguals		
Strongly related	561	91
Weakly related	591	108
Unrelated	619	128
Intermediate Bilinguals		
Strongly Related	686	162
Weakly Related	759	213
Unrelated	779	217
Proficient Bilinguals		
Strongly Related	606	128
Weakly Related	649	125
Unrelated	701	122

CHAPTER 4

DISCUSSION

The present findings add to our understanding of the relationship between bilingualism and performance on automatic and controlled lexical decision priming tasks and highlight some complexities in that relationship. The results of the present study support earlier findings that bilinguals' level of L2 proficiency determines their performance on automatic lexical decision priming task and that a high level of L2 proficiency makes bilinguals' performance comparable to that of monolingual native speakers of bilinguals' L2. The present study also demonstrated the presence of a priming effect for strongly related words as compared to weakly related words for monolinguals and bilinguals alike.

Effects of Bilingualism on Controlled and Automatic Information Processing

The primary hypothesis tested in the present study stated that relative to monolinguals, bilinguals would do better on the controlled lexical decision priming task that would allow them to apply their skills in conscious information processing than on the automatic lexical decision priming task where they would be deprived of such an opportunity. However, the data analysis showed that monolinguals were faster on the lexical decision priming task, though they did not show a larger priming effect than bilinguals.

Evidence about the bilingual performance on controlled tasks comes from studies that relied on the use of verbal (Bijeljic-Babic et al., 1997; Green, 1998) and nonverbal

tasks, though the majority of it comes from studies that relied on use of nonverbal measures of cognitive control, such as the Simon task (e.g., Bialystok et al., 2004) or the dimensional change card sort task (e.g., Bialystok, 1999). In different experiments that used these response-conflict tasks bilinguals demonstrated their advantage over monolinguals. However, in some studies that used nonverbal tasks no bilinguals advantage was found when groups of young adults were used (Bialystok, Craik, Grady, Chau, Ishii, Gunji & Pantev, 2005; Bialystok, Martin & Viswanathan, 2005), so this line of research has produced mixed results. When no difference was found between young bilingual and monolingual adults, the authors attributed this finding to the fact that young adults were very skilled at computer use and, therefore, they were comfortable with tasks involving rapid response to visual stimuli. The extensive experience with computers could have improved the efficiency of these participants to such a degree that there was little that bilingualism could do to further improve their reaction times on the response-conflict task.

Of interest for the present study is Bialystok, Craik, Grady, Chau, Ishii, Gunji and Pantev's (2005) finding that bilinguals differ from monolinguals in the brain areas they use when they work on tasks that require a resolution of a certain mental conflict. The present study was a replication of Neely's (1977) experiment that used related and unrelated prime-target pairs. When participants were presented with related and unrelated prime-target pairs, their attention was supposed to be directed to the area in lexical memory that contained the target word. This process was complicated when related and unrelated trials were presented at random as this manner of stimuli presentation created a certain mental conflict. In Bialystok, Craik, Grady, Chau, Ishii, Gunji and Pantev's

(2005) study where bilinguals and monolinguals completed a response-conflict task in the MEG, bilinguals demonstrated faster reaction times with greater activity in their superior and middle temporal, cingulate, and superior and inferior frontal regions, largely in their left hemisphere; whereas monolinguals demonstrated faster reaction times with activation in middle frontal brain regions. This neuroimaging study revealed a systematic change in frontal executive function for the bilingual group as compared to the monolingual group. The authors explained this change by the necessity for the bilinguals to manage two competing language systems. Other neuroimaging studies that compared monolinguals and bilinguals on the speed of their responses during a lexical decision task found that bilinguals (but not monolinguals) recruit their left hemisphere to perform the task (e.g., Van Heuven et al., 2008). The importance of Broca's area for bilingual performance on response-conflict tasks has already been discussed in the present paper. The fact that bilinguals have this brain area more activated than monolinguals during performance on response-conflict tasks means that bilinguals develop their cognitive processes in a different way than do monolinguals. Broca's area is associated with language production and research shows that bilinguals rely on this area for the resolution of both verbal and nonverbal conflict. Based on the results of the neuroimaging research, it is possible to make a suggestion that monolingual and bilingual participants in the present study recruited different cortical regions when they worked on the lexical decision priming task.

The hypothesis about the monolingual advantage on the automatic lexical decision priming task has been partially supported in the present study, though absence of a significant interaction between the length of SOA and the language group shows that

this advantage was demonstrated by monolinguals in both conditions of the lexical decision priming task – automatic and controlled. When monolinguals, proficient bilinguals and intermediate bilinguals were compared on strongly related, weakly related and unrelated trials presented at short SOA, a significant difference was found between monolinguals and intermediate (but not proficient) bilinguals and a nonsignificant difference was found between proficient and intermediate bilinguals. The original prediction for the present study was that all language groups would demonstrate an automatic priming effect when processing words that are strongly related to their category meaning as compared to words that are weakly related to their category meaning and that this priming effect would be larger in the groups of monolinguals and proficient bilinguals than in the group of intermediate bilinguals. However, because a nonsignificant difference was found between proficient and intermediate bilinguals when the data were analyzed, this hypothesis received only a partial support. Comparison of monolinguals', proficient bilinguals' and intermediate bilinguals' reaction times showed that the level of L2 proficiency was an important factor in bilinguals' performance in that it allowed proficient bilinguals to perform as efficiently as monolinguals on the automatic lexical decision priming task. Bilingualism is a continuum where bilinguals strive to attain a high level of proficiency not only in their L1 but also in L2. The closer bilinguals get to the desired level of L2 proficiency the more efficient their cognitive processes become.

Research shows that when bilinguals achieve high levels of proficiency in their L2 they show automatic priming effects that are similar to those of monolinguals (Favreau & Segalowitz, 1983; Frenck-Mestre & Prince, 1997). In Favreau and

Segalowitz's (1983) study, unequal-reading-rate bilinguals showed automatic priming of L1 words but not L2 words, whereas equal-reading-rate bilinguals showed automatic priming in both languages. The authors attributed the advantage that equal-reading-rate bilinguals had over unequal-reading-rate bilinguals at automatic priming to unequal-reading-rate bilinguals' reduced sensitivity to orthographic features and semantic context of L2 and to the fact that unequal-reading-rate bilinguals were not schooled in their L2 as long as equal-reading-rate bilinguals and, thus, were not exposed to L2 words as frequently as equal-reading-rate bilinguals.

Frenck-Mestre's (1993) study provided additional support for the notion that bilinguals become more efficient at using the orthographic structure of their L2 as they become more practiced in it. Although Frenck-Mestre (1993) did not come to a definite conclusion whether it is the use of L2 orthographic structure that improves bilinguals' word identification skills or extended practice with L2 words improves bilinguals' use of L2 orthographic structure, a positive relationship between bilinguals' use of L2 words and the speed of word identification was established. Based on existing research, monolinguals' and proficient bilinguals' faster reaction times that have been demonstrated in the present study can be attributed to their extended practice with English words and intermediate bilinguals' slower reaction times can be attributed to their lack of practice with L2 words.

A positive relationship between individuals' frequency of exposure to words and subsequent speed of processing of these words can be further established through the comparison of the reaction times shown by participants when they were broken down into two groups based on their PPVT-III scores. The analysis of covariance showed that

the difference between monolinguals and bilinguals disappeared when participants' PPVT-III scores were included in the overall model as a covariate and participants' performance on the strongly related, weakly related or unrelated words depended on the PPVT-III group they were in – that with lower or higher PPVT-III scores. PPVT-III is an achievement test of receptive vocabulary attainment for standard English that indicates the level of a person's vocabulary acquisition. A high level of English language proficiency is generally associated with high frequency of exposure to English words, this is true for monolinguals and bilinguals alike. Frenck-Mestre's (1993) study that examined the relationship between bilinguals' speed of processing of L2 lexical stimuli and their practice with these lexical stimuli borrowed the hypothesis about a positive relationship between these two constructs from the monolingual literature on reading skills that compared the skills of inefficient and skilled readers.

Presenting visual words to individuals implies that they will have to engage in decoding the symbols and making use of orthographic structure of words, a process that clearly would be more challenging for intermediate bilinguals than proficient ones or monolingual native speakers of the language in which words are presented. An example of a word that would present a challenge for a nonnative speaker is a French word *arbre* (“tree” in English) that contains orthographic redundancies characteristic of the French language and not found in the English language. In line with monolingual studies (Fraisse, Noizet, & Flament, 1963; Gardner, Rothkopf, Lapan, & Lafferty, 1987; Gordon, 1985), Frenck-Mestre (1993) found that word recognition speed was largely determined by a word's subjective frequency, i.e. the amount of past and present use of the word by a person than a person's use of orthographic structure of the word. Frenck-Mestre (1993)

maintained that contrary to the common thinking, not only the use of orthographic structure of words facilitates word recognition process, but the inverse relationship between these two processes may be also true. The results of the study point to a possibility that repeated use of the language enables individuals to assimilate the orthographic structure of that language.

Results of the present study where monolinguals' and bilinguals' level of English language proficiency was found to affect their performance on the lexical decision priming task provide additional support for the theory about a positive relationship between individuals' speed of processing of a particular word and the degree of their familiarity with that word. While no interaction was found in the present study between the strength of target association with the category prime and the language group, an interaction between the PPVT-III and the strength of target association with the category prime makes it possible to make predictions about the strength and the quality of individuals' priming effect based on their PPVT-III scores.

Differences between participants with higher and lower PPVT-III scores were found when their reaction times were compared for processing strongly related, weakly related and unrelated prime-target pairs. Participants with higher PPVT-III scores were shown to process strongly related and weakly related prime-target pairs almost equally fast, with a slight difference between the means. However, they processed strongly related prime-target pairs significantly faster than unrelated prime-target pairs and weakly related prime-target pairs were processed significantly faster than unrelated prime-target pairs. This means that fluency in English and repeated exposure to English words that is associated with a high level of proficiency in the English language makes individuals

equally efficient at processing words of varying strength of target association with the category prime, but related words are still processed faster than the unrelated ones due to the priming effect of the category name that precedes the presentation of the target word.

Participants with lower PPVT-III scores processed strongly related prime-target pairs faster than weakly related prime-target pairs or unrelated prime-target pairs and they processed weakly related prime-target pairs faster than unrelated prime-target pairs. Thus, all participants demonstrated a priming effect in that their processing of related words was facilitated in comparison to unrelated words and, besides, participants with lower and higher PPVT-III scores demonstrated the presence of a category effect to a different degree.

Participants with lower PPVT-III scores demonstrated a category effect in that relative to unrelated words, their processing of strongly related words was facilitated in comparison to weakly related words and participants with higher PPVT-III scores demonstrated a partial category effect in that their processing of related words was significantly facilitated in comparison to unrelated words. The results of the data analysis show that bilinguals' level of proficiency in the language of testing is more important for their performance on the lexical decision priming tasks than bilingualism per se. This means that future bilingual studies should include an objective measure of bilingual participants' language skills in the language of testing. Research demonstrates that bilingualism creates an advantage in cognitive functioning (e.g., Bialystok et al., 2008; Peal & Lambert, 1962); however this advantage may only be achieved when bilinguals attain high levels of proficiency in the language they are tested in.

Category effect

The prediction for the present study was that monolinguals and proficient bilinguals in the automatic condition of the lexical decision priming task would show a priming effect for strongly related words as compared to weakly related words and intermediate bilinguals would show this effect, but to a smaller degree. This prediction found partial support as participants were found to process strongly related words faster than weakly related pairs; however, the interaction between the strength of target association with the prime and the language group turned out to be nonsignificant. Thus, no difference was found between the language groups in terms of processing of target words of varying strength of association with the category prime. However, a significant interaction was found between the strength of target association with the category prime and the length of SOA, showing that at short SOA all participants processed strongly related words faster than weakly related words or unrelated words and weakly related words were processed faster than unrelated words. At long SOA, strongly related and weakly related words were processed equally fast, but strongly and weakly related pairs were processed faster than unrelated pairs. Thus, the automatic priming effect in the present study was combined with a strong category effect in that processing of strongly related words was facilitated in comparison to weakly related words for monolinguals and bilinguals alike.

The prediction that monolingual and bilingual participants would show a priming effect for strongly related words was based on a view that strongly related words tend to come to mind easily when one thinks of any particular category. For instance, when we think about category FURNITURE, words such as *desk* and *chair* come to mind easily because it is hard to find a person nowadays who would not use them at home and at

work. Therefore, when words *desk* and *chair* are processed in the automatic condition of the lexical decision priming task following the prime (category name), they are activated much faster than such words as *futon* or *cabinet*, though these words belong to the same category (Overschelde et al., 2004).

When participants perform a lexical decision priming task, they first process visual words in terms of their orthographic word forms and then access the semantic meaning of those words in their lexicon. Bilinguals have to access the meaning of L2 words in their combined lexicon for L1 and L2 words, a process that has been shown to be complicated by its nonselective nature, i.e. L1 and L2 word competition. Research shows that for monolinguals and bilinguals alike word processing is facilitated by their previous experience with these words (e.g., Frenck-Mestre, 1993). When the reader processes a word that was encountered often in the past, the activation of the word meaning followed by its identification occurs much faster than for words that were rarely encountered and processed in the past. The same may be true for words that are strongly associated with their category meaning, which would explain why such words are named by a large percentage of participants who do the naming task (and why these words often appear first on the list) when the normative data about words and their membership strength are collected (Overschelde et al., 2004). Although strength of association of a word is not the same as frequency of occurrence of that word, it is logical to expect to see a positive relationship between words' strength of association and frequency of occurrence. But there are also exceptions to this as some words are strongly associated with their category meaning and have a low frequency of occurrence and, vice versa, some words are weakly associated with their category meaning and have a high

frequency of occurrence. For instance, according to the normative data (Overschelde et al., 2004), the word *silk* is very strongly associated with its category FABRIC (70% of participants named it within the given category; 20% of these participants named it first and 80% of participants named it second), but this is a low frequency word (12 per million) according to Kucera and Francis (1967) ratings of word frequencies. The word *heart* is very weakly associated with its category BODY (only 27% of participants named it within the given category and only 4% of these participants named it first, no one named it second), but this is a high frequency word (173 per million) according to Kucera and Francis (1967) ratings of word frequencies.

If high frequency words are processed faster than low frequency words because they come to mind easily, strongly associated words should be also processed faster than weakly associated words after the presentation of the prime word (category name) because then they also should come to mind easily. Thus, understanding how high frequency words are processed may lead to our understanding of the mechanisms that underlie processing of strongly associated words.

Facilitation of processing high frequency words as compared to low frequency words has been demonstrated in many studies. Duyck et al. (2008) called frequency “the most controlled variable in the literature on word recognition and production” (p. 850) and maintained that word frequency effect reflects an important property of the organization of individuals’ mental lexicon. Studies that manipulated word frequency used a variety of lexical tasks, including lexical decision task, picture naming, semantic categorization task, etc. (e.g., Carroll & White, 1973; Whaley, 1978). Lemhöfer et al.’s (2008) study that used a wide variety of within-subject and between-subject variables found that out of a number

of within-subject variables, the written and spoken frequency of words was a better predictor for their processing by bilinguals than other factors, such as word length, concreteness, and some other ones. Duyck et al.'s (2008) study revealed a word frequency effect in Dutch-English bilinguals' L1 and L2. The authors found the results of the study to be compatible with the theory that frequency effects originate from implicit learning. According to this theory, lexical representations of words are strengthened by repeated exposure to these words, which lowers a recognition threshold for these words (Morton, 1970). High frequency words are associated with decreased latencies during word recognition because their lexical representations reach and surpass the recognition threshold faster than those of low frequency words.

The pattern of results obtained in the present study shows that even intermediate bilinguals who are constantly exposed to L2 words become sensitive to the varying degree of association between L2 words and the categories they belong to. Strong category effect shown by all three language groups in the present study reflected in significantly faster processing speed of strongly related words means that bilinguals during lexical decision priming tasks performed in their L2 categorize the words like native speakers of their L2, when they have attained a certain level of proficiency in their L2.

Some limitations of the present study need to be addressed as they could have affected the patterns of performance demonstrated by participants, specifically the bilingual group. Research on lexical access in word recognition and in spoken language production demonstrates that both L1 and L2 remain active when bilinguals process information in one of these languages, i.e. lexical access in bilinguals has a non-selective

nature (e.g., Colome, 2001; Gollan & Kroll, 2001; Kroll & Dijkstra, 2002). This means that information processing in one language is complicated for bilinguals by the necessity to inhibit the irrelevant information that comes from the language that is not being used at the moment and the more proficient bilinguals become in their L2 the more inhibitory control is required for them to function well when they use one of their languages. This finding has an important implication for the present study that used monolinguals, intermediate bilinguals and proficient bilinguals. Even though a high level of L2 proficiency makes bilinguals' performance comparable to that of monolinguals, it is also associated with a certain cost as proficient bilinguals have more interference from the "unwanted" language than intermediate bilinguals and monolinguals do not have to deal with this kind of interference at all. In the present study, where the bilingual group comprised native speakers of different languages, it was not possible to compare their performance in L2 with their performance in L1 to see how much cross-language interference could have affected their performance on the lexical decision priming task. Although cross-language interference becomes an issue when bilinguals have to do tasks that require constant switching between their L1 and L2 and in the present study bilinguals performed a lexical decision priming task in one language only (their L2), L1 interference can not be excluded completely. Research shows that the nontarget language is activated and cross-language effects appear even in tasks that are purely monolingual and are performed in bilinguals' L1 (Van Hell & Dijkstra, 2002; Van Wijnendaele & Brysbaert, 2002).

Based on the results of the earlier studies (e.g., Preston & Lambert, 1969), it is possible to make a suggestion that some bilinguals in the present study experienced a

certain degree of L1 interference if their L1 was orthographically similar to the English language that was used in the automatic lexical decision priming task. A suggestion can be made that for some bilinguals it was more of a problem than for others, depending on how similar orthographic features of bilinguals' L1 were to the orthographic features of the English language. For instance, for French-English and German-English bilinguals more control would be required during the lexical decision priming task than for Russian-English bilinguals because the orthographic features of the French and German languages resemble those of the English language to a greater degree than the orthographic features of the Russian language. On the other hand, Japanese-English bilinguals and other bilinguals whose L1 uses a nonalphabetic orthography should have experienced minimal L1 interference during the task.

The slight difference in means between monolinguals and proficient bilinguals in the present study could possibly be attributed to this interference. That this interference was not dramatic was demonstrated by a nonsignificant difference between monolinguals' and proficient bilinguals' reaction times on the lexical decision priming task.

Another limitation associated with the use of different L1s is that it introduced variability to the data and made it harder to detect effects that were of interest for the present study. If bilinguals in the present study were all speakers of the same L1, it could have produced a systematic change in the data that would be easier to detect than with native speakers of multiple L1s.

The fact that bilinguals in the present study were native speakers of different L1s also made it impossible to control for the degree of their proficiency in other languages,

such as their L1 and any other languages they named as the languages they were fluent in. Bilinguals who are used in bilingual research often speak more than two languages, however a distinction is rarely made between truly bilingual participants and those who speak multiple languages. Participants are traditionally called “bilingual” if they speak more than one language. Meanwhile, it would be logical to expect to see a positive relationship between the number of languages a person speaks and the efficiency of cognitive processes that are examined in psychological research. However, assessment of multilingual participants’ language skills could become problematic, as it was in the present study, where some participants claimed they spoke three or four languages.

To summarize, even though the use of different L1s in the bilingual group used in the present study made it possible to control for the possible effect of culture that usually becomes an issue in bilingual research because of the difficulty of separating this effect from the language effect, it also introduced certain limitations to the present study.

In future research, it would be of interest to address the issue of word processing in a lexical decision priming task, where target words would vary not only in the strength of association with the prime word (category meaning), but would also vary in the type of association with the prime word. For instance, the type of association between the prime words and the target words could be manipulated if besides strongly related and weakly related words on the lexical decision priming task words would be used that are associated with each other through everyday experience (e.g., bread – butter). The strength of the semantic priming effect could be compared between strongly related, weakly related and simply associated pairs of words and, possibly, some qualitative data

could be collected that would provide an insight into the strategies that participants use when they process these groups of words.

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Appendix

Language Background Questionnaire

Name _____ Email _____

Age _____ Phone# _____

Country of birth _____ Native language _____

Education (circle the highest level): Elementary school BA/BS MA/MS Doctoral

Country where you received your education (list several if necessary) _____

How many years did you study English at school _____

How many years did you study English at an American university _____

Occupation in the US _____

Length of stay in the US (or any other English-speaking country) _____ years

Age at which you began speaking English _____

Number of years you have been speaking English on the daily basis _____

Do you use your native language on the daily basis as well? (circle the right answer) Yes/No
On a 9-point scale (where 1 = very low fluency and 9 = native-like fluency) how would you assess your English-speaking skills compared to those of the English native speakers?

Speaking	1	2	3	4	5	6	7	8	9
Reading	1	2	3	4	5	6	7	8	9
Oral comprehension	1	2	3	4	5	6	7	8	9
Writing	1	2	3	4	5	6	7	8	9

If you speak any other languages besides your native language and English, list them:
