The Effects of Aging and Bilingualism on Language-specific Attention Control

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Abstract

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Relational elements of language (*e.g.*, prepositions, articles) act to direct attention to other aspects of the incoming message. The listener or reader must be able to use these elements to focus and refocus attention on the mental representation that is being constructed. Recent research has shown that this type of attention control is specific to language and can be distinguished from more general attention control. This thesis contains two papers that examine language-specific attention control in two different groups, older monolingual adults and younger bilingual adults, each as compared to younger monolingual adults. Participants completed two conditions of a task switching paradigm. The relational condition involved processing spatial prepositions, and the semantic condition involved processing nouns and adjectives. Attention control was operationalized in terms of shift costs obtained in an alternating runs experimental design. Results indicated that both older adults and younger bilingual adults had similar switch costs in the relational and semantic conditions, whereas the younger monolingual adults had significantly larger switch costs (i.e., lower attention control) in the relational condition than the semantic condition. Switch costs did not correlate with measures of working memory or inhibition for any of the three groups. Implications of the results are discussed.

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Human behaviour is characterized by its flexibility. We have control over a range of behaviours, and are able to start, stop, and switch between them in accordance with the demands of our environment or internally driven goals. For example, the simple task of answering a phone requires one to stop the current behaviour and switch to a new one. Historically, cognitive models typically made a distinction between the abilities or systems (e.g., language, memory, or attention), and the control processes of those systems (Atkinson & Shiffrin, 1968; Shiffrin & Schneider, 1977). The study of control of attention dates back to the late 19th century (see Hommel & Ridderinkhof, 2002), but has only resurfaced as a topic of interest within the last decade or so. Cognitive control of attention, or more simply, attention control, allows individuals to shift from one attentional process to another quickly, while inhibiting the behaviours from the previously relevant process (Hommel & Ridderinkhof, 2002). One paradigm to study attention control is task switching, which requires participants to rapidly switch between two tasks. While the majority of task switching studies have focused on elucidating the underlying mechanisms involved in task switching itself, the paradigm has also been used to examine the role of attention control in specific cognitive abilities like memory (e.g., Baddeley, Chincotta, & Adlam, , 2001; Mayr & Kleigl, 2000), perception (e.g., Logan & Gordon, 2001), and bilingual code-switching (e.g., Meuter & Allport, 1999).

Recent research takes advantage of the task switching paradigm to examine language-specific attention control – a type of attention control that is used when processing language, and is distinct from more general attention control abilities (Segalowitz & Frenkiel-Fishman, 2005; Taube-Schiff & Segalowitz, 2005a; Taube-Schiff

& Segalowitz, 2005b). The current studies add to that body of research by examining attention control specific to language in two populations: older adults and younger bilingual adults, each as compared to a group of younger monolingual adults. More specifically, Study 1 examines whether older adults experience a decline in switching between relational elements of language, similar to the declines seen in working memory abilities (Emery, Myerson & Hale, 2007) and inhibition (Hasher & Zacks, 1988) that negatively affect language performance. Study 2 examines whether younger bilingual adults have a benefit in switching between the relational elements of language, similar to the benefit seen in non-linguistic tasks of inhibition (Bialystok, 2009), and attention control (Prior and MacWhinney, 2010).

Language-specific attention control is a relatively new area of research. As of yet, there are only a small number of published studies specifically examining this ability (Segalowitz & Frenkiel-Fishman, 2005; Taube-Schiff & Segalowitz, 2005a; Taube-Schiff & Segalowitz, 2005b). As such, this thesis refers to the larger bodies of research from which the concept emerged. Because language-specific attention control has been studied by using task switching paradigms, theories of attention control and task switching mechanisms are outlined. Linguistic theories and experimental studies of the role of relational elements are then reviewed. Following this, previous research using the task switching paradigm to examine attention control for relational elements is summarized. Finally, an overview of the present experiments is given.

Attention Control

In our everyday lives, we are constantly required to respond to objects encountered in our environment. In order to perform a specific task, *a task set* must be employed. A task set encompasses the chain of processes that have been selected, linked and configured, allowing for the accomplishment of a particular goal (Rogers & Monsell, 1995). Norman and Shallice's (1986) Attention-to-Action (ATA) model is frequently cited as a useful framework for understanding control processes. The model states that action control (which includes the control of attention) consists of two distinct processes: automatic and willed. Automatic control is activated for the performance of routines and habits. In situations eliciting automatic control, behaviour is guided by *schemas* that are selected based on environmental cues and internal motivations (1986). For example, automatic control would be involved in the effortless routine of picking up a coffee mug and drinking from it, walking along a flat surface, or in over-learned sequences like brushing one's teeth before bed. Actions like this are often completed with little attention being paid to the task – the tasks are habitually performed with no conscious effort.

Automatic control of schemas can account for routine tasks; however, novel tasks require more complex cognitive operations. According to Norman and Shallice (1986) tasks requiring willed control are those that involving planning, novel sequences of action, technically difficult tasks, and tasks that require inhibition to be overcome. Additionally, even when each single part of a task is routine, the organization of, and switching between, several schemas is not routine. For this purpose, the ATA model contains a controller for willed control, called the Supervisory Activating System (SAS). For an example, when driving, one might employ a routine schema for the general process of keeping a foot on the gas pedal, and looking forward, however, when cued by a stop sign, the SAS would function to switch to the schema of moving the foot to the brake pedal, and scanning the area for pedestrians.

Task Switching Mechanisms

In order to study attention control processes, many have employed task switching paradigms (e.g., Cameron, Watanabe, Pari, & Munoz, 2010; Karbach, & Kray, 2009; Rogers and Monsell, 1995; Vandierendonck, Liefooghe, & Verbruggen, 2010). In task switching experiments, the participant is required to switch between performing one of two simple tasks. For example, participants may be presented with a number; for Task A they would be required to judge is parity (even or odd), for Task B they would be required to judge the numbers magnitude (higher or lower than 5). The correct task (A or B) for a given trial is signaled by either a task cue or its position in a run. The instructions for each task make up the task set, the paradigm's equivalent of Norman and Shallice's thought schema (1986). The task set involves perception and encoding of a stimulus, judgment of the stimulus, and selection and execution of a response. Thus, a task set must include the representation of task-relevant stimuli and task-relevant responses and the corresponding stimulus-response (SR) mappings. For some tasks, the SR mappings are relatively easy because they are highly overlearned (like in word reading or object naming), whereas for other tasks the SR mappings are more difficult to establish because they are arbitrary (e.g., if the stimulus is blue press the left response key, or if the stimulus is red press the right response key) or because they overlap for the two possible tasks (e.g., naming the ink color of a color word or reading the word itself; e.g., Stroop, 1935).

The burden on the attention control system is then measured in terms of increased reaction time when the participant is required to switch from one task to another. Jersild (1927) was the first to introduce an experimental measure of task switching - using what is now referred to as a "mixing task". In his original design, participants completed homogenous blocks of the same trial (e.g., AAAA or BBBB) and compared the reaction times to completing a heterogeneous block where the two trials alternated (e.g., ABAB). He found increased reaction time (RT) on the heterogeneous block compared to the homogeneous blocks, and concluded that the increase in RT reflected the difficulty in re-adjusting to the new, upcoming task. Jersild referred to this extra time as "shift loss", but it is now most often called a mixing cost, or global switch cost.

Task switching was not examined again for 70 years, when Rogers and Monsell (1995), modified the classic paradigm to correct what they saw as two major faults. The first of these is that attention control processes could not exclusively explain RT differences between homogeneous and heterogeneous blocks, as the blocks differed in terms of working memory demands. For the heterogeneous blocks, participants had to hold two rules (one for Task A and one for Task B), compared to one rule, in working memory. Additionally, comparison between, rather than within blocks, means that differences in arousal or effort could have an effect on response latency. To control for these differences, Rogers and Monsell (1995; also, Allport et al, 1994; Meiran, 2000), developed the alternating-runs paradigm. This new paradigm involved only one block of stimuli that required participants to learn two types of trials (e.g., A, B) and alternate between them in a predictable manner (e.g., AABBAA). Alternation between the two tasks resulted in every other trial being either a repeat, or a switch compared to the previous trial (RSRSR). This allowed a switch cost to be calculated (Switch RT minus Repeat RT). The switch cost reflects the additional attention control needed to change to a new task set, and it is often referred to as a local, or specific, switch cost, to differentiate it from the global switch cost (i.e., comparing RT for heterogeneous blocks to homogeneous blocks).

As an alternative to Rogers and Monsell's (1995) predictable sequence, a task-cuing paradigm with unpredictable sequences has been developed (e.g., Meiran, 1996). In this paradigm, the order of the tasks is random. This means that the order of the repeat and switch trials are also random. The current task is signaled by an explicit cue. For example, Sudevan and Taylor's (1987) had participants switch between categorizing a digit as odd or even or as smaller or larger than 5. The letters OD/EV and LO/HI cued the two tasks. As in predictable task switching paradigms, performance in switch trials is compared with performance in repeat trials. Performance is typically worse in switch trials than in repeat trials, and the paradigm elicits robust switch costs (see, e.g., Altmann, 2004; Hoffmann, Kiesel, & Sebald, 2003; Koch, 2001; Meiran, 1996; Meiran, Chorev, & Sapir, 2000). Task-cuing paradigms also reduce reliance on working memory, especially for older adults. Research suggests that providing a cue acts as an external memory aid for older adults, and reduces any age-related differences that might be seen in performance if participants are required to track the order of the trials themselves (Einstein & McDaniel, 1990, Van Asselen & Ridderinkhof, 2000). Thus, it seems that an important factor in determining the magnitude of age-related differences in task switching is working memory load. With low working memory load (i.e., using external cues), older adults are able to switch between tasks as effectively as younger adults. On the other hand, when trial sequence must be remembered and monitored, older adults perform more poorly than younger adults (Kramer, Hahn & Gopher, 1999).

A substantial amount of research has attempted to elucidate the mechanisms involved in task switching, resulting in a number of hypothesis being generated. The majority of these theories can be distinguished by whether they attribute switch cost to preparation for an upcoming task, or interference due to the just finished task. Task preparation has been mainly examined in studies that vary the timing prior to stimulus onset. In alternating runs paradigms, the interval between the response in the preceding trial and the onset of the next task stimulus (response-stimulus interval, RSI) can be varied. In the task-cuing paradigm, the interval between cue and stimulus (CSI) as well as the interval between response in the preceding trial and onset of the cue (RCI) can be varied.

Rogers and Monsell (1995) varied the RSI to provide participants with extra time to prepare for the upcoming task, and found reduced switch costs. They proposed that this reduction of switch costs with long RSIs suggests preparation, or in their terms, advance reconfiguration, for the upcoming task. Preparatory reductions of switch costs have been demonstrated in many studies, using a variety of stimuli, (e.g., Hoffmann, Kiesel, & Sebald, 2003; Koch, 2001). Decreasing switch costs have also been found with increasing CSI (or RSI), and are additional evidence of task preparation. However, even with ample time for preparation, (up to 5000ms) residual switch costs remain (e.g., Meiran, 2000; Rogers & Monsell, 1995; Rubinstein, Meyer, & Evans, 2001), meaning that even when given a sufficient amount of time to prepare, participants still perform more poorly on switch than repeat trials. To account for the residual switch cost, the reconfiguration hypothesis was put forward by Monsell and colleagues (Monsell, Yeung, & Azuma, 2000; Rogers & Monsell, 1995). They suggested that preparing for the upcoming trial involves two components, or stages. The first of these is an endogenous control component, which can begin when the participant knows the status of the upcoming task, either through monitoring task order (in an alternating run) or because a cue has been presented. The second component is an exogenously driven component that can only begin once the stimulus has been presented. This two-component model posits that residual costs (seen even when participants are given ample preparation time) reflect the exogenously driven component of task switching.

In contrast to task preparation accounts, task interference accounts assume that residual switch costs are not related to preparation at all, although they do assume an active reconfiguration process. According to these types of models, the active reconfiguration process can be carried out before the stimulus (if there is sufficient time), and can account for the reduction in switch cost with preparation. However, interference accounts differ from strict task preparation models in that they view residual switch costs as evidence for task interference (e.g., Monsell, 2003). Task interference accounts attribute residual switch cost to a failure to inhibit the irrelevant task set, leading to interference from the previous task set being carried over into the current switch trial. In other words, the greater RT seen on switch trials is attributed to the irrelevant task set remaining in focus and interfering with the configuration for the new task set (Wylie & Allport, 2000).

Researchers now acknowledge that more than one mechanism may underlie shift costs (e.g., Logan & Gordan, 2001; Sohn & Anderson, 2001) although the component that each mechanism is responsible for is still somewhat unclear (see Monsell, 2003). An emerging consensus is that both top-down preparatory and bottom-up stimulus-driven processes are involved, and their contribution to the switch cost is affected greatly by the design of the paradigm (Allport & Wylie, 2000; Meiran, 2000; Monsell, Yeung, & Azuma, 2000; Sohn & Anderson, 2001). What is especially relevant for this thesis is the role that working memory and inhibition may play in the process of switching between tasks. A number of manipulations to the paradigm have been found to affect the need for working memory and inhibition processes; those that are applicable to the task switching design used in the current studies are reviewed here.

Task Switching Manipulations

Research on task switching has revealed evidence for task interference at both the level of processing the target stimuli and when executing the required responses. Switch costs are strongly affected by whether the target stimulus of a current trial does or does not afford application of the irrelevant task (i.e., whether the target stimuli are univalent or bivalent). Switch costs are lower with univalent stimuli, that is, when stimuli are specific to one task only, whereas substantial switch costs emerge for bivalent stimuli. For example, Rogers and Monsell (1995) used a digit classification task and a letter classification task and presented bivalent stimuli (e.g., G7) or univalent stimuli (e.g., G#). If stimuli are univalent, as soon as a stimulus appears, the participant will know which task to complete. Bivalent stimuli, on the other hand, are ambiguous with respect to task. The participant must either remember the task sequence (e.g., AABB), or use the task cue to figure out which task set to use. Rogers and Monsell found that switch costs were higher on bivalent stimuli than univalent (1995). With bivalent stimuli, the participant must inhibit the irrelevant aspect of the stimulus. For example, with the digit-letter stimuli, if "G7" were presented on a switch trial, along with a task cue indicated "digit classification", the participant would have to inhibit attending to the previously relevant letter, and attend to the digit instead. In this way, bivalent stimuli require inhibition of attention. This manipulation is relevant to the current studies, as inhibition has been shown to be an ability that: declines with age (Braver & West, 2007) , negatively affecting language comprehension (Burke & Shafto, 2007), and seems to be enhanced in bilinguals (Bialystok, 2006), because of their need to constantly inhibit one of their two languages. These aspects, although mentioned throughout the General Introduction, will be more fully explored in the Introductions to each of the two studies.

Bivalent stimuli make another form of manipulation possible: whether the bivalent stimuli are congruent or incongruent with respect to response key. In the digit and a letter classification task, pressing a right response key could indicate "odd digits" in the digit task and "vowels" in the letter task, whereas pressing a left response key could indicate "even digits" or "consonants". Therefore, with a stimulus like "G7", the correct response during a digit trial would be a right key press, whereas the correct response during a letter trial would be a left key press. This type of trial is referred to as response-incongruent. For a stimulus like E7, the correct response, regardless of the type of trial, would be a right key press. This type of trial is response-congruent. Rogers and Monsell (1995) found that RTs were higher on incongruent than congruent trials, and that incongruent trials engender higher switch costs than congruent trials. This is because incongruent trials, as compared to congruent trials, increase conflict, and the need for inhibitory control. Again, this manipulation is relevant to the current studies, as conflict resolution has been shown to be an ability that, due to deficits in working memory, declines with age (Braver & West, 2007), and, like inhibition, seems to be enhanced in bilinguals (Costa, Hernández, Sebastián-Gallés, 2008). Additional research has found that performance on incongruent trials is related to working memory: those with low working memory spans perform more poorly on incongruent trials than those with high working memory spans (Kane & Engle, 2003).

In sum, it appears that there are both preparatory and inhibitory processes involved in task switching. Furthermore, certain aspects of a task switching paradigm can be manipulated in order to increase switch costs by increasing: the burden on working memory, the need for inhibitory control, and the degree of conflict between task sets. The current studies make use of these manipulations, in order to examine language-specific attention control in older monolinguals and younger bilinguals, as compared to younger monolinguals. The details and justifications for these manipulations will be further discussed in the individual studies. At this point, in order to address the issues of language comprehension relevant to the current studies, the linguistic theories and experimental studies of the role of relational elements are reviewed. Following this, previous research using the task switching paradigm to examine attention control for relational elements will be summarized. Finally, an overview of the present experiments is given.

Open- and Closed-Class Systems of Language

Historically, the field of linguistics has made a distinction between competence (understanding of language rules) and performance (the ability to deploy language rules) models of language. For example, Chomsky (1965) stated that his ideal speaker must be "unaffected by such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest . . ." Generative models (theories of syntax and grammar) in particular focused exclusively on developing competence models, with no regard to basic cognitive abilities like memory and attention (Myachykov, Tomlin, & Posner, 2005). There has been a recent emergence of theories, however, which view language as reciprocally tied to cognitive abilities. In the field of psychology, language has been typically viewed as a target for attention – one side of the reciprocal relationship. The other side comes from the idea that language can act as an attention-directing mechanism itself (Langacker, 1987; Slobin, 1996; Talmy, 2000). Language is normally used to draw attention to objects and events by naming them, but it is also used convey how relationships between objects and events are construed. Talmy (2000) states that any aspect of a sentence can be highlighted through the "windowing of attention". For example, the scene of a cat sitting on a chair could be variously described as *The cat was sitting on a chair, The chair had a cat sitting on it,* and so on. These sentences draw attention to the presence of a cat sitting and of a chair, but attention is directed to different elements (e.g., whether the main focus is the chair or the cat).

The idea of language as an attention-directing mechanism is derived from the longstanding view that language consists of two separate subsystems, one containing "open-class" and the second consisting of "closed-class" words. Open-class words are the roots of nouns, verbs and adjectives. They are so called because this category of words can be added to; for example, the relatively new word *computer.* Closed-class words, on the other hand, make up a much smaller group, which is generally stable. They consist of, but are not limited to, bound morphemes, grammatical categories and relations, as well as syntactic structures (Morrow, 1986). Furthermore, closed-class categories tend to have grammatical functions, whereas open-class categories have semantic functions.

Therefore, it has been proposed that closed-class units make up the structure of language, whereas open-class words make up the content (Talmy, 2000).

Evidence for dissociable conceptual and structural systems of language comes from the deficits seen in agrammatic aphasics. People suffering from this syndrome have deficits in the production and comprehension of closed-class units, while the open-class system remains intact (see Froud, 2001). Swinney, Zurif, and Cutler (1980) compared the performance of agrammatic aphasics and healthy controls on an auditory word monitoring task and found that the controls showed no effect of word class, while the aphasics responded slower to closed-class words compared to open-class words. In a similar study (Biassou, Obler, Nespoulous, Dordain, & Harris, 1997), when three agrammatic aphasics were required to read 16 open-class items and 16 closed-class items in isolation and in sentence context, they made significantly more phonological errors on closed-class items, even though all words were matched on frequency and length. Additional evidence comes from neuroimaging data of normal controls, showing that the two systems produce different electrophysiological responses. For example, several EEG studies have found that a component called N280 was evoked by closed-class words (Munte, Wieringa, Weyertes, Szentkuti, Matzke & Johannes, 2001; Neville, Mills & Lawson, 1992; Nobre & McCarthy 1994) whereas an N400 (Nobre & McCarthy 1994; Van Petten & Kutas, 1991) was evoked only by open-class words. Positron emission tomography studies indicate activation in response to syntactic complexity in different parts of Brodmann area 44 (Caplan 2001), functional magnetic resonance imaging experiments (Friederici, Opitz & von Cramon, 2000; Friederici, Ruschemeyer, Hahne, & Fiebach, 2003) and analysis of evoked magnetic fields (Wang et al., 2008) have shown that the processing of open- and closed-class words may be functionally and structurally separate.

Relational Elements of Language

The attention-directing mechanism of language is driven by the grammatical, or relational, elements from the closed-class system of language. Relational devices for directing attention include, but are not limited to, prepositions, verb aspect, definite and indefinite articles, tense markers, and word order. These elements cannot be experienced in a direct manner but instead shape the way the recipient construes the scene. For example, "*Matthew loved his fiancé despite her sense of humour*" compared to "*Matthew loved his fiancé because of her sense of humour*". *Despite* and *because of* do not direct attention to specific images or concepts, but they do shape how the reader construes the scene. A skilled listener or reader will construct different representations of this scene based on the relational elements. For example, the referent *because* of indicates that "her sense of humour" is to be emphasized as contributing to Matthew's love: whereas *despite* specifies that "her sense of humour" is not responsible for Matthew's love towards her. These types of conjunctions (e.g., because, despite, etc), along with other relational elements of language, direct the receiver's attention to important aspects of the unfolding message. They are used to modify and update the message, to ensure that it is ultimately understood as intended by the speaker or writer. As such, the message receiver, upon encountering these elements, must shift focus of attention frequently and rapidly. The ability to shift attention between these relational elements of language is the main focus of the following two experiments.

The aforementioned ideas regarding relational elements and their attention directing functions have been based on theoretical linguistic research (e.g., Slobin, 1996; 2003); however experimental studies of the role of attention in organizing the production of relational elements have been conducted. For example, Tomlin (1995, 1997) designed a computer animation program called the "Fish Film". Participants were asked to describe a movie about a darkly coloured fish and a lightly coloured fish as it occurred in real-time. In each trial one of the two fishes was visually cued, in order to attract the participants' attention. During the movie, one fish ate the other. Results indicated that English speakers varied their sentences, based on which fish had been visually cued (Tomlin, 1995). When the dark fish was cued and was then eaten by the light fish the participants said, *"the dark fish was eaten by the light fish"*. However, in the same scenario, if the light coloured fish was cued, participants described the scene as, *"the light fish ate the dark fish"*. Attention to the cue influenced the choice of the syntactic subject of the sentence and the choice of grammatical voice that mapped onto this assignment.

An additional account comes from Nappa and colleagues (2004) who presented participants with scenes that could be described differently, depending on the use of relational elements (e.g., "A dog is chasing a man"/ "A man is running from a dog"). Similar to the Fish Film studies, one of the characters was cued. In Study 1 this was done with a cross hair, while Study 2 used a subliminal attention-capture cue. In both studies, participants employed relational elements to construct sentences wherein the cued character was the primary subject of the sentence, even when the sentence would not normally be constructed in that manner. For example, most people would naturally say, "The man gave the woman a present", rather than "The woman received a present from the man", because of the active nature of the verb. In these studies, if the woman had been cued (even subliminally) participants more often produced the latter of the two sentences. These results demonstrate that underlying the grammatical choice there is an attentional component, which illustrates how the cognitive system imposes regular constraints on language.

Task Switching Studies Using Relational Elements

The aim of the current studies is to elucidate the relationship between attention control and the closed-class system during language comprehension by examining switching between relational elements. The studies reviewed in the following paragraphs have operationalized linguistic attention control by employing a modified version of Rogers and Monsell's (1995) alternating-runs design.

Segalowitz and Frenkiel-Fishman (2005) had English-French bilinguals switch their attention between conjunctions and time-related adverbials, which they respectively categorized as either expressing causality or not (e.g., *because*, *consequently*; *although*, *but*), and representing the very near future or a more distant future (e.g., *now*, *promptly*; *tomorrow*, *never*). The category of trial switched every two trials, following the alternating-runs AABB design, and participants performed English and French versions of the task. Switch costs (RT on switch trials minus rt on repeat trials) were found in both languages. This indicates that participants had to use attention control to switch between the relational elements of language. Additionally, switch costs in participants' second language were strongly related to their proficiencies in that language, with 32% of the variance in shift cost being shared with the level of proficiency (Segalowitz & Frenkiel-

Fishman, 2005). This suggests that language-relevant control of attention plays a significant role in skilled L2 ability. Furthermore, their results highlight the relationship between language and attention, as viewed from the cognitive linguistic point of view. and more generally contribute to the literature suggesting that efficient attention control is a necessary element for skilled performance of complex cognitive tasks.

Using a similar design, Taube-Schiff and Segalowitz (2005a) also found shift costs in monolinguals when the relational elements were presented in sentence fragments, thus demonstrating the generalizability of Segalowitz and Frenkiel-Fishman's task to more complex linguistic situations. Finally, Taube-Schiff and Segalowitz (2005b) compared the performance of asymmetrical bilinguals (stronger L1 than L2) on a semantic and a relational condition in their first and second languages. The semantic condition consisted of alternating judgments about the type of transportation mode (two- vs. four-wheeled) and the type of travel (air vs. water), and was used as a measure of general attention control. The relational condition consisted of verticality (above vs. below) and proximity (near vs. far) trials. Their results showed that participants had significantly larger switch costs in the relational condition than the semantic condition in the L2 block, whereas relational and non-relational switch costs did not differ in the L1 block. Additionally, the switch cost for the relational condition was larger in L2 compared to L1, but there was no difference between the two language blocks for the semantic condition (1995). In other words, participants showed greater language-specific attention control in L1 (lower switch costs in the relational condition), as compared to their weaker L2, but showed no difference in attention control on the non-relational task.

Importantly, this suggests that the performance on the non-relational task reflects general, rather than language-specific, attention control.

The Present Studies

The two studies presented here examined language-specific attention control in two different groups. The first study compared the performance of older monolingual adults to younger monolingual adults. As will be discussed in the introduction of Study 1, older adults show age-related declines in a number of cognitive abilities, including inhibition, working memory, and attention control (see Braver & West, 2007). Additionally, these declines are thought to underlie age-related declines seen in language comprehension (see Burke & Shafto, 2007). Given these deficits, older adults make up an important group for studying attention control specific to language. Based on the literature that is reviewed in the first study, we have made the following predictions. First, we predicted that overall, older adults would have higher reaction times than younger adults on the switching task. Second, we predicted that older adults would perform similarly to younger adults when switching between semantic elements of language, as the literature shows that older and younger adults typically have similar switch costs after taking general slowing into account (Verhaeghen & Cerella, 2002). Finally, we predicted that older adults would perform more poorly than younger adults when switching between relational elements of language, due to the age-related decline areas of language comprehension (see Burke & Shafto, 2007).

The second study compared the performance of young bilinguals to young monolinguals. As will be discussed in the introduction to Study 2, recent research has suggested that bilingualism confers an advantage in non-linguistic cognitive tasks

(Bialystok, 2008a, b). This research has shown that bilinguals perform better than their monolingual counterparts on tasks requiring inhibition (Bialystok, Craik, Klein & Viswanathan, 2004), conflict resolution (Costa, Hernández, Sebastián-Gallés, 2008), and attention control (Prior & MacWhinney, 2010). Study 2 seeks to examine how these cognitive benefits affect language-specific attention control. Based on the literature that is reviewed in the second study, we predicted that bilingual participants would perform better than monolingual participants when switching between both semantic and relational elements of language. However, we hypothesized that the difference between the two groups would be even greater for relational elements, due bilinguals having to master the control of relational elements in two different languages.

The Effects of Aging on Language-specific Attention Control

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Abstract

Age-related declines in language comprehension may be, in part, related to declines in working memory, inhibition and attention control. One area of language that has not been examined in aging is attention control of relational elements. Relational elements of language act to direct attention to other aspects of the incoming message. The listener or reader must be able to use these elements to focus and refocus attention on the mental representation that is being constructed. Recent research has shown that this type of attention control is specific to language and can be distinguished from more general attention control. Sixteen younger adults (18-30 years) and fourteen older adults (60-81 years) completed two conditions of a task switching paradigm. The relational condition involved processing spatial prepositions, and the semantic condition involved processing nouns and adjectives. Attention control was operationalized in terms of shift costs obtained in an alternating runs experimental design. Older adults, although they performed slower overall, had similar switch costs in the relational and semantic conditions, whereas the younger adults had significantly larger switch costs (i.e., lower attention control) in the relational condition than the semantic condition. Switch costs did not correlate with measures of working memory or inhibition for either age group, however, younger adults showed a negative correlation between relational switch costs and a switch score derived from a trail-making task. This correlation was not significant for older adults. Taken together, the results suggest that the older adults, through additional years of language experience, have developed an efficient system of attention control that is specific to language, and is not related to general attentional abilities.

The Effects of Aging on Language-specific Attention Control

Age-related change in language performance has been an active area of research for many decades (Mysak & Hanley, 1958), most likely because of how important language is throughout the lifespan. The rapid and accurate comprehension of spoken (or read) messages is necessary for performing everyday tasks and maintaining normal social relations. And, although it often seems to proceed effortlessly, comprehension of written and spoken language relies on the ability to correctly process word and phrase meanings, sentence grammar, and discourse or text structure. Difficulties in any of these domains can produce comprehension problems. Age-related memory declines have been reported in many studies comparing younger and older adults on language comprehension tasks. Therefore, it is believed cognitive capacity limitations in older adults may cause language comprehension problems (Burke & Shafto, 2007). One area of language that has not been examined in aging is attention control of relational elements. Relational elements of language act to direct attention to other aspects of the incoming message. The listener or reader must be able to utilize these elements in order to focus and refocus attention on the mental representation that is being constructed. Recent research has shown that this type of attention control is specific to language; it can be distinguished from more general attention control (Taube-Schiff & Segalowitz, 2005a,b; Segalowitz &Frenkiel-Fishman, 2005). Given the substantial literature pointing to age-related declines in attentional processes that negatively impact language processing; this study seeks to examine language-specific attention control in aging.

Age-related Language Decline

A growing body of research documents age-related impairment in language performance (see Burke & Shafto. 2007). For example, older adults have more difficulty comprehending and producing grammatically complex sentences, compared to their younger counterparts (Kemper, 1992). Older adults also tend not to recall as much after reading or listening to texts (Zelinski & Gilewski, 1988). In the last decade, identifying the underlying cause of age differences in language performance has been a major focus. In addition to examining linguistic abilities themselves. a substantial research effort has been aimed at examining how declines in attentional processes (i.e., working memory, inhibition, executive functioning) affect language processing (for a review see Burke & Shafto, 2007) One theory is that age-related declines in language comprehension are due to reduced working-memory capacity.

Working memory and language. Baddeley and Hitch (1974) define working memory as a limited capacity system responsible for manipulating information and temporarily storing the products of this manipulation. The central executive of working memory has been described as a pool of attentional resources competing for these processing and storage functions. This system is thought to be involved in most cognitive operations. In language comprehension especially, working memory is assumed to have a crucial role, because the intermediate products of comprehension have to be kept active as the incoming message is being processed, in order to ensure comprehension (Caplan & Waters, 1999). For example, understanding who told whom the secret in the sentence, "*Rylan who liked Heather told her the secret*" requires the listener to detect the overall sentence frame, "*Rylan told her the secret*," and the embedded clause, "*who liked*

Heather," and to integrate the two appropriately in working memory. As such, working memory is known to restrict the comprehension of sentences with complex syntactic structures (see the review in Wingfield & Stine-Morrow, 2000) and could explain why older adults show a preference for right branching sentences (Kemper & Kemptes, 2001) and become less efficient at comprehending and producing syntactically complex sentences (Kemper, Greiner, Marquis, Prenovost & Mitzner, 2001). Older adults appear to allocate the majority of their cognitive resources to deal with the processing of the incoming message, leaving fewer resources for maintaining the previously processed information. The difficulty in dealing with the incoming message could cause the information from the previous phrase to be lost (Just & Carpenter, 1992). Indeed, various studies have found that older adults have smaller working memory spans, and furthermore, that span measures correlate with both language comprehension and language production (see, e.g., Norman, Kemper, Kynette, Cheung, & Anagnopoulos, 1991; Stine & Wingfield, 1990; Tun, Wingfield, & Stine,1991)

Inhibitory control and language. An alternative view of age-related language decline comes from the Inhibition Deficit Hypothesis (IDH). Hasher and Zacks (1988) proposed that many age-related deficits observed across cognitive domains (including selective attention, language, and episodic memory) can be explained by a single common mechanism - declining efficiency in inhibitory function with increased age. According to the IDH model, older adults are impaired in their ability to filter the incoming information. Specifically, they cannot efficiently and accurately delete irrelevant information from cognitive representations of current task demand. Reduced inhibitory processing then affects working memory in two ways. Firstly, reduced inhibition means that higher amounts of irrelevant and non-goal information will enter into working memory, and secondly, information will not be deleted or suppressed when it becomes nonrelevant. Hasher and Zacks (1988) suggested that adult age differences in working memory abilities result from deficits in inhibitory function (May, Hasher, & Kane, 1999). They argued that working memory involves not only the storage and manipulation of information, but also inhibitory mechanisms that prevent the entrance of task-irrelevant information (Hasher & Zacks, 1988). A substantial amount of empirical support for the IDH model has been amassed. For example, Phillips and Lesperance (2003) tested whether older adults have greater difficulty than younger adults in ignoring task-irrelevant information during reading as a result of age-related decline in inhibitory processes. They presented participants with highly constrained, semantically meaningful sentences followed by individual probe words containing task-irrelevant distractor words. A probe word following each sentence was either related to the meaning of the sentence, related to the distractor words, or was not related to either. Their results suggested that embedded distractor words interfered with older participants' ability to process for meaning. Because the older adults were unable to inhibit processing the distractor words, the target sentences were rendered syntactically irregular, resulting in diminished priming for sentence related material.

Attention control and language. Cognitive control, or attention control, has been defined in many ways; however each definition generally refers to the formation, maintenance and realization of internal goals (Miller & Cohen, 2001). There is a consensus in the literature that attention control allows individuals to shift from one attentional process to another quickly, while inhibiting the behaviours from the previously relevant process. As such, it can be seen as a mechanism playing a role in controlling what enters working memory. For example, Engle, Kane et al. (1999) argued that individual differences in performance on complex working memory tasks are primarily due to differences in the central executive component, or attention control component, of working memory. In the last few years, this explanation has gained greater acceptance (Friedman & Miyake, 2004, Unsworth & Spillers, 2010). Using complex working memory tasks, Kane & Engle (2002) demonstrated that the performance of low span participants under interference conditions can be simulated by dividing the attention of high span participants. This is consistent with the idea that attention-control ability is the source of individual differences between high and low working memory participants. Kane and Engle (2002) also propose that working memory and inhibition reflect the extent to which an individual is able to control attention, particularly in situations involving interference from competing information, activated representations, or task demands.

In sum, decades of research indicate that age-related declines in working memory, inhibition, and attention control negatively affect aspects of language comprehension. However, in spite of barriers such as these, healthy older adults are generally able to effectively communicate. Linguistic knowledge, and the procedural rules for implementing this knowledge, appear to be well preserved in normal aging (Wingfield and Stine-Morrow, 2000). Research indicates that in all but late-stage Alzheimer's disease, the ability to comprehend at least the surface meaning of speech are maintained (Kempler, 2005).

Linguistic Theories of Relational Elements

The current study seeks to examine how aging affects specialized attention control driven by language constructs. In other words, this study seeks to examine how older adults switch between relational elements of language. The idea behind this language-specific attention control is derived from theories within the field of cognitive linguistics. A number of linguists have put forth the hypothesis that although attention is focused on language, certain aspects of language act to direct attention themselves. In other words, language acts as an attention-directing mechanism itself. For example, the scene of a man standing underneath a clock could be variously described as *The man was standing under a clock, There was a clock above the man*, and so on. These sentences draw attention to the presence of a man standing and of a clock, but each focuses in a different way on the specific relationships between these elements, (e.g., whether the main focus is the man or the clock, whether the action was ongoing or completed, whether the clock was a specific clock). Talmy (2000) refers to this phenomenon as "windowing of attention", wherein any aspect of the sentence can be "windowed" or highlighted in particular ways.

The attention directing mechanism of language is driven by relational elements in the closed-class system of language. According to Talmy (2000), closed-class words specify conceptual structure, whereas open-class words specify conceptual content, and these two "formally distinguishable" systems work together in a conceptual co-system. Relational devices for directing attention include prepositions (e.g., *after*, *then*), verb aspect (e.g., *swim, swimming, swam*), definite and indefinite articles (e.g., *the, a*), conjunctions (e.g., *because, despite*), as well as bound morphemes on lexical items that mark case or tense (see Talmy, 2000). These and other linguistic devices cannot be experienced in a direct manner (e.g., through perception), but instead shape the way the recipient construes the scene. The relational elements serve to focus the listener or reader's attention on important aspects of the representation, and ensure that it is modified, and updated in the manner that the speaker or writer intended. In the normal course of listening to or reading a message, attention must be shifted frequently and rapidly as relational elements are encountered.

The ability to shift attention among these relational elements of language is the main focus of the following experiment. Given the age-related declines in other cognitive processes underlying language comprehension, this study seeks to examine language-specific switching abilities in older adults.

Task switching and Language-specific Attention Control

Recently, Taube-Schiff and Segalowitz (2005a) used an alternating-runs switching task, to examine switching between relational linguistic stimuli. Their task was based on the alternating-runs design (Rogers & Monsell, 1995) with linguistic stimuli presented in a contextualized manner (embedded in sentence fragments). Participants had to switch between the two tasks – Task A (making an *above-below* judgment) and Task B (making a *past-present* judgment) – in a predictable, AABB sequence. The *above– below* judgment task used stimuli such as " . . . *all alone above the location* . . ." and " . . . *from below the site with them* . . ." The *past–present* judgment task used stimuli such as " . . . *since we waited with someone* . . . " or " . . . *when he's standing all alone* . . ." As in Rogers and Monsell's (1995) study, these two tasks were presented, one at a time, with stimuli appearing on the screen on successive trials in an adjacent cell of a 2 X 2 presentation matrix, moving in a clockwise fashion around the matrix. Every second trial is was a repeat (R) of the previous task type or a switch (S) to the other task type. This resulted in a SRSRSR sequence, allowing comparison of reaction times for repeat and switch trials within a single condition. From this, a switch cost (Switch RT – Repeat RT) could be calculated. A significant shift cost was found for these contextualized relational stimuli, with 100% of the participants showing a switch cost. These results indicate the appropriateness of the alternating-runs design for studying issues concerning language, and linguistic attention control. Furthermore, the results demonstrate the idea that relational elements require an individual to refocus attention on a different aspect of the mental representation of the meaning contained in a phrase, thereby giving rise to attentional shift costs.

In another study, Taube-Schiff and Segalowitz (2005b) tested moderate bilinguals using a similar attention shifting task and found a greater shift cost effect (i.e., reflecting a greater attentional burden) in the participants second, less proficient language than in their first language. Furthermore, the relationship between attention and proficiency was obtained only when the task stimuli were relational elements (function words) and not with concrete nouns (semantic words). Taken together, these results provide evidence that when the relational elements of a sentence force an individual to refocus his or her attention, a shift cost is involved, which is specific to language.

The current study will be the first to examine this ability in aging, but, many studies have looked at general task switching in older adults. Given that working memory and inhibition have been shown to decline with age, one would expect that older adults would show similar age-related deficits in switching tasks. However, data on aging and task switching are decidedly mixed, with most reporting moderate-to-no age differences (Brinley, 1965; Hartley, Kieley, & Slibach, 1990; Kramer, Hahn, & Gopher, 1999; Kray & Lindenberger, 2000; Mayr & Kliegl, 2000a; Salthouse, Fristoe, McGuthry, & Hambrick, 1998). Thus, there is surprisingly little evidence that the ability to switch between task sets is particularly sensitive to aging. This makes the task switching paradigm a perfect vehicle for examining switching between the relational elements of language in aging, as any age-related declines would be due to declines in language-specific attention control, rather than age-related changes in general switching ability.

The objective of the current study was to examine age-related differences in the ability to switch between relational elements of language, using an alternating-runs design switching task similar to that used by Taube-Schiff and Segalowitz (2005a, b). We presented older and younger adults with full sentences containing target stimuli relevant to both the relational and semantic (control) conditions. The target stimuli in the relational condition were relational elements of language (function words) that required a location judgment or a proximity judgment. The target stimuli in the semantic, or control condition were nouns and adjectives that required a size judgment or a category judgment. Unlike the Taube-Schiff & Segalowitz (2005a) study, stimuli did not appear on the screen in a 2 X 2 presentation matrix, moving in a clockwise fashion around the matrix. Instead, our stimuli appeared in the middle of the screen, and task was cued by a word at the top of the screen. This was done to eliminate differences between the age groups that might arise from having to keep the sequence of the tasks in memory.

Given the results of the previous linguistic attention control studies, we hypothesized greater switch costs in the relational condition, than the semantic condition, because of the additional burden on attention control required to switch between attention-directing elements of language. Older participants were expected to perform more slowly overall than younger adults, but to have similar switch costs in the semantic (control) condition, as shown in previous task switching studies (Verhaeghen & Cerella, 2002). However, older participants were expected to have larger switch costs in the relational condition (as compared to the semantic condition) than younger adults. We hypothesized this age-related difference based on research showing that older adults perform more poorly on language tasks requiring working memory and inhibition (Burke & Shafto, 2007).

Methods

Participants

Sixteen monolingual younger adults ranging in age from 18-35 years (mean age = 22.25, sd = 4.48, female = 43.7%). and 14 monolingual older adults, ranging in age from 60-81 years (mean = 68.8, sd = 6.3, female = 85.7%) were tested. Participants who were eligible students from Concordia University received partial credit for course fulfillment for taking part; those who were not were paid CAD$10/hour. Inclusion criteria for all participants included self-reported good health, and no prior history of head injury, medical illness, or chronic use of medication that might affect cognitive functioning. All participants were English monolingual adults, with minimal exposure to any other languages (e.g., restricted to basic expressions of courtesy). Participants were matched for years of education, $t(1,28)=-1.57$, $p=.127$. Scores on the MoCA, $t(1,28) = -2.3$, $p=.029$ indicate that younger adults performed better than older adults. Table 1 shows means and standard deviations for age, years of education, and MoCA scores. One younger adult was excluded due to a MoCA score below the cut-off of 26.

Apparatus

All computerized tasks were presented using Millisecond Software Inquisit Version 2.0.61004.7 on a Dell Computer with a 33 cm x 24 cm screen. Participants responded to stimuli using a Logitech gamepad.

Measures

Standardized neuropsychological tasks.

The Montreal Cognitive Assessment (MoCA; Nasreddine, Phillips et al., 2005). The MoCA is designed to screen for Mild Cognitive Impairment, and has a sensitivity of

Table 1

Means and Standard Deviations for Age, Years of Education, MoCA Scores for Younger and Older Participants

	Younger		Older	
	Mean	*SE*	Mean	*SE*
Age (years)	22.25	*1.11*	68.79	*1.68*
Education (years)	14.94	*0.36*	13.86	*0.61*
MoCA (max 30)	28	*1.26*	26.71	*1.77*

90%. It tests several cognitive domains, including: short-term memory, visuospatial abilities. executive control, language, abstraction, concentration and orientation. It is scored on a 30-point scale, where a score equal to or great then 26 is considered within the normal range. Participants who scored below 26 were excluded from the study. One younger bilingual participant was excluded from the study for having a score below 26.

Comprehensive Trail-Making Test (CTMT; Reynolds, 2002). The CTMT consists of five visual search and sequencing tasks of increasing complexity. The CTMT allows assessment of attention, concentration, distractibility, and set-shifting. Participants are required to connect a series of stimuli in a specified order as quickly as possible, without making any errors. For this study we analyzed only Trails 2 and 5. On Trail 2 participants must connect the numbers 1 to 25, in order. The trail also contains distractor circles containing non-numerical symbols. On Trail 5, participants must connect the numbers 1 to 13 and letters A to M, by alternating between the numbers and letters in order (e.g., from 1 to A, A to 2, 2 to B, etc). This trail also utilizes distractor circles containing non-numerical symbols A Trails Difference Score (Trail 5 RT minus Trail 2 RT), provides a measure of switching ability, while taking baseline performance into account. This analysis is comparable to the original Trail Making Tests Trails A and B (Reitan, 1955). The original Trail Making Test has been extensively used in research in neuropsychology, in part because it has been postulated to reflect executive processes, such as planning and switching.

Letter Number Sequencing subtask of the Wechsler Adult Intelligence Scale III (WAIS-III) subtests. This task assesses working memory capacity and manipulation. The examiner reads aloud a series of numbers and letters. The participant must recall the digits first, in ascending order, followed by the letters in alphabetical order. The test consists of seven blocks, which each increase by one stimulus, with three trials per block. Participants were given one point for every correct trial, and the total number of correct trials was recorded.

Computerized tasks.

The Simon Task (Simon & Rudell, 1967). This task was used to assess inhibition of an irrelevant stimulus element, as well as permit comparison with previous findings (Bialystok et al., 2004). The design of the task in this study was based on that of Bialystok and colleagues, (2004).Visual stimuli were a red square or a blue square appearing on the left or right side of the black screen. A white fixation cross appeared for 800 ms, followed by a blank black screen for 150 ms, then the red or blue square remained on screen until the participant responded or 1000 ms passed. A response-stimulus interval of 500 ms was used. Participants responded using the left button on a gamepad to categorize the square as blue and the right button key to categorize the square as red. On half of the trials the square's location on the screen was congruent with the response button side, and on half of the trials it was incongruent. Congruent and incongruent trials and red and blue stimuli appeared in a random sequence. It allowed comparison of RTs on trials where a left or right key response to a coloured block is incongruent with the target's spatial location on the screen, with RTs on trials where response side and stimulus location are congruent. The RT difference provided a measure of general attention control.

Language-Specific Attention Control task. The present task was a modified version of the design of Taube-Schiff and Segalowitz (2005b), which itself was based on the Rogers and Monsell (1995) alternating runs switch design. The attention-shifting task consisted of a relational and semantic condition composed of a training stage and an experimental stage. Stimuli can be seen in Table A1. In each condition, the tasks alternated in an AABB design, such that every other trial was a task repetition (e.g., AA) or switch (e.g., AB). Switch costs are the difference between RT on trials that are repeats compared to those that are shifts. On each trial, a cue indicating which task to perform appeared at the top of the screen. After 1300 ms a sentence appeared in the middle of the screen and remained on screen until a response was made. The next trial began after a 250 ms post-trial pause. In order to minimize working memory load, we placed key assignment reminders at the bottom left and right side of the screen, corresponding to the left and right response buttons on the gaming remote. In each condition, the key assignment reminders for both tasks remained visible at all times.

The same set of sentences was used in the relational and semantic conditions; only the cue indicating which task to perform was different. As such, each sentence afforded any of the four judgment tasks. The sentences were in white, Arial font of 18 logical units in height and thickness of 600/900, against a black background. Sentences consisted of a person or group of persons, a verb indicating that they were looking or searching, the semantic condition size adjective (small, tiny, fat or big), the semantic condition category noun (dog, pig, watch, or glove), the relational condition proximity preposition (just, a bit, well, way), the relational condition verticality preposition (above, over, under, below) and a location. For example, *"They located the tiny glove far above the window"*.

Sentences were constructed a priori in a counterbalanced manner to ensure that all target stimuli were equally paired together, and equally paired with the filler words. One exception is that no sentences were constructed such that an incorrect answer for the current task could be a correct answer for the second task. So, the words indicating large size were always paired with the animal category, small size with the object category, far with above, and near with below. Sentences were constructed a priori in a counterbalanced manner to ensure that all target stimuli were equally paired together, and equally paired with the filler words. One exception is that the stimuli for the two tasks in each condition were incongruent with respect to their stimulus-response mappings. So, the words indicating large size were always paired with the animal category, small size with the object category, distant with higher, and close with lower. The rationale for this is that all stimulus-response mappings were incongruent, increasing the need for inhibition and conflict resolution. For example, if during the semantic condition a right key press indicated *large* for the size task, and a left key press indicated *small*, then a right key press would indicate *object* for the category task, and a left key press would indicate *animal*.

Stimuli were sentences containing the target words, surrounded by a location filler word (e.g., *window*, *shelf*, *clock*) and other filler phrases and words (e.g., *They located the*, *The group noticed a*, *She found the*). A list of all sentences can be seen in Table A2. The relational condition alternated between proximity and verticality judgments. For the verticality judgment task, participants decided whether an object was above or below a particular location. In the proximity judgment task, participants decided whether an object was near to or far from a particular location. The semantic condition alternated between size and category judgments. For the size judgment task, participants decided whether an object was big or small, based on an adjective preceding the object. In the category judgment task, participants decided whether an object was living or non-living. For each of these tasks, sentences were selected from the list quasi-randomly and in a counterbalanced manner. The same set of sentences was used in all four subtasks of the two conditions. For example, participants might see a sentence like, *"She found the fat dog just under the shelf"*, which afforded any of the four judgment tasks. In the relational condition, if the task cue was *position*, the participant was required to indicate whether the dog was above or below the shelf, whereas if the task cue was *distance*, they would have to indicate whether the dog was near to or far from the shelf. In the semantic condition, if the task cue was *size*, the participant was required to indicate whether the dog was big or small, whereas if the task cue was *category*, they would have to indicate whether the dog was an animal or an object. Cues appeared on screen for 1347 ms before the sentence, and then the cue and sentence remained on screen until the participant responded. The preceding trial occurred after a 250 ms inter-trial interval. In order to minimize working memory load, key assignment reminders (*higher, lower, close, distant, animal, object, big* and *small*) for both subtasks in each condition remained visible at the bottom left and right side of the screen at all times. The placement of the reminders corresponded to the left and right response buttons on the gaming remote, and the reminders were the same colour as their corresponding cue (e.g., if the cue *size* was red, then *big* and *small*, were also red). None of the words used as key assignment reminders appeared in any of the phrases.

For the training stage, completed prior to each experimental block, participants practiced the two tasks separately. They completed enough training trials to demonstrate that they understood the task and were accustomed to the task cues and key reminders.

Participants then completed practice trials that simulated the experimental conditions, by alternating in an AABB design between the two subtasks. These practice trials also contained "catch trials". Catch trials contained misspelled words that the participants were required to identify before they could move on to the next trial. These were included to ensure that participants were reading the entire sentence. Throughout the training, practice and experimental trials, participants were given feedback in the form of a 1000hz tone when they responded incorrectly.

The experimental conditions consisted of 24 warm-up trials. 12 at the beginning of the condition, and 12 after a break in the middle of the condition. Within each of the 12 warm-up trials there were 4 catch trials. Data were gathered from the remaining 72 trials in the condition. No more than four consecutive left or right button presses ever occurred in a row, and key assignment and order of conditions were counterbalanced across participants.

Procedure

Participants were contacted by phone to complete a language and health screening questionnaire to assess that they met all inclusion/exclusion criteria (Appendix B). Participants who met the criteria were tested on one occasion, lasting 1 to 1.5 hours. Participants were seated in a comfortable chair and informed consent (Appendix C) was obtained at the beginning of the session. Order of task administration can be seen in Appendix D .The MoCA was administered first, to screen for participants with cognitive impairment. Following this, participants completed the animacy judgment task, then one practice and one experimental condition of the language-switching task. The order of the conditions (relational and semantic) was counterbalanced so that half of the participants completed the relational condition first and half received the semantic condition first. Following this, the participants completed the WAIS-III Letter-Number Sequencing task, the Simon Task, and the CTMT. Finally, they completed the second practice and experimental conditions of the language-switching task.

Results

For all statistical tests reported below, the alpha level for significance was set at .05. All t-tests are two-tailed.

Neuropsychological Tasks

Standardized tests. Table 2 contains means and standard deviations for neuropsychological tasks. Independent t-tests revealed that the older and younger groups did not differ on the WAIS-III Vocabulary subtest when using raw scores, $t(1,28)= -1.57$; $p =.127$, but did differ when scores were standardized according to age and education. $t(1,28) = -3.36$;$p=.002$, with younger adults having a higher standard score than older adults. The two age groups differed on the WAIS-III Letter-number Sequencing task using raw scores, $t(1,28)=-2.05$, $p =.05$, but did not differ when using standardized scores, $t(1,28)=-.12$, $p = .90$ A repeated-measures analysis of variance (ANOVA) of RT data with Trail (Simple, Complex) as a within-subjects factor and Age Group (older, younger) as a between subjects factor revealed a significant between-subjects main effect of Age Group, $F(1,28)=19.06$; $p < .001$, indicating that older adults were slower overall, and a significant effect of Trail, $F(1,28)= 29.71$; $p < .001$, with longer RTs on the complex trail. Although the interaction effect was not significant, there was a trend for older adults to have a larger difference between Trails 2 and 5 than younger adults ($p=.072$).

Computerized tests.

Simon task. Repeated-measures analyses of variance (ANOVAs) of the RT and accuracy data were performed, with Congruency (congruent, incongruent) as a within-

Table 2

Means and Standard Errors for Neuropsychological Tasks for Younger and Older Participants

	Younger		Older	
	Mean	*SE*	Mean	*SE*
Vocabulary *(max 60)*	55.88	*4.87*	53.13	*8.29*
LNS *(max 21)*	13.88	*.092*	11.36	*0.79*
Simon Congruent *(rt)*	397.74	*13.98*	553.03	*35.29*
Simon Incongruent *(rt)*	424.92	*12.64*	607.62	*20.85*
Simon Difference (*Incongruent – Congruent)*	27.18		54.59	
CTMT Trails 2 *(rt)*	48.75	*1.86*	48.93	*3.50*
CTMT Trails 5 *(rt)*	49.81	*3.16*	73.36	*8.07*
CTMT Difference *(Trail 5- Trail 2)*	1.06		24.43	

subjects factor and Age Group (older, younger) as a between subjects factor was performed. The RT analysis revealed a significant between-subjects main effect of Age Group, F (1, 27) =35.35; $p<.001$, indicating that older adults were slower overall than younger adults, and a significant effect of Congruency, F (1, 27) =18.78; $p<.001$, with longer RTs on incongruent trials. The interaction effect was not significant ($p=.158$). The analysis of the accuracy data revealed that the two groups did not differ in accuracy, F (1, 27) =1.27; $p=.269$. A significant effect of Congruency, F (1, 2) =7.28; $p=.012$, indicated that participants were less accurate on the incongruent trials. The interaction effect was not significant ($p=.269$).

Language-Specific Attention Control Task

Only correct RTs were used to calculate the means, and any incorrect trial following an error was omitted. Additionally, to remove outliers within each participant's data set, responses faster than 200 ms and slower than 2 standard deviations above the mean were removed. The means were calculated separately for each of the eight conditions formed by crossing task (proximity, verticality, size and animacy) by trial type (repeat or switch). Table E1 contains the means and standard errors for RT for each of the eight conditions, for younger and older participants. Preliminary tests were conducted to ensure that the alternating-runs design yielded shift costs as expected in the relational and semantic conditions. Inspection of the data indicates that 16 out of 16 younger and 12 out of 14 older participants showed a switch cost in the relational condition, and 12 out of 16 younger and 11 out of 14 older adults did in the semantic condition. A priori t-tests of shift versus repeat RTs in each of the conditions, for each age group, yielded significant shift costs, $p<.001$ in all cases.

One of the goals in this experiment was to extend the results of Taube-Schiff and Segalowitz (2005b) to older adults, that is, to examine whether LSAC declines with age. We submitted the RTs to a 2 X 2 X 2 repeated-measures ANOVA with Condition (relational, semantic) and Trial Type (repeat, switch) as within-subjects factors, and Age Group (younger or older) as a between-subjects factor. Mean RTs and standard errors, Raw Switch Costs and Proportional Switch Costs for the two conditions, for older and younger adults can be seen in Table 3. The results yielded a significant main effect of Age Group, F (1, 28) =12.426, MSE= 4475204.05, p=.001, which indicates that older adults performed more slowly than younger adults. There was a main effect of Condition, F (1, 28) =18.154, MSE=503400.746, p<.001, indicating that RTs for the relational condition were significantly longer than those for the semantic condition. The results also yielded a main effect of Trial Type, F (1, 28) =39.928, MSE=100661.253, p<.001, indicating that RTs for the switch trials were significantly longer than those for the repeat trials. The between-subjects factor also interacted significantly with Condition, F (1, 28) = 4.181, p = .050, with older adults showing no difference between the two conditions, and younger adults performing slower in the relational compared to the semantic condition. There was no effect of Trial Type, F(1, 28) = .105, p = .748. The interaction between Condition and Trial Type was significant, F (1, 28) = 4.185, p = .050, with a larger difference between repeat and switch trials in the relational condition than the semantic condition. The three-way interaction between Condition, Trial Type and Age Group did not reach significance, F (1, 28) = 3.960, p = .056, although there was a trend.

We also compared switch costs by running a 2 X 2 ANOVA on the switch costs

Table 3

Language-specific Attention Control Mean Reaction Times and Standard Errors, Switch Costs and Proportional Switch Costs for Older and Younger Adults

	Younger		Older		Younger		Older	
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
	Relational				Semantic			
Repeat	2678.34	*263.4*	3827.44	*283.3*	1999.31	*231.9*	3541.68	*360.4*
Switch	3165.97	*281.2*	4215.01	*294.8*	2207.77	*214.4*	3925.38	*403.3*
Cost	487.63		387.58		208.46		383.70	
Proportional Cost	.2243		.1147		.1525		.1202	

(Switch RT minus Repeat RT), with Condition (relational, semantic) as a within-subjects factor, and Age Group (younger or older) as a between-subjects factor. The main effect of Age Group did not reach significance, F (1, 28) =0.105, MSE=201322.5, p=.748. The effect of Condition was significant, F (1, 28) =4.185, MSE=71463.77, p=.050, indicating that switch costs for the relational condition were larger than those for the semantic condition. The interaction effect did not reach conventional levels of significance, F (1, 28) =3.960, *p*=.056. However, planned comparisons revealed that for older adults, switch costs in the relational and semantic condition were not significantly different, F (1, 28) =0.001, *p*= .979, whereas the younger had significantly larger switch costs in the relational compared to the semantic condition, F (1, 28) =8.725, *p*=.006.

In order to account for general slowing and to more accurately compare switch costs for younger and older adults, we ran a 2 X 2 ANOVA on the proportional switch costs (Switch RT minus Repeat RT divided by Repeat RT), with Condition (relational, semantic) as a within-subjects factor, and Age Group (younger or older) as a between-subjects factor. The proportional switch cost factors out the effects of processing speed. The main effect of Age Group did not reach significance, F (1, 28) =1.60, MSE=.075, p=.216, nor did the main effect of Condition, F (1, 28) =1.76, MSE=.016, p=.308. The interaction effect was not significant, F (1, 28) =1.465, MSE=0.022, p=.236. Planned comparisons revealed that for older adults, proportional switch costs in the relational and semantic condition were not significantly different, F (1, 28) =0.014, *p*= .906. The younger adults showed a trend towards larger proportional switch costs in the relational compared to the semantic condition, however, this did not reach significance, F (1, 28) =2.707, *p*=.111.

We submitted the accuracy data to a 2 X 2 X 2 repeated-measures ANOVA with Condition (relational, semantic) and Trial Type (repeat, switch) as within-subjects factors, and Age Group (younger or older) as a between-subjects factor. The results yielded only a main effect of Trial Type, $F(1, 28) = 17.186$, $MSE = 0.002$, $p < .001$, indicating that accuracy was higher for repeat trials than switch trials.

Correlations were performed on the Semantic and Relation Switch Costs and each of the neuropsychological tasks. Only those that reached significance are reported here. Scatterplots of the Trails Difference score and the Relational and Semantic Switch Costs for the younger and older groups can be seen in Figure 1. For the younger group, the Trails Difference score did not correlate with relational switch cost, $r = -.269$, $p = .313$, but correlated negatively with semantic switch cost, $r = -.499$, $p = .049$. For the older group, the Trails Difference score did not correlate with either semantic switch cost, $r = -.396$, $p = .161$, or relational switch cost, $r = .039$, $p = .895$. This correlation indicates that younger participants that were slowed by having to switch between numbers and letters on the CTMT had lower semantic switch costs.

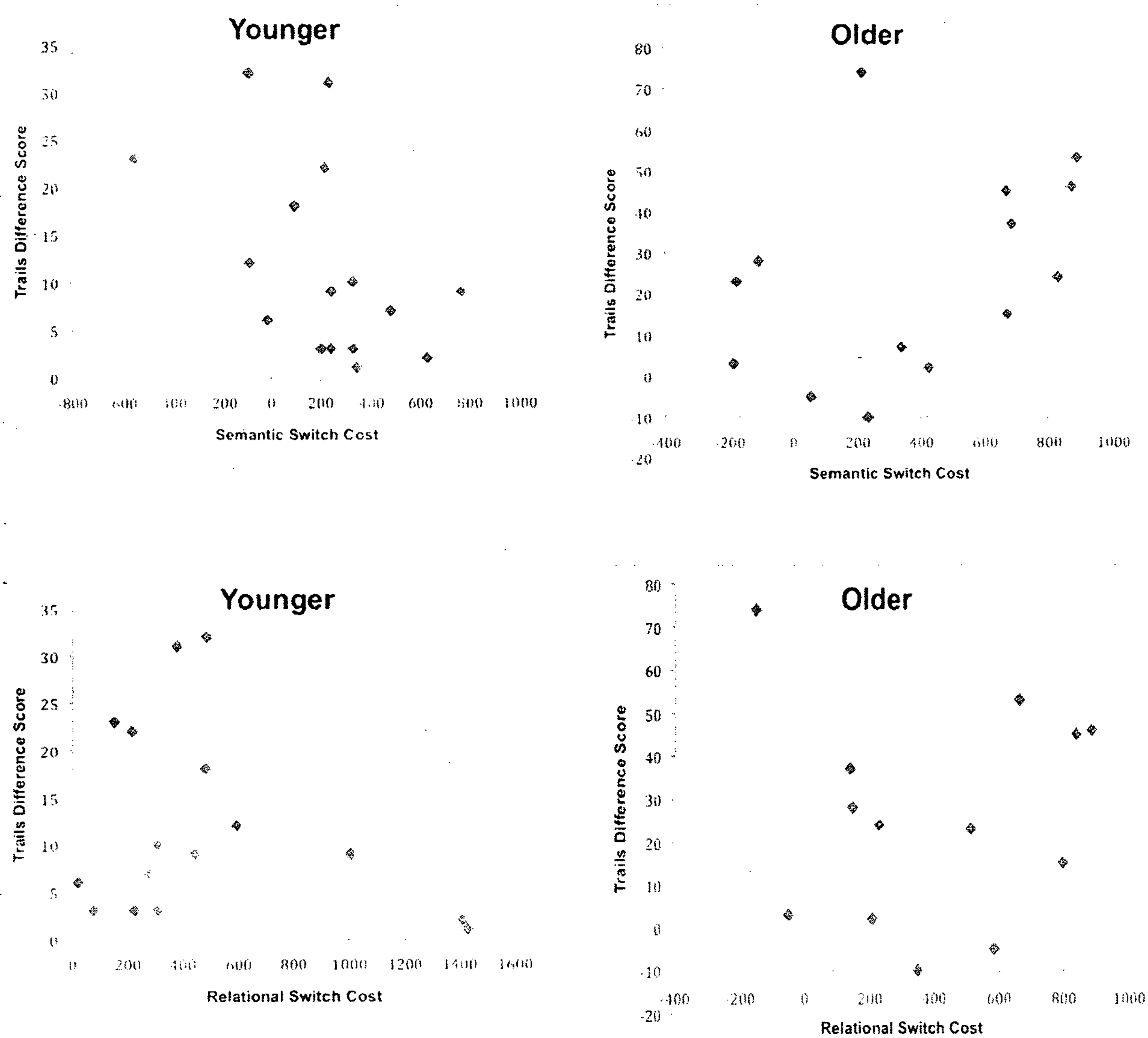

Figure 1. Scatterplots for the relationship between Trails Difference Scores and Semantic and Relational Switch Costs for the Younger and Older Participants.

Discussion

This study builds upon previous work by Taube-Schiff and Segalowitz (2005a,b) and Segalowitz and Frenkiel-Fishman (2005) who operationally defined language-specific attention control. Using a modified alternating-runs task, they showed that switching between relational elements requires language-specific attention control (Taube-Schiff & Segalowitz, 2005a). whereas switching between semantic elements does not (Segalowitz & Frenkiel-Fishman. 2005). This current study directly compared the results of older and younger adults on switching between relational and semantic elements, in order to examine whether language-specific attention control declines with age. In doing so, this study furthers our understanding of the relationship between language and attention control in aging.

In order to characterize the two groups (older and younger adults) we compared their performance on a number of neuropsychological tasks. Although the results from the Letter-Number Sequencing task did show age-related decline, interestingly, older adults performed similarly to younger adults on many of the other tasks, a finding that is at odds with the cognitive aging literature. This could indicate that our sample of older adults is particularly high functioning, which is consistent with their overall high education level. Indeed, results showed that the two age groups were similar in years of education, verbal intelligence, and English language proficiency.

On the Simon Task younger adults performed more quickly than older adults. However, the two age groups both took longer to respond to incongruent items than congruent items and this difference (the Simon effect) was the same for older and younger adults. Thus, the participants in both age groups were less able to inhibit the influence of the incongruent information, but age did not decrease inhibitory effectiveness. This finding is in contrast to other studies that have found that older adults demonstrate a larger Simon effect than their younger counterparts (e.g., Bialystok, Craik, Klein, & Viswanathan, 2004; Pick & Proctor, 1999;Vu & Proctor, 2008). For instance, Pick and Proctor (1999) conducted an experiment similar to the version used in the current study, as well as an auditory version. They found that older adults showed a greater Simon effect than younger participants in both tasks. This was the case even after correcting for the general slowing associated with aging. These previous research findings imply that age-related differences in the Simon task may occur when a single stimulus conveys more than one type of information, and these differences may be caused by an age-related decline in the processing resources available for cognitive tasks.

Older adults also did not show age-related deficits on the Comprehensive Trail Making Task, however there was a close trend for older adults to be slower on Trail 5, which required switching between numbers and letters, compared to Trail 2, which did not. Were this trend significant, it would suggest an age-related deficit in switching abilities. However, the current study is not alone in finding that no age-related differences in performance. Salthouse and colleagues (2000) used structural equation modelling to analyse the results of a variant of the Trail Making Test (called the Connections Test) and found that there were no direct effects of age on either the non-alternating or alternating versions of the Connections Test (which are similar to the original TMT Versions A and B, respectively); instead, all age-related effects were mediated through differences in perceptual speed.

In sum, the current findings from the neuropsychological data seem to indicate that our sample of older adults is particularly high functioning, which is consistent with their overall high education level, however there is evidence that the older adults had poorer working memory, and were not able to switch as efficiently as the younger adults on the CTMT.

Finally, the main goal of the study was to directly compare the performance of the two age groups on the language-specific attention control task. The results of the omnibus analysis of mean reaction time data reveals that overall the younger adults performed the task more quickly than older adults. Also, as expected, reaction times were faster for repeat than switch trials, indicating that the paradigm was successful in eliciting switch costs in both groups. Participants were also faster overall in the semantic than the relational condition, suggesting that processing relational elements is more difficult than processing semantic elements.

Analysis of the raw switch costs (Switch RT – Repeat RT) showed that both groups had larger switch costs in the relational than the semantic condition. We predicted that the older group would have similar switch costs in the semantic group compared to younger adults, larger switch costs in the relational condition compared to the younger adults, due to age-related declines in attention control, working memory and inhibition. Our results revealed that switch costs did not differ between the two age groups for either condition. However, for older adults, switch costs in the relational and semantic condition were not significantly different from each other, whereas the younger adults had significantly larger switch costs in the relational compared to the semantic condition. Contrary to our hypothesis, this suggests that the older adult group did not experience an additional burden on attention control when switching between relational elements of language, as compared to switching between semantic elements, whereas the younger adults group did. Interestingly, the correlational data indicate that, for older adults, the ability to efficiently switch between relational elements was related to working memory. This issue will be discussed more fully below.

We also analyzed proportional switch costs, (Switch RT – Repeat RT)/Repeat RT, in order to control for age-related differences in general speed. Previous research has shown that raw measures of switch cost, Switch RT – Repeat RT, which do not take baseline speed of responding into account, are sensitive to both specific (i.e., executive function) processes and processing speed (Kramer, Hahn, & Gopher, 1999). Analyses showed that proportional switch costs did not differ between the two age groups for either condition. Importantly, the results did show a trend in the younger group for larger proportional switch costs in the relational than the semantic condition, whereas there was no trend for older adults, paralleling the findings from the raw switch cost analyses. It is important to remember that the sample used is comprised of only 15 and 16 individuals in the older and younger group, respectively, and this small sample size has created a reduced power in the statistical analyses and increased the likelihood of type II error in the results. Nevertheless, the fact that the older group did not show a difference in proportional switch costs between the two conditions, while the younger group showed a trend towards a difference is consistent with the data from the raw switch cost analysis, suggesting that increased age confers a benefit on language-specific attention control. These conclusions were strengthened by the fact that the two groups did not differ on any of the conditions of the tasks in terms of accuracy, meaning that there was no speed-accuracy trade-off for either age group.

The data ruled out a potential alternative explanation for the results. The two age groups may have performed differently because they may differ in their basic ability to process the relational stimuli. The analysis of the data from the repeat trials ruled out this possibility. On repeat trials, no interaction effect between condition and age group was found, indicating that although processing the relational stimuli was slower than processing semantic stimuli, this was true for both age groups, and cannot explain the differences found in the analysis of the switch costs.

Our findings that older adults are equally efficient at switching between relational elements of language as they are at switching between semantic elements is striking, especially given the vast literature on age-related declines in many cognitive and language abilities. To be sure, many aspects of language ability decline with aging, but an equally intriguing finding is that general language comprehension remains relatively stable. One hypothesis is that older adults' increased experience with language has honed their language-specific attention control. Two reasons could underlie enhanced attention control for relational elements with increased age. Firstly, relational elements express a relatively small set of conceptual distinctions that apply to most object and relation categories. As such, in comparison to semantic elements, there are far fewer relational elements, and they are used more often and in more situations. For example, the semantic element *apple* refers singularly to the object, and upon encountering it in a sentence the reader would construct a mental representation of an apple. On the other hand, a relational element like *above*, refers to a location in space, but could be paired with any number of semantic elements, resulting in a myriad of mental representations (e.g., *the mirror was above the sink, the bird flew above the trees).* Additionally, many relational elements also have less concrete meanings such as, *He valued honesty above all else*, or, *It was 2 degrees above freezing*. Secondly, during comprehension, relational elements must be utilized to make sense of the more specific information conveyed by content words. Slobin (1996) hypothesizes that, because they must be continually taken into account, it is important that they are expressed by the most structural and obligatory part of language. Thus, older adults may have spent more time using relational elements than younger adults, and more time using them than using semantic elements, and this increased exposure may have resulted in better attention control.

Our correlational analysis provides some insight into the age differences found on the linguistic attention control task. We found that working memory and inhibition were not related to linguistic attention control for either of the age groups. This additional piece of information suggests that older adults need not be disadvantaged by declining cognitive abilities when processing relational elements of language.

Strengths and Limitations of the Study

One clear strength of the work is that it is the first time that linguistic attention control has been demonstrated using stimuli embedded in full sentences. Full sentences were used to increase generalizability. Language-specific attention control is needed in everyday conversation; when individuals engage in a conversation, the rapid stream of sentences will require attention control processes in order to shift between the various ideas being expressed. For example, in processing *The dog remained on the doorstep because the man wasn't home*, a person first has to focus attention on the spatial relationship between *dog* and *doorstep* (triggered by *on*) and then shift attention to the causal connection between the upcoming second clause and the first clause (triggered by *because*), and so forth. As hypothesized, shift costs were observed in both the relational and semantic conditions, confirming that the paradigm can be used with full sentences and remain sensitive to the attention shift manipulation.

It is also the first time that language-specific attention control has been examined in aging. Additionally, multiple cognitive abilities (working memory, attention control, conflict resolution) were examined, in order to get a clearer picture of the mechanisms involved in switching between relational elements of language. A major limitation of the current work is the small sample sizes. With more participants, more sophisticated analyses would be possible. Rather than correlations, hierarchical regression could be used to examine how language-specific attention control relates to non-linguistic cognitive abilities for the two groups. Additionally, although language proficiency and semantic word knowledge were examined, there were no tests examining knowledge of closed-class words. Including a measure like the Test for Reception of Grammar (TROG-2; Dorothy Bishop, 2003) would allow the measurement of how the understanding of grammatical, or relational elements, contributes to, or is necessary for attention control for these elements. The difference between knowledge of, and attention control for, is an important one, that could help explain why some studies find that grammatical abilities decline with age (e.g, Kemper, Thompson & Marquis, 2001), whereas others find no age-related differences (e.g., Wingfield & Stine-Morrow, 2000). Finally, our sample of older adults was particularly high functioning, as indicated by their performance on the neuropsychological tasks, as well as their generally high level of education. As such, our results may not generalize to all older adults.

Summary

The present study showed that older adults performed similarly when switching between judging semantic elements and judging relational elements of language, whereas young adults were significantly slower dealing with relational elements as compared to semantic elements. Additionally, the ability to switch between judging relational elements did not correlate with measures of working memory, inhibition, or general attention control. As this is a relatively new area of research, previous work has examined attention control for relational and semantic elements in young adults only, and has not attempted to correlate performance with non-linguistic cognitive abilities. Although further investigation and replication is required, these results have important implications for cognitive models of language comprehension, suggesting that language-specific attention control may attenuate age-related language declines in older adults.

The Effects of Bilingualism on Language-specific Attention Control

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Abstract

Recent research suggests that bilinguals have better executive control abilities in nonverbal tasks requiring conflict resolution, attention control and inhibition. This study seeks to examine how these executive control benefits may affect attention control specific to language. Relational elements of language act to direct attention to other aspects of the incoming message. The listener or reader must be able to use these elements to focus and refocus attention on the mental representation that is being constructed. Recent research has shown that this type of attention control is specific to language and can be distinguished from more general attention control. Sixteen monolingual adults (18-30 years) and sixteen bilingual adults (18-30 years) completed two conditions of a task switching paradigm. Bilingual participants completed an L1 and an L2 block. The relational condition involved processing spatial prepositions, and the semantic condition involved processing nouns and adjectives. Attention control was operationalized in terms of shift costs obtained in an alternating runs experimental design. Overall, bilingual participants performed similarly in L1 and L2, in both the relational and semantic condition. Furthermore, in their L1, they had similar switch costs in the relational and semantic conditions, whereas the monolingual participants had significantly larger switch costs (i.e., lower attention control) in the relational condition than the semantic condition.

The Effects of Bilingualism on Language-Specific Attention Control

At least half the world's population is bilingual to some degree (Baker & Jones, 1998) and this proportion is growing with increased geographic mobility. These trends point to a growing number of bilinguals living in Canada, and consequently to the need for greater understanding of the implications of bilingualism for cognitive functioning. Recent evidence points to differences between monolinguals and bilinguals on non-linguistic tests of executive functioning and attention control, with bilinguals performing significantly better than their monolingual counterparts (Bialystok, 2009). However, research to date has not directly examined how this benefit impacts or interacts with language processing skills *per se*. There is, therefore, a question of whether the bilingual advantage can be seen in specific linguistic attention control abilities, over and above enhanced general attention control itself. The present research examines whether bilinguals show superior linguistic attention control compared to monolinguals.

The Bilingual Advantage

Numerous studies have shown a bilingual advantage on executive control tasks (Bialystok, 2009). For example, Bialystok and colleagues (Bialystok, 1999; Bialystok & Martin, 2004) gave the dimensional-change card-sort task (DCCS; Zelazo, Frye, & Rapus, 1996) to 4- and 5-year-old children. In this task, children sort cards either by the color (red, blue) or shape (circle, square) of diagrams on the cards. Participants first sort by one dimension (e.g., color) but are later instructed to switch to the other dimension (e.g., shape). Young children typically persist in sorting by the original dimension. However, bilingual children were more successful in switching to the second dimension following the rule change, indicating higher levels of executive control. Carlson and

Meltzoff (2008) refined this position by demonstrating an advantage for 6-year-old bilingual children in executive-control tasks that require inhibition of attention to conflicting response options but not in tasks requiring inhibition of a habitual response to a familiar stimulus.

Research with adults has revealed similar results, showing, for example, that bilingual adults respond faster than their monolingual counterparts to conflict conditions in the Stroop task (Bialystok, Craik, & Luk, 2008a) and flanker task (Costa, Hernández, & Sebastián-Gallés, 2008). Bilinguals were less disrupted than monolinguals when the response to a stimulus required participants to ignore an irrelevant feature of the stimulus. Bialystok and colleagues (Bialystok, Craik, Klein, Viswanathan, 2004) had bilinguals and monolinguals complete several modifications of the Simon Task. In the simplest condition, one of two colored squares was presented in the center of a computer screen and the task was to press the corresponding response key as rapidly as possible. In another condition, the classic Simon task design was used. A colored square appeared at the side of the screen, either above the correct response key (congruent) or on the opposite (incongruent) side. The longer time needed to respond in the incongruent presentation compared to the congruent one is called the Simon effect; larger Simon effects imply greater difficulty in suppressing the irrelevant spatial information. In Bialystok and colleagues' (2004) study, there were no differences found between monolinguals and bilinguals on the simple condition, but the size of the Simon effect was larger for monolinguals than bilinguals.

Theories of the Bilingual Advantage

Studies hypothesize that this "bilingual advantage" stems from a history of managing two concurrently active languages (e.g. Bialystok, Craik, & Luk, 2008b; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Kroll, Bobb, Misra,& Guo, 2008). Better ability to deal with conflicting stimuli is thought to be tied to the fact that bilinguals need to hold two lexical representations in mind, switch between them whenever there is a need to respond in one language versus another, and inhibit the irrelevant language (Green, 1998). Recent research suggests that, for bilinguals, both languages are active when completing word recognition or language production tasks, even when only one language is required (Francis, 1999; Hermans, Bongaerts, de Bot & Schreuder, 1998; Van Heuven, Dijkstra, & Grainger, 1998). Additional evidence stems from studies involving word reception and production tasks that show cross-language interference (see reviews by Kroll et al., 2008). A recent example of such a study was conducted by Colomé and Miozzo (2010). In their study, proficient Spanish–Catalan speakers were presented with pairs of partially overlapping colored pictures and were instructed to name the green picture and ignore the red picture. In Experiment 1, distractor pictures with cognate names interfered more than distractor pictures with noncognate names. In Experiment 2, facilitation was observed when the names of the distractor pictures in the irrelevant language were phonologically related to the names of the target pictures. Overall, these results indicate that nontarget words are activated in the irrelevant language, at least in the case of proficient bilingual speakers -which supports the idea of two constantly active languages in bilinguals.

Although having to constantly switch between two language representations may be what confers the advantage in cognitive tasks, the studies demonstrating a bilingual benefit do not examine attention control per se. The majority of the studies fall into the category of inhibition or conflict resolution, rather than controlled switching between task sets. To date, only one study has directly examined the effects of bilingualism on attention control during task switching. Prior and MacWhinney (2010) cued university-aged bilinguals and monolinguals to judge the colour (Task A) or shape (Task B) of simple visual stimuli in randomly mixed heterogeneous blocks. Results showed that the two language groups performed similarly on repeat trials, but bilinguals were significantly faster on switch trials than monolinguals. Analysis of switch costs (switch RT minus repeat RT) revealed that the bilinguals did indeed incur smaller switching costs than the monolinguals, suggesting that bilingualism confers an advantage on attention control.

Bilingualism and Language

Bilingualism does not confer advantages in all cognitive abilities. Many studies of vocabulary knowledge report that bilinguals score lower in each of their languages than monolingual speakers of that language. Additionally, this deficit is found at all ages across the lifespan (Bialystok, 2001). A recent study examined vocabulary scores in English, with over 1700 children between the ages of 3 and 10 years old (Bialystok, Luk Peets & Yang, 2009). The study found that monolingual children scored higher than bilingual children at every age, even though all the bilingual children were fluent in English and used it daily at school (2009). Similarly, studies of language processing in adults have shown disadvantages for bilinguals in tasks that require rapid lexical access and retrieval. Even in their dominant language, bilinguals are slower and commit more errors in picture-naming, they score lower on verbal-fluency tasks, and experience more interference in lexical decision tasks (Michael & Gollan, 2005).

Bialystok and colleagues (Bialystok, Craik & Luk, 2008a) sought to examine whether the two conflicting influences (improved cognitive abilities, reduced language abilities) are found in the same individuals. They had younger and older monolinguals and bilinguals complete tasks assessing language proficiency, lexical access and executive functioning. The results showed that monolinguals performed better on the linguistic tasks, whereas bilinguals performed better on the executive tasks. Although these results appear to show that lexical and executive processes are independent, certain language processing tasks require executive control. One such task is the fluency task, where participants are given 60 seconds to generate words that belong to a particular category, such as animals. Because there are closer associations among names for animals than between the name of an animal and, for example, the name of a tool—the number of responses provides an index of vocabulary size or language proficiency. In comparison, for letter fluency tasks, participants are asked to generate words that begin with a particular letter, typically without using proper names, numbers, or variations on the same word (e.g., *take, takes, taking*). Letter-fluency tasks require monitoring and working memory, as well as effortful search through representational space (Bialystok, Craik & Luk, 2008b). As such, they assess both language proficiency and executive control of attention. Typically, bilinguals generate fewer words on the semantic-fluency task than do monolinguals, but sometimes perform as well as monolinguals on the letter fluency task (Rosselli, Ardila, Araujo, Weekes, Caracciolo, Padilla, & Ostrosky-Solis, 2000). This suggests that bilinguals are able to utilize their enhanced cognitive abilities to aid language performance.

Linguistic Theories of Relational Elements

Research on the relationship between language and attention has generally viewed language as a target of attention. For example, investigations of the relationship between visual attention span and reading in children (Bosse & Valdois, 20009), or studies exploring how attention deficits negatively impact language comprehension in aphasic adults (Murray, 1999). In the case of bilinguals, others have studied people's ability to attend to which language to respond in (Christoffels, Firk & Schiller, 2007). In all such research, attention is seen as a focusing mechanism directed toward some aspect of language as a target. An additional component involved in the interplay between language and attention has emanated within the field of cognitive linguistics (Talmy, 1996, 2000; Langacker, 1987). The idea put forth is that although attention is focused on language, certain aspects of language act as attention-directing mechanisms themselves. Speakers normally use language to draw attention to objects and events by naming them. However, speakers also use language to convey how they *construe* relationships between objects and events.

These attention-directing elements of language direct the listener to make particular focal adjustments (Langacker, 1987). Talmy (2000) refers to this phenomenon as the "windowing of attention", wherein any aspect of the sentence can be "windowed" or highlighted in particular ways. This theory is derived from the longstanding view in the field that language consists of two separate subsystems: the first containing "open-class" elements and the second consisting of "closed-class" elements. Open-class elements are the roots of nouns, verbs and adjectives. They are so called because this category of words can be added to; for example, recent additions like: *email, ringtone,* or *computer.*

Closed-class elements, on the other hand make up a much smaller group, are generally stable, and are difficult to add to. They consist of, but are not limited to, prepositions (e.g., *in* , *with*), determiners (e.g., *both, some*), conjunctions (e.g., *and, but*) and pronouns (e.g., *he, she*).

It has been proposed that the attention directing mechanism of language is driven by certain relational elements in the closed-class system. These relational devices for directing attention include prepositions, verb aspect, definite and indefinite articles, tense markers, and word order. They cannot be experienced in a direct manner (i.e., perceptually), but instead shape the way the recipient construes the scene. For example, "*Matthew called his fiancée despite their argument*" compared to "*Matthew called his fiancée because of their argument*". *Despite* and *because of* do not direct attention to specific images or concepts, but they do shape how the reader construes the scene, through defining the relationships amongst the semantic elements. As a message unfolds, attention has to be redirected to the content (semantic information) to update the mental representations. This is done in order to take into account the newly highlighted relationships among the semantic elements. In other words, there is a continuous focusing and refocusing of attention as relational elements in the message are encountered.

Task switching and Language-specific Attention Control

Recently, Taube-Schiff and Segalowitz (2005a), using a modified alternating runs design switching task (based on that of Roger's & Monsell, 1995), examined the ability to switch between the attention directing properties of relational elements. English monolingual participants switched between two tasks – Task A (making an *above-below* judgment) and Task B (making a *past-present* judgment) – in a predictable, AABBAABB sequence. Every second trial is was a repeat (R) of the previous task type or a switch (S) to the other task type, resulting in an SRSRSR sequence. This sequence allowed the comparison of reaction times for repeat and switch trials within a single condition, and as a result, a switch cost (Switch RT – Repeat RT) could be calculated. Taube-Schiff and Segalowitz found significant switch costs for the contextualized relational stimuli, indicating the appropriateness of the alternating-runs design for studying issues concerning language, and linguistic attention control.

Often, relational elements, in contrast to non-relational or lexical elements, do not correspond directly across languages. This, combined with the fact that relational elements cannot be directly sensed or experienced in a perceptual manner, makes them inherently more difficult to master in a second language (L2) than non-relational elements, or than relational elements in a first language (L1). According to Slobin (1996), the difficulty is caused by the fact that relational elements only exist through language, and therefore they can only be learned through extensive language experience.

Segalowitz and Frenkiel-Fishman (2005) used an alternating runs design similar to that of Taube-Schiff and Segalowitz (2005a) with decontextualized relational stimuli (time adverbials and causal conjunctions), in order to examine whether linguistic attention control was a significant factor underlying bilingual proficiency. Their results showed that L2 shift costs for relational words correlated strongly with L2 proficiency, after controlling for performance in the L1. Taube-Schiff and Segalowitz (2005b) hypothesized that attention control differences in the processing of relational elements may exist between an asymmetrical bilingual's dominant L1 and weaker L2. They had participants complete a relational and semantic condition, in L1 and L2, using stimuli contextualized in short phrases. For the relational condition, participants switched between classifying spatial location in the vertical dimension (as "higher" or "lower") and relative spatial proximity (as "close" or "distant"). For the semantic condition the switch between classifying types of vehicles (as being "two-wheeled" or "four-wheeled") and modes of transportation (as involving "air travel" or "sea travel"). This was done separately in L1 and L2 blocks. Participants showed significantly lower attention control (larger switch costs) for relational elements in the L2 block compared to in L1, and no difference between L1 and L2 switch costs for semantic elements. Based on these results, and the results from Segalowitz and Frenkiel-Fishman (2005), they concluded that because switch costs for semantic stimuli were not related to participants' language skill, they must reflected general (non-linguistic) attention abilities, whereas switch costs for relational stimuli reflect language-specific attention control.

In summary, previous research reports a bilingual advantage in various non-linguistic cognitive abilities, which putatively stems from the need to control two language systems by recruiting executive processes. To date, no study has directly examined the potential benefits to language processing skills *per se*. Segalowitz and colleagues (Segalowitz & Frenkiel-Fishman, 2005; Taube-Schiff & Segalowitz, 2005a; 2005b) designed tasks that suggest the existence of a form of linguistic attention that is specific to the relational elements of language, and is related to linguistic proficiency in one's L2. Additionally, they found a significant relationship between participants' performance on tasks of attention shifting with relational linguistic stimuli in L2 and their proficiency in L2, which was not observed for semantic stimuli. However, what past research has not examined is whether bilinguals show greater linguistic attention control, in the form of lower switch costs on relational elements, than monolinguals. We therefore designed the present study to compare English monolinguals and English-French bilinguals' ability to switch between relational elements of language.

In the present experiment we used an alternating runs design similar to that of Taube-Schiff and Segalowitz (2005b), with a relational and semantic condition. We combined the semantic and relational stimuli in each sentence, so that the sentences were the same across the two conditions, eliminating any differences between the conditions that could be caused by sentence length or difficulty. In addition, every trial in each condition contains task-relevant and task-irrelevant stimuli, eliciting the need for conflict resolution. Each sentence contained a verticality and proximity preposition, and a size and category word, along with filler words. For example, *They located the little watch far above the window*, contains the verticality preposition *above*, the proximity preposition *far*, an adjective indicating the size *small*, and the noun *watch*, which is an inanimate object. For the relational condition, in one subtask they were cued to respond to the proximity prepositions embedded in the sentences (*way, far, a bit, just*), and in the second subtask they were cued to respond to the verticality prepositions (*above, over, below, under*). As in Taube-Schiff and Segalowitz (2005b) the semantic condition was used as a control condition, in order to account for general attention control abilities. In this condition, participants were cued to respond to either the size (*tiny, small, big, fat)* or the category (*watch, glove, dog, pig*) of the noun embedded in the sentences. For both conditions, subtasks followed an AABB alternating runs design, such that every other trial was either a repeat or a switch. Taube-Schiff and Segalowitz (2005 a,b), employing an alternating-runs design, found significant switch costs using similar stimuli embedded in short phrases. The present experiment attempted to replicate this finding, by comparing the L1 and L2 performance of the bilingual participants, using complete and transparent sentences (the same sentences were used for all tasks in all conditions). Furthermore, the current study aims to directly compare the performance of monolinguals and bilinguals on the L1 version of the task. The rationale for this direct comparison is to examine whether a bilingual benefit will be found for language-specific attention control. We also had participants perform several neuropsychological tasks, measuring language, and executive control abilities, in order characterize the two groups on cognitive abilities such as working memory, language proficiency, conflict resolution, and executive function, and to examine how these cognitive abilities correlate with performance on the language-specific attention control task.

Methods

Participants

Thirty-two younger adults, ranging in age from 18-35 years were tested. Of this group, 16 were English/French bilinguals (mean age = 23.25, sd = 4.15, female=56.3%) and 16 were English monolinguals (mean age = 22.25, sd = 4.48, female = 43.7%). Participants were paid CAD$10/hour or received partial credit for course fulfillment for taking part. Inclusion criteria for all participants included self-reported good health, and no prior history of head injury, medical illness, or chronic use of medication that might affect cognitive functioning.

Language-related inclusion criteria for bilinguals required moderate to high proficiency in L2 and high proficiency in L1, measured using self-report, and an animacy judgment task (administered during the testing session). All bilinguals had learned French before the age of 9, and became fluent in French before the age of 13. They also were actively using French in at least one area of their life (i.e., at work, in the home or with friends). Since the neural mechanisms underlying language processing in multilinguals is yet to be fully understood (Abutalebi, Cappa, Perani, 2001) only participants with minimal competency in additional languages were retained for the study, in order to reduce any possible confounds due to multilingualism. For monolinguals, some exposure to French was allowed, as long as the participants did not consider themselves fluent, or use French regularly in any area of their life. Within the bilingual group, 7 participants learned English first, 6 learned the two languages simultaneously, and 3 felt that they had learned French first; however all bilingual participants rated English to be their most dominant language, and they either had, or were currently, attending university in

English. As such, in this study, L1 refers to English. Additionally, the 3 participants who learned French first, learned English at the ages of 3, 3, and 5. Table 1 shows means and standard errors for age, years of education, L2 self-rating, and L2 age of acquisition for both language groups.

Apparatus

All computerized tasks were presented using Millisecond Software Inquisit Version 2.0.61004.7 on a Dell Computer with a 33 cm x 24 cm screen. Participants responded to stimuli using a Logitech gamepad.

Measures

Testing consisted of: the Montreal Cognitive Assessment (MoCA; Nasreddine, Phillips et al., 2005) to assess overall cognitive functioning, the Vocabulary task from the WAIS-III (Wechsler, 1997) and an animacy judgment task to assess relative language proficiency (Segalowitz, & Frenkiel-Fishman, 2005), a computerized Simon Task (Bialystok et al., 2004), and the Comprehensive Trail Making Test (CTMT; Reynolds, 2002) as measures of general attention control, the Letter-number Sequencing (LNS) task from the WAIS-III (Wechsler, 1997), as a measure of working memory, and the experimental LSAC task.

Neuropsychological tasks.

MoCA (Nasreddine, Phillips et al., 2005). The MoCA is a 10-minute cognitive screening tool, able to detect mild cognitive impairment with a sensitivity of 90%. It tests several cognitive domains, including: visuospatial/executive control, naming ability, memory, attention, language, abstraction and orientation. It is scored on a 30 point scale,

Table 1

Means and Standard Errors for Age, Years of Education, L2 Self-rating, and L2 Age of Acquisition for Both Language Groups

	Monolingual		Bilingual	
	Mean	*SE*	Mean	*SE*
Age *(years)*	22.25	*1.12*	23.25	*1.04*
Education *(years)*	14.94	*0.36*	15.75	*0.45*
MoCA (*max 30*)	28.00	*0.32*	28.19	*0.31*
L2 self-rating *(max 5)*	1.42	*0.17*	4.47	*0.16*
L2 Age of Acquisition *(rt)*	N/A	*N/A*	1.63	*0.68*

where a score equal to or greater than 26 is considered within normal range. One bilingual participant was excluded from the study for having a score below 26.

CTMT (Reynolds, 2002). The CTMT is a standardized set of five sequencing and visual search tasks. Participants must connect a series of stimuli (Trails 1-3: numbers, Trail 4: numbers expressed as numerals or in word form, Trail 5: numbers and letters) in a specified order as quickly as possible. For this study we analyzed only Trails 2 and 5. On Trail 2 participants must connect the numbers 1 to 25, in order. The trail also contains distractor circles containing non-numerical symbols. On Trail 5, participants must connect the numbers 1 to 13 and letters A to M, by alternating between the numbers and letters in order (e.g., from 1 to A, A to 2, 2 to B, etc). This trail also utilizes distractor circles containing non-numerical symbols A Trails Difference Score (Trail 5 RT minus Trail 2 RT), provides a measure of switching ability, while taking baseline performance into account. This analysis is comparable to the original Trail Making Tests Trails A and B (Reitan, 1955). The original Trail Making Test has been extensively used in research in neuropsychology, in part because it has been postulated to reflect executive processes, such as planning and switching.

***2 Wechsler Adult Intelligence Scale III (WAIS-III) tasks: LNS & Vocabulary* (Wechsler, 1997).** These tasks were administered according to standardized procedures. The WAIS-III is a standardized battery of tests that measures different aspects of cognitive ability. The *LNS* assesses working memory and attention. Participants are read increasingly longer series of numbers and letters, presented in a set random order. They must then repeat back the numbers, in numerical order, followed by the letters in alphabetical order. There are seven blocks of increasing length, with three trials per block. Participants were given one point for every correct trial, and the total number of correct trials was recorded. *Vocabulary* assesses the ability to comprehend and verbally express vocabulary.

Computerized tasks.

Animacy judgment task (Phillips, Segalowitz, O'Brien, & Yamasaki, 2004; Segalowitz, & Frenkiel-Fishman, 2005). This task was used as an objective measure of language proficiency (see Segalowitz & Frenkiel-Fishman, 2005). Participants are asked to classify an animate or inanimate object (L1 and L2 conditions). Reaction time in the L1 and L2 conditions was used as a measure of lexical access measurements, while the coefficient of variation (CV; mean RT/sd RT) provided a measure of efficiency, or stability, of lexical access.

As used here, this task consisted of three conditions (Neutral, L1 and L2), each with 8 practice trials followed by 64 trials. The neutral condition allowed participants to become familiar with the task, by indicating whether stimuli were numbers or letters. L1 words were preceded by the articles *the* and *a*, and L2 words were preceded by the articles *le* or *la* and *un* or *une*, counterbalanced across animate and inanimate nouns. These articles were used to highlight the English/French character of the target words and to ensure that English words were read as nouns, as opposed to verbs, since many English nouns can be interpreted as verbs (e.g., *cook*). There were no translation equivalents between the L1 and L2 versions. The task was designed such that the two language conditions were balanced in terms of the number of animate and inanimate nouns.

Stimuli were presented in the centre of the screen in white, Arial font of 18 logical units in height and thickness of 600/900, against a black background. Stimuli remained onscreen until a response. There was a 300 ms interval between the participant's response and onset of the following stimulus. For the Neutral condition, participants had to classify a single stimulus as being either a number or a letter, by pressing the right or left button on the gamepad. The right button corresponded with number, and the left button with letter. For the L1 and L2 conditions, participants had to judge whether a noun was a living or nonliving object. Participants responded using the left button on the gamepad to categorize the noun as an animate object and the right button key to categorize the noun as an inanimate object. The neutral condition was always administered first, whereas the L1 and L2 conditions were alternated in a counterbalanced fashion.

The Simon Task (Simon & Rudell, 1967; Bialystok et al., 2004). This task was used to assess inhibition of an irrelevant stimulus element, and permit comparison with previous findings. This task allowed comparison of RTs on trials where target location was congruent with correct response side to those where it was incongruent. Participants were required to indicate whether the stimulus was a red (right response button) square or a blue (left response button) square regardless of where it appeared on the screen. A white fixation cross appeared for 800 ms, followed by a blank black screen for 150 ms, then the red or blue square remained on screen until the participant responded or 1000 ms passed. A response-stimulus interval of 500 ms was used. On half of the trials the square's location on the screen was congruent with the response button side, and on half of the trials it was incongruent. Congruent and incongruent trials and red and blue stimuli appeared in a random sequence.

Experimental computerized task.

Language-specific attention control task. The present task was a modified version of the design of Taube-Schiff and Segalowitz (2005b), which itself was based on the Rogers and Monsell (1995) alternating runs design. Stimuli can be seen in Table A1. The task consisted of a relational and a semantic condition, each containing two tasks. For each condition, the tasks alternated in an AABB design, such that every other trial was a task repetition (e.g., AA) or switch (e.g., AB). Switch costs are the difference between RT on trials that are repeats compared to those that are shifts. On each trial, a cue indicating which task to perform appeared at the top of the screen. After 1300 ms a sentence appeared in the middle of the screen and remained on screen until a response was made. The next trial began after a 250 ms post-trial pause. In order to minimize working memory load, we placed key assignment reminders at the bottom left and right side of the screen, corresponding to the left and right response buttons on the gaming remote. In each condition, the key assignment reminders for both tasks remained visible at all times.

The same set of sentences was used in the relational and semantic conditions; only the cue indicating which task to perform was different. As such, each sentence afforded any of the four judgment tasks. The sentences were in white, Arial font of 30 logical units in height a font weight of 700, against a black background. Sentences consisted of a person or group of persons, a verb indicating that they were looking or searching, the semantic condition size adjective (small, tiny, fat or big), the semantic condition category noun (dog, pig, watch, or glove), the relational condition proximity preposition (just, a bit, well, way), the relational condition verticality preposition (above, over, under, below) and a location. For example, *"They located the tiny glove far above the window"*. A list of all L1 sentences can be seen in Table A2, and a lost of all L2 sentences can be seen in Table A3. As much as possible, the stimuli used in the L2 versions were direct translations of the L1, however, as noted in Taube-Schiff and Segalowitz (2005b), proximity and verticality prepositions in English and French do not correspond exactly to each other. The stimuli chosen for this study were chosen for their relative ease of processing by even moderately skilled bilinguals, and did not pose any systematic cross-language differences in the way they are typically used.

Sentences were constructed a priori in a counterbalanced manner to ensure that all target stimuli were equally paired together, and equally paired with the filler words. One exception is that the stimuli for the two tasks in each condition were incongruent with respect to their stimulus-response mappings So, the words indicating large size were always paired with the animal category, small size with the object category, distant with higher, and close with lower. The rationale for this is that all stimulus-response mappings were incongruent, a manipulation known to increase switch cost (Rogers & Monsell, 1995). For example, if during the semantic condition a right key press indicated *large* for the size task, and a left key press indicated *small*, then a right key press would indicate *object* for the category task, and a left key press would indicate *animal*.

Task cues were either red or blue, and written in capital letters, Arial font of 52 logical units in height and a font weight of 800. The cues for the relational condition tasks were *position* and *distance*. The cues for the semantic condition tasks were *category* and *size* (in L2: *position*, *distance*, *categorie* and *taille*). The key assignment reminders corresponded in colour to the relevant task cue. The reminders for the relational tasks were, *higher, lower, close, distant,* and for the semantic tasks were, *animal, object, big* and *small.* The L2 key assignment reminders (*position superieure, position inferieure, proche, éloigné, animal, objet, taille importante, taille faible*) were necessarily more formal than their L1 counterparts, due to the smaller L2 vocabulary to choose from, and the criteria that none of the key assignment reminders appeared as target stimuli in the phrases.

Monolingual participants completed the two conditions in English, whereas bilingual participants also completed the French versions of the two conditions, for a total of four conditions. A training stage was completed prior to each experimental block. In the training stages, participants practiced each sub-task separately, in order to become accustomed to the task cues and key reminders. Participants completed enough training trials of each task to demonstrate that they understood the task, as determined by the experimenter. Following this, participants completed practice trials simulating the experimental conditions. The practice trials required switching between the two tasks (following an AABB pattern), and also contained "catch trials". Catch trials were used to encourage participants to read the entire sentence. In a catch trial, a random, non-stimulus word was miss-spelled. To move past a catch trial, and on to the next trial, required the participant to press the "3" key on the gamepad.

The experimental conditions consisted of 24 warm-up trials, 12 at the beginning of the condition, and 12 after a break in the middle. Within each of the 12 practice trials there were 4 catch trials. The rest of each condition consisted of 72 test trials. Trials were presented in a counterbalanced manner to account for left and right side responses (no more than four consecutive left or right button presses were ever required). Key assignment and order of conditions were counterbalanced across participants.

Procedure

Participants were contacted by phone to complete the Language and Health Questionnaire (Appendix B), to assess that they met all inclusion/exclusion criteria. Participants who met the criteria were tested on one occasion, lasting 1.5-2 hours for bilingual participants, and 1 hour for monolingual participants. Participants were seated in a comfortable chair and informed consent (Appendix C) was obtained at the beginning of the session. They were encouraged to ask any questions or express any concerns before testing began. Order of task administration can be seen in Appendix D. The MoCA was administered first, in order to ensure that no participants were suffering from cognitive impairment prior to completing the remainder of the tasks. Following this, they completed the animacy judgment task, to determine their level of proficiency in the two languages. Next, participants completed one practice and one experimental condition of the language-switching task. The order of the conditions was counterbalanced so that half of monolingual participants completed the relational condition first and half received the semantic condition first. For the bilingual participants, the order was further divided so that half of the participants completed the L2 conditions first, and half completed the L1 conditions first.

After completing one block of the language-switching task, monolingual participants completed the WAIS-III LNS and Vocabulary tasks, the Stroop Task, the Simon Task, and the CTMT. Finally, they completed the second practice and experimental conditions of the language-switching task. Bilingual participants completed the first condition of the LSAC task, the two WAIS-III tasks, and then completed their second condition of the language-switching task, the Stroop Task, the Simon Task, the third condition of the language-switching task, the CTMT, and finally the fourth condition of the language-switching task. Participants were given a debriefing sheet, and any questions or concerns they had were addressed.

Results

For all statistical tests reported below, the alpha level for significance was set at .05. All t-tests are two-tailed.

Neuropsychological Testing

Means and standard errors for the Neuropsychological test data are presented in Table 2. Independent t-tests revealed that the two language groups did not differ on the Vocabulary task (p=.262), the LNS task (p=.839), the Simon Task (Congruent trials, p=.917; Incongruent trials, p=.479; Incongruent-Congruent, p=.381) or the Comprehensive Trail Making Test (Trail 2, p = .551; Trail 5, p=.481; Trail 5 – Trail 2, p=.220).

Animacy Judgment Task

Mean and standard error for RT, accuracy, and coefficient of variation (CV) for the Animacy Judgment task can be seen in Table 3. Mean RTs on correct responses were calculated for each participant. Outliers (below 200 ms and larger than 2 standard deviations above the mean) were removed for each individual in each condition. The animacy judgment task was used as an objective measure of language fluency and proficiency. It allowed the ability to ensure: that bilingual participants were comparable to monolingual participants in L1 proficiency, that bilinguals had high L2 proficiency, and, that the monolingual participants had minimal proficiency in L2. The RT, accuracy, and CV data were submitted to three separate 2X2 repeated measures Analysis of Variance (ANOVA), with Language Condition (L1, L2) and Language Group (bilingual, monolingual) as factors. The RT data were used as a speed index of proficiency, whereas the CV data provide a measure of cognitive efficiency (Segalowitz & Frenkiel-Fishman,

Table 2

Means and Standard Errors for Neuropsychological Test Data for Bilingual and Monolingual Participants

	Monolingual		Bilingual		
	Mean	*SE*	Mean	*SE*	*p*
Vocabulary *(max 60)*	55.88	*4.87*	53.13	*8.29*	0.262
LNS *(max 21)*	13.88	*3.67*	14.13	*3.20*	0.839
Simon Congruent *(rt)*	397.74	*55.92*	399.89	*57.73*	0.917
Simon Incongruent *(rt)*	424.92	*50.56*	438.40	*54.05*	0.479
Simon Difference (*Incongruent – Congruent)*	27.18	*40.39*	38.51	*29.11*	0.381
CTMT Trails 2 *(rt)*	48.75	*12.96*	51.53	*12.72*	0.551
CTMT Trails 5 *(rt)*	49.81	*9.85*	47.27	*10.00*	0.481
CTMT Difference *(Trail 5- Trail 2)*	1.06	*12.90*	-4.27	*10.55*	0.220

Table 3

Mean and Standard Error of RT, Accuracy, and CV Data for the Animacy Judgment Task, for Bilingual and Monolingual Participants

		Monolingual		Bilingual	
		Mean	*SE*	Mean	*SE*
RT					
	L1	721.16	*40.49*	745.18	*35.27*
	L2	1055.05	*66.21*	791.88	*47.92*
Accuracy					
	L1	0.94	*0.01*	0.96	*0.01*
	L2	0.75	*0.03*	0.95	*0.01*
CV					
	L1	0.29	0.29	0.25	*0.03*
	L2	0.34	0.34	0.27	*0.03*

2005). The CV (each individual standard deviation of RT divided by mean RT) provides a measure of the variability of performance per millisecond of RT. A lower CV (i.e., lower variability) indicates more stable and efficient processing (see Segalowitz & Segalowitz, 1993).

For RT, the main effect of Language Group approached significance $F(1,28)=3.790$, $p=.062$, with an overall trend for bilinguals to have quicker RTs. There was a significant effect of Language Condition, $F(1,28) = 48.687$, $p<.001$, with RTs in the L1 condition being faster overall than RTs in the L2 condition. Most importantly, the Language Condition by Language Group interaction was significant, $F(1,28)= 27.484$, $p<.001$. Planned comparisons revealed that, for bilinguals, RTs were not significantly different in the two conditions ($p=.215$), whereas monolinguals had significantly longer RTs in the L2 condition ($p<.001$). Additionally, bilingual and monolingual participants did not differ in the L1 condition ($p = .724$).

For accuracy, the main effect of Language Group was significant, $F(1, 28) =35.793$, $p < .00$, with bilinguals showing higher accuracy than monolinguals. The main effect of Language Condition, was significant, $F(1,28) = 58.813$, $p <.001$, with higher accuracy in the L1 condition. The Language Condition by Language Group interaction was significant, $F(1, 28) =44.223$, $p < .001$. Planned comparisons revealed that, bilinguals were equally accurate in the two language conditions, ($p=.626$), whereas monolinguals were significantly less accurate in the L2 condition compared to the L1 condition ($p<.001$).

The analysis of the CV data revealed that the main effect of Language Group was not significant, $F(1,28)=2.542, p=.122$. There was a significant effect of Language Condition, $F(1, 28) = 5.155, p = .031$, with lower CVs overall in the L1 condition. The Language Condition by Language Group interaction was not significant, $F(1,28)=0.583$, $p = .452$, however planned comparisons revealed that, for bilinguals, CVs were not significantly different in the two conditions ($p=.279$), whereas monolinguals had significantly larger CVs in the L2 condition ($p = .047$).

Language-Specific Attention Control Task

Calculating RTs and removing outliers. For all analyses, the mean RT and accuracy were calculated separately for each of the 8 cells formed by crossing task (proximity, verticality, size and category) by trial type (repeat and switch). To remove outlier trials within a participant's data set, responses faster than 200ms and slower than 2 standard deviations above the mean were removed. Finally, only correct RTs were used to calculate the means, and any incorrect trial following an error was omitted.

Comparing tasks across L1 and L2 blocks for bilinguals. Table E2 contains means and standard errors for RT data for all trials in the L1 and L2 blocks for bilingual participants. In order to verify whether we could collapse the two tasks in each condition, the relational and semantic conditions for the L1 and L2 blocks were submitted to 2 separate ANOVAs with Trial (repeat, switch), Task (proximity, verticality; category, size) and Language block (L1, L2) as within-subjects factors.

For the relational condition, there was a significant difference overall for between the L1 and L2 blocks, $F(1, 15) = 12.34, p = .003$, indicating that RTs were higher overall in the L2 block. There was no significant difference overall between the proximity and verticality tasks, $F (1, 15) = 0.04$. $p = .853$. There was a significant Trial effect, indicating that RTs on switch trials were significantly slower than on repeat trials, $F (1, 15) = 37.54$, $p < .001$. The interaction between Task (proximity, verticality) and Language block was not significant, $F (1, 15) = 0.02$, $p = .891$, however the interaction between Trial and Task approached significance, $F (1,15) = 4.16$, $p = .060$. The three-way interaction between Language block, Task and Trial type, $F (1,15) = 0.06$, $p = .811$, was not significant.

Analysis of the semantic condition revealed that there was no significant difference overall for between the L1 and L2 blocks, $F (1, 15) = 1.26$, $p = .279$. There was no significant difference overall between the size and category tasks, $F (1, 15) = 0.66$, $p = .429$. There was a significant Trial effect, indicating that RTs on switch trials were significantly slower than on repeat trials, $F (1, 15) = 15.10$, $p = .001$. The interaction between Task (size, category) and Language block was not significant, $F (1, 15) = 0.01$, $p = .917$, however the interaction between Trial and Task approached significance, $F (1,15) = 4.08$, $p = .062$. The three-way interaction between Language block, Task and Trial type, $F (1, 15) = 1.73$, $p = .811$, was not significant.

Comparing tasks across L1 conditions for bilinguals and monolinguals. Table E3 contains means and standard errors for RT and accuracy data for all trials in the L1 block for monolingual and bilingual participants. The data for each L1 condition were submitted to 2 separate 2 X 2 X 2 repeated measures ANOVAs, with Trial (repeat, switch) and Task (proximity, verticality; category, size) as within-subjects factors, and Language Group (bilingual, monolingual) as a between-subjects factor.

For the relational condition, there was no significant difference overall for between the bilinguals and monolinguals, $F (1, 30) = 2.65$, $p = .114$. There was also no significant difference overall between the proximity and verticality tasks, $F(1, 30) = 0.71$, $p = .406$. There was a significant Trial effect, indicating that RTs on switch trials were significantly slower than on repeat trials, $F(1, 30) = 35.64$, $p<.001$. The interaction between Language group and Trial was not significant, $F(1, 30) = 1.51$, $p = .228$. The interaction between Task (proximity, verticality) and Trial was significant, $F(1, 30) = 6.85$, $p = .014$, indicating a non-significant trend for shorter reaction times of proximity repeat trials than verticality repeat trials ($p = .068$). The three-way interaction between Language Group, Trial and Task was not significant, $F(1, 30) = 2.30$, $p = .140$.

Analysis of the semantic condition revealed that there was no significant difference overall for between the bilinguals and monolinguals, $F(1, 30) = 0.05$, $p = .823$. There was also no significant difference overall between the size and category tasks, $F(1, 30) = 2.35$, $p = .135$. The analysis yielded a significant Trial effect, indicating that RTs on switch trials were significantly slower than on repeat trials, $F(1, 30) = 24.87$, $p<.001$. The interaction between Language group and Trial was not significant, $F(1, 30) = 0.30$, $p = .591$. The interaction between Task (proximity, verticality) and Trial was not significant, $F(1, 30) = 1.27$, $p = .269$. The three-way interaction between Language Group, Trial and Task was not significant, $F(1, 30) = 0.00$, $p = .1983$.

Preliminary analysis of switch costs and accuracy data. Preliminary tests were conducted to examine whether the design yielded switch costs (a positive number when subtracting repeat trials from switch trials) in the relational and control conditions, separately for the two groups, and in both languages for the bilingual participants (Table E2, E3). Inspection of the data indicates that 16 out of 16 monolinguals and 13 out of 16 bilinguals showed longer RT for switch than repeat trials in the relational condition, while 12 out of 16 monolingual participants and 14 out of 16 bilingual participants longer RT for switch than repeat trials in the semantic condition. For the L2 conditions, 14 out of 16 bilinguals showed longer RT for switch than repeat trials in the relational condition, and 13 out of 16 showed longer RT for switch than repeat trials in the semantic condition. Importantly, a priori t-tests of mean switch versus mean repeat RTs in each of the conditions yielded significant switch costs in each condition, $p<.016$ in all cases. Analysis of the accuracy data indicates that the two groups had very high accuracy for both repeat and switch trials in the two conditions, as well as for the L2 language block for bilinguals (> 99% for all trial types).

Bilingual group analysis: L1 vs. L2.

Accuracy. Table 4 shows means and standard errors for percent accuracy, for repeat and switch trials for the bilingual group in the L1 and L2 blocks. These data were submitted to a 2 x 2 x 2 repeated-measures ANOVA, with Language block (L1, L2), Condition (relational, semantic), and Trial Type (repeat, switch) as factors. The accuracy analysis results yielded no significant effect of Language block, $F(1, 15) = 0.14, p = .716$. There was no significant effect of Condition $F(1, 15) = 0.67, p = .427$. There was a significant effect of Trial Type, with more errors made on switch trials, $F(1, 15) = 13.56, p = .002$. None of the interactions were significant, all *ps* >.369.

RT. Figure 1 shows means and standard errors for switch cost data for the bilingual group in the L1 and L2 blocks. These data were submitted to a 2 × 2 repeated ANOVAs, with Language block (L1, L2) and Condition (relational, semantic) as factors. The switch costs analysis results yielded no significant effect of Language block, $F(1, 15) = 1.37, p = .260$.

Table 4

Mean and Standard Error for Accuracy of the Switch Cost Data for L1 and L2 Blocks of the Linguistic Attention Shifting Task, for Bilingual Participants

		Accuracy (% correct)			
		L1		L2	
		Mean	*SE*	Mean	*SE*
Relational					
	Repeat	99.97	*0.009*	99.96	*0.011*
	Switch	99.94	*0.011*	99.93	*0.017*
Semantic					
	Repeat	99.98	*0.007*	99.97	*0.009*
	Switch	99.94	*0.013*	99.95	*0.010*

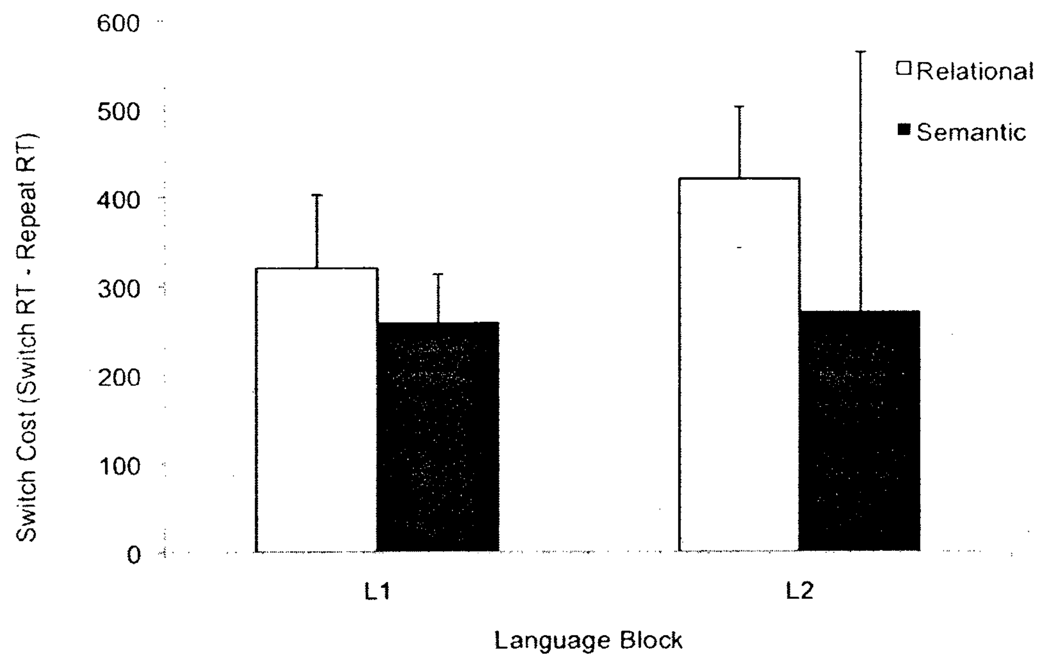

Figure 1. Switch Costs - Switch RT (ms) minus Repeat RT(ms) - for the Relational and Semantic Conditions for the L1 and L2 Blocks, for the Bilingual Group.

There was no significant effect of Condition $F(1, 15) = 0.13$, $p = .723$. The interaction effect (Language block X Condition) was also not significant, $F(1, 15) = 0.83$, $p = .376$.

Bilingual vs. monolingual analysis: L1 performance.

Accuracy. Table 5 shows means and standard errors of percent accuracy, for repeat and switch trials for the monolingual and bilingual groups in the L1 block. These data were submitted to a 2 x 2 x 2 repeated ANOVAs, with Language group (monolingual, bilingual) as a within-subjects factor, and Condition (relational, semantic), and Trial Type (repeat, switch) as between-subjects factors. The accuracy analysis results yielded no significant effect of Language group, $F(1, 30) = 0.97$, $p = .332$. There was no significant effect of Condition, $F(1, 30) = 1.12$, $p = .298$. There was a significant effect of Trial Type, with more errors made on switch trials, $F(1, 30) = 19.60$, $p < .000$. None of the interactions were significant, all *ps* > .387.

RT. Figure 2 shows means and standard errors for switch costs for the both language groups in the L1 block. Switch cost (Switch RT minus Repeat RT) data were submitted to a 2 x 2 repeated measures ANOVA with Condition (relational and semantic) as a within-subjects factor, and Language Group (bilingual, monolingual) as a between-subjects factor. The analysis results yielded no significant between-subjects (Language Group) effect, $F(1, 30) = .347$, $p = .571$. There was a significant Condition effect $F(1, 30) = 8.52$, $p = .007$, with higher switch costs in the relational condition. The interaction effect (Language Group X Condition) approached significance, $F(1, 30) = 3.470$, $p = .072$. Planned comparisons revealed that monolingual participants had a significantly greater relational than semantic switch cost, $F(1, 30) = 11.43$, $p = .002$, whereas switch costs for bilinguals were not statistically different between the two conditions, F (1, 30) = 0.56, p=.461.

Table 5

Mean and Standard Error for Switch Cost Accuracy Data for L1 Block of the Linguistic Attention Shifting Task, for Bilingual and Monolingual Participants

		Accuracy (% correct)			
		Monolingual		Bilingual	
		Mean	*SE*	Mean	*SE*
Relational					
	Repeat	99.91	*0.061*	99.97	*0.009*
	Switch	99.88	*0.060*	99.94	*0.011*
Semantic					
	Repeat	99.98	*0.006*	99.98	*0.007*
	Switch	99.94	*0.012*	99.94	*0.013*

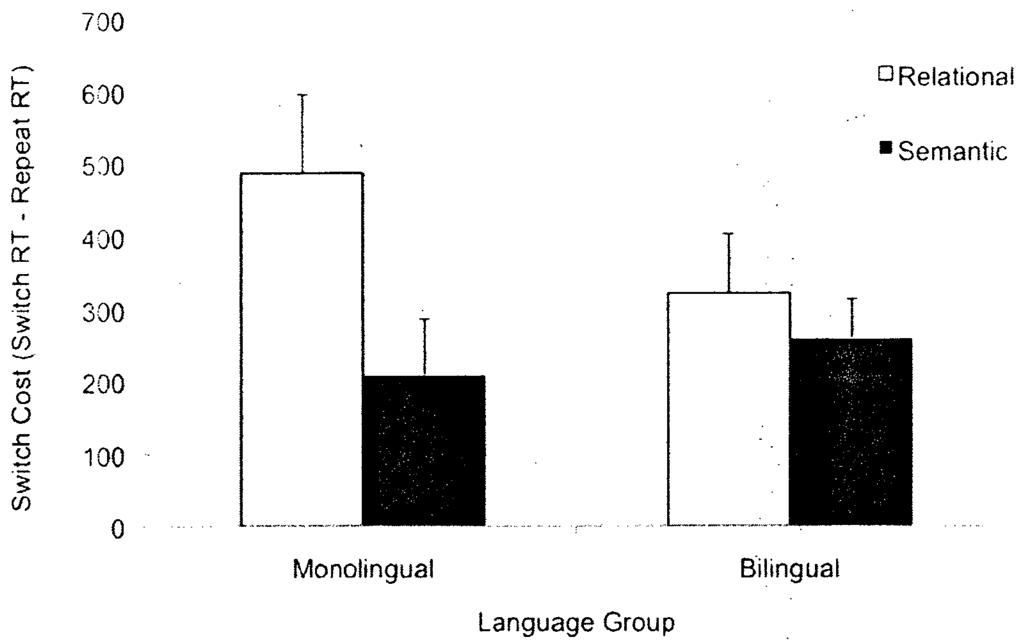

Figure 2. Switch Costs - Switch RT (ms) minus Repeat RT (ms) - for the Relational and Semantic Conditions for the Monolingual and Bilinguals Groups in L1.

Baseline Performance. To ensure that the findings reported above were not due to an overall greater difficulty of the relational condition, the RT and accuracy data from repeat trials were taken as a measure of baseline performance (as they did not require an attention shift). and submitted to 2 separate two-way repeated-measures ANOVA with the factors being Language Group and Condition.

RT. For the RT data, there was no significant difference overall between bilinguals and monolinguals, F (1, 30) = .812, p = .375. There was a significant Condition effect indicating that responses in the relational condition were slower than in the semantic condition (F (1. 30) = 14.56, p =.001. However, there was no significant interaction between Language Group and Condition, F (1, 30) = 2.44, p =.129. This indicates that although the RTs on repeat trials were larger for the relational condition than for the semantic group, the degree of difficulty did not differ between the two language groups. Furthermore, it indicates that the switch costs differences reported earlier are attributable to the attention shift requirements on switch trials, and not simply due to any greater difficulty of processing the relational versus semantic stimuli between the two groups.

Accuracy. For the accuracy data, there was no significant difference overall between bilinguals and monolinguals, F (1, 30) = .951, p = .337. There was no significant effect of Condition, (F (1, 30) = 1.15, p =.291. There was no significant interaction between Language Group and Condition, F (1, 30) = 0.98, p =.330.

Correlations. Scatterplots of the Trails Difference Scores (Trail 5 RT – Trail 2 RT) and the Relational and Semantic Switch Costs for the bilingual and monolingual groups can be seen in Figure 3. For the bilingual group, there was a significant positive correlation between Trails Difference score (Trail 5 RT – Trail 2 RT) and Semantic Switch Cost, r=.603, p = .013, and Relational Switch Cost, r=.558, p = .025. These correlations indicate that bilingual participants with lower switch costs on the linguistic switching task (indicating better attention control) were less affected by having to switch between numbers and letters on Trail 5 as compared to no switching on Trail 2. For the monolingual group, there was a significant negative correlation between Trails Difference score and Semantic Switch Cost, -r = .499, p = .049. This correlation indicates that monolingual participants that had lower switch costs on the linguistic switching task were more affected by having to switch between numbers and letters on Trail 5, compared to no switching on Trail 2. The correlation with relational Switch Cost was not significant, r = -.269, p = .313.

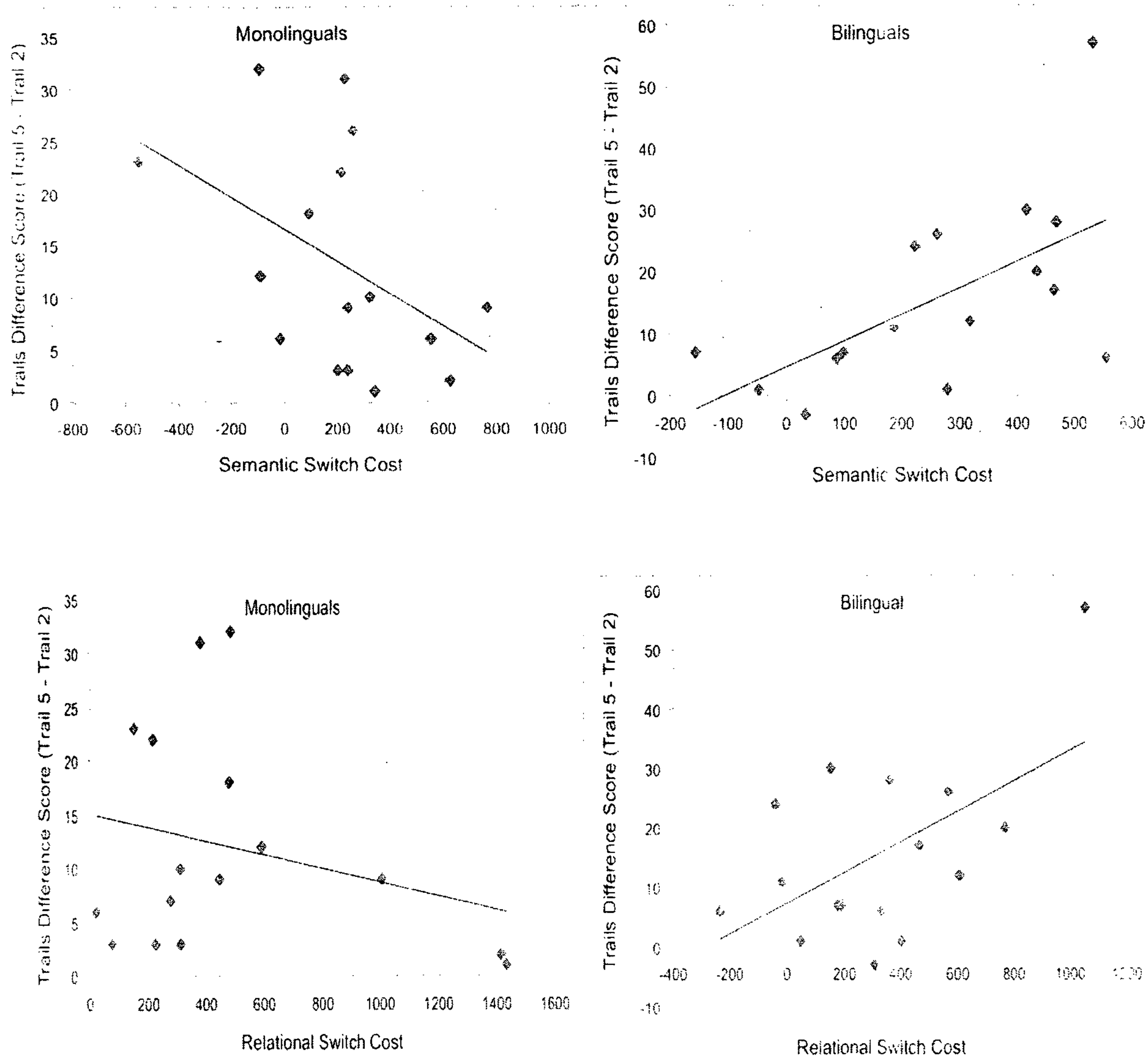

Figure 3. Scatterplots for the Relationship Between Trails Difference Scores and Relational and Semantic Switch Costs for the Monolingual and Bilinguals Groups.

Discussion

This study builds upon previous work by Taube-Schiff and Segalowitz (2005a,b) and Segalowitz and Frenkiel-Fishman (2005) who operationally defined language-specific attention control. Using a modified alternating-runs task, they showed that switching between relational elements requires language-specific attention control (Taube-Schiff & Segalowitz, 2005a), whereas switching between semantic elements did not (Segalowitz & Frenkiel-Fishman, 2005). Furthermore, they demonstrated that the ability to switch between relational elements was more difficult in a second language (Taube-Schiff & Segalowitz, 2005b). This present study directly compared the results of proficient bilinguals and monolinguals on switching between relational and semantic elements in their LI, in order to examine the nature of any bilingual benefit. In doing so, this study furthers our understanding of the relationship between language and attention control.

One of the goals of the present experiment was to extend the results of previous research to the processing of full sentences. This was done because language-specific attention control is needed in everyday conversation; when individuals engage in a conversation, the rapid stream of sentences will require attention control processes in order to shift between the various ideas being expressed. For example, in processing *The dog remained on the doorstep because the man wasn't home*, a person first has to focus attention on the spatial relationship between *dog* and *doorstep* (triggered by *on*) and then shift attention to the causal connection between the upcoming second clause and the first clause (triggered by *because*), and so forth. As hypothesized, switch costs were observed in all conditions, confirming that the paradigm can be used with full sentences and remain sensitive to the attention shift manipulation. However, our analysis of L1 compared to L2 performance by the bilinguals did not support previous results from Taube-Schiff & Segalowitz (2005b). Taube-Schiff and Segalowitz (2005b) found that bilinguals responded more quickly in L1 than L2 and that this difference was driven by slower responding in the L2 relational condition. In contrast, our findings do not show any L1 or L2 differences, or any effect of condition. One possible reason for this is that the bilinguals in Taube-Schiff and Segalowitz's (2005b) study differed in their L2 proficiency. whereas this study recruited only highly proficient bilinguals. The animacy judgment task indicated that reaction times and CVs on the English and French tasks did not differ for bilingual participants. This suggests they were equally fluent and proficient in their two languages. Highly proficient bilinguals were specifically recruited for this study, in order to examine the possible benefit of bilingualism on language-specific attention control.

The main goal of the study was to directly compare the performance of the two language groups on the language-specific control task. Analysis of the switch costs showed that both groups had larger switch costs in the relational than the semantic condition. We predicted that the bilingual group would have larger switch costs in the semantic group compared to monolinguals, but that the difference between the two groups would be even greater for the relational condition. Although the interaction effect did not reach significance, planned comparisons showed that for the monolingual group, switch costs were significantly larger in the relational than semantic condition, whereas the switch costs were similar in the two conditions for the bilinguals. It is important to remember that the sample used is comprised of only 16 individuals in each group, and this small sample size may have lead to reduced power in the statistical analyses and increased the likelihood of type II error in the results.

Nevertheless, that the bilingual group does not show a difference in switch costs between the two conditions, while the monolingual group does is consistent with the idea that bilingualism confers a benefit on language-specific attention control. While the monolingual group showed an increased burden on attention control when switching between relational elements of language (as compared to switching between the semantic elements) the bilingual group performed similarly in the two conditions. This would suggest that they are better able to utilize relational elements to focus attention during language comprehension. These conclusions were strengthened by the fact that the two groups did not differ on any of the conditions of the task in terms of accuracy, meaning that there was no speed-accuracy trade-off for either language group.

The data ruled out another potential explanation for the results. The two language groups may have performed differently because they may differ in their basic ability to process the relational stimuli. The analysis of the data from the repeat trials ruled out this possibility. On repeat trials, no interaction effect between word type and language group was found, indicating that although processing the relational stimuli was slower than processing semantic stimuli, this was similar for both language groups, and cannot explain the differences found in the analysis of the switch costs. That the bilingual and monolingual groups perform similarly on the repeat trials is further evidence that the groups differ in their abilities to switch attention between language-specific relational elements in their L1.

In order to characterize our two language groups, we compared the performance of bilinguals and monolinguals on a number of cognitive tasks. Results showed that the two language groups were similar in age, years of education, verbal intelligence, and working memory. The Simon Task, a measure of attention control, was included, as previous research has demonstrated that bilinguals show better inhibition of the irrelevant spatial location than monolinguals (Bialystok et al, 2004). Importantly, the current results indicate no significant overall speed difference between the bilingual and monolingual groups. Additionally, the two language groups both took longer to respond to incongruent items than congruent items and this difference (the Simon effect) was the same for bilinguals and monolinguals. Thus, the participants in both language groups were less able to inhibit the influence of the incongruent information, and bilingualism did not increase inhibitory effectiveness. This is in contrast to the findings of Bialystok et al. (2004) who found that bilinguals were less affected by the incongruent stimuli than monolinguals. However, other studies using the Simon Task have failed to find a language group difference (Bialystok, 2006; Bialystok et al., 2005, Morton & Harper, 2007). As stated by Bialystok et al. (2005), young adults, and especially university students are generally the most skilled computer users and the most comfortable with tasks involving rapid response to visual stimuli. Therefore, the young age, and experience with computers, may improve the efficiency of these participants to such a degree that there is little that bilingualism can do to further improve reaction times.

Our correlational analysis provides some insight into the group differences found on the linguistic attention control task. The correlations indicate that bilingual participants with lower switch costs on the linguistic switching task (indicating better attention control) were less affected by having to switch between numbers and letters on

Trail 5 as compared to no switching on Trail 2. For the monolingual group, participants that had lower switch costs on the linguistic switching task were more affected by having to switch between numbers and letters on Trail 5, compared to no switching on Trail 2, and there was no correlation with relational switch cost.

The present research proceeded from the view that bilingualism confers a benefit on language-specific attention control. Previous work has focused on how attention mechanisms help keep the bilingual's two languages from interfering with each other (Bialystok, 2001; Green, 1993) and on what happens when a bilingual switches from one language to another (e.g. von Studnitz and Green, 2002; Meuter and Allport, 1999). Others, (De Bot, 1992; Levelt, 1995) have addressed the role of attention in terms of focusing on the language itself, or on elements within the language, such as correctly producing phonological or lexical items. The present work complements these approaches by demonstrating the importance of understanding how language itself serves an attention-directing function. Language proficiency involves, among other things, the ability to focus and refocus attention on the mental representation one is constructing in real time while processing the incoming message. Bilinguals must be able to do so in two language systems, which often differ in the way that the relational elements are used (Slobin, 1996). The hypothesis guiding the present study was that bilingualism provides additional practice using language-specific attention control with respect to focusing on relational elements in their two different language systems. The results obtained here provided evidence for this view and in doing so they enrich our understanding of how attention control is necessary to language comprehension.

Strengths and Limitations of the Study

One clear strength of the work is that it is the first time that linguistic attention control has been demonstrated using stimuli embedded in full sentences, and the first time performance in L1 has been compared between monolinguals and bilinguals Another strength of the work is that non-linguistic cognitive abilities were examined, in order to get a clearer picture of the mechanisms involved in switching between relational elements of language. A major limitation of the current work is the small sample sizes. With more participants, more sophisticated analyses would be possible. Rather than correlations, hierarchical regression could be used to examine how language-specific attention control relates to non-linguistic cognitive abilities for the two groups. Additionally, although language proficiency and semantic word knowledge were examined, there were no tests examining knowledge of closed-class words. Including a measure like the Test for Reception of Grammar (TROG-2; Bishop, 2003) would allow the measurement of how the understanding of grammatical, or relational elements, contributes to, or is necessary for attention control for these elements.

Summary

The present study showed that bilinguals performed similarly to monolinguals when switching between judging semantic elements and judging relational elements of language, whereas monolingual participants were significantly slower dealing with relational elements as compared to semantic elements. Additionally, the ability to switch between relational elements correlated positively with a measure of attention control for bilinguals, but not for monolinguals. Although further investigation and replication is required, these results have important implications for cognitive models of language comprehension in bilinguals, suggesting that the additional experiences dealing with language that bilinguals encounter may benefit language-specific attention control in the first language.

General Discussion

The two studies presented here were designed to evaluate language-specific attention control in two different groups: older monolingual adults and young bilingual adults, each as compared to young monolingual adults. The studies builds upon previous work by Taube-Schiff and Segalowitz (2005a,b) and Segalowitz and Frenkiel-Fishman (2005) who used a modified alternating-runs task, to show that switching between relational elements requires a type of attention control that is specific to language (Taube-Schiff & Segalowitz, 2005a). The results of the two current studies are relevant to the literature on task switching, and language-specific attention control - in general, and in relation to bilingualism and aging. These areas will be discussed in the following sections.

In general, our results support the use of task switching paradigms as a vehicle for examining more than just the mechanisms involved in switching itself. Previously, the paradigm has also been used to examine the role of attention control in specific cognitive abilities like memory (e.g., Baddeley, Chincotta, Adlam, 2001; Mayr & Kleigl, 2000), perception (e.g., Logan & Gordon, 2001), and bilingual language-switching (e.g., Meuter & Allport, 1999). We used the task to examine how attention control is used during language comprehension, or more specifically, how attention control is used to switch between semantic elements of language, and relational elements of language. As the paradigm successfully elicited switch costs in all conditions, it can be concluded that task switching is an effective tool for examining the relationship between attention control and language. Furthermore, the switch costs were found using full sentences as stimuli, which increases the overall generalizability of the paradigm.

As outlined in the General Introduction, the task switching paradigm contains many aspects that can be manipulated without taking away the ability to examine attention control (see Monsell, 2003). We were able to adapt the task in a manner that made it more specific to language, primarily by using linguistic stimuli. Also, by using explicit cueing, in addition to a predictable sequence, we eliminated any age-related differences in working memory that would be caused by having to remember task sequence. Research has shown that older adults are more adversely affected by having to keep task sequence in working memory than younger adults (Kray, 2006). Although this is an interesting finding, the current studies were designed to examine whether working memory abilities were related specifically to linguistic attention control, rather than the process of maintaining and updating task sequence. The use of explicit cues has been shown to reduce, but not eliminate, switch costs (Koch, 2001). However, another aspect of our design was implemented with the intention of increasing switch costs. Our stimuli (the full sentences) contained semantic and relational elements relevant to each of the four possible tasks across the two conditions. As such, each sentence afforded all four possible responses. Prior research has shown that bivalent stimuli (stimuli relevant to each of the two possible tasks in a condition) increase switch costs, perhaps through the need for conflict resolution or inhibition (Monsell, 2003). The decision to adapt the task in order to elicit the need for inhibition, or conflict resolution, while decreasing the need for working memory (by using explicit cues) may seem counter intuitive, however the explanation is simple. The need to keep task sequence in memory, as discussed earlier, was irrelevant to the goals of the two studies. The use of bivalent stimuli, however, is a more appropriate analogue to language comprehension in real life. In reading or during a conversation, the receiver will often encounter more than one relational element in a phrase, and will certainly encounter more than one semantic element. Thus, the use of bivalent stimuli was related to the linguistic aspects of the task, and made the task more similar to real life.

At the same time, one criticism that can be made of the task is that it is not an exact parallel of how language is encountered and comprehended in everyday life. During reading or speech comprehension, the receiver is constantly in the process of building a mental representation of the incoming message. Certain elements of language (i.e., relational elements) act to bring parts of the message to the foreground, or conversely, push them to the background (Langacker, 1987, Talmy, 1996, 2000). As such, control over these elements is integral for skilled language use. In this sense, control could be defined as the ability to focus and refocus attention on the incoming message. The paradigm acts to replicate such a situation by having participants switch between relational elements of language, while using repeat trials as a baseline measure. In this artificial replication, participants are explicitly told, via a cue, which elements they need to direct their focus of attention towards (e.g., distance, size), and switches are made across trials. This is different from language comprehension in two ways. Firstly, in natural language comprehension, this "cue" would have to come from the sentence itself, and be determined endogenously. There is a possibility that older adults would have more trouble extracting the attention-directing information from sentences without the aid of external cues. Secondly, in the task, switches are made from sentence to sentence, whereas during language comprehension, attention control is often needed *within* sentences, in order to switch between relational elements, or from relational elements to the semantic content. In sum, the paradigm measures attention control of relational elements, however the process may not be completely analogous to doing so within a phrase, or while building a single mental representation.

Our results also add to the newly emerging literature on language-specific attention control. Specifically, the current studies suggest that for both older adults and bilinguals, the semantic and relational switch costs did not differ, whereas young monolingual adults were significantly slower to shift attention control for relational elements as compared to semantic elements. In other words, the bilingual group and the older adults showed no more difficulty in switching between relational elements, as compared to switching between semantic elements, whereas younger monolingual adults incurred significantly larger switch costs in the relational condition than the semantic condition. Previous research has found shift costs for monolingual participants using relational stimuli, and for bilingual participants for both relational and semantic stimuli (Segalowitz & Frenkiel-Fishman, 2005; Taube-Schiff and Segalowitz, 2005ab). For the bilingual participants, switch costs were larger in the relational condition than the semantic condition in the weaker L2 block, whereas relational and non-relational switch costs did not differ in the L1 block (Taube-Schiff & Segalowitz, 2005b). In other words, the relational and semantic switch costs did not differ in the language block in which the bilingual participants' were fully fluent. Segalowitz and Frenkiel-Fishman (2005) suggest that this relationship between language proficiency and language-specific attention control in best understood in terms of skilled performance. They point out that for skilled cognitive performance, experts are distinguished from novices by their superior ability to control attention, rather than through better memory or domain-relevant knowledge

(2005). So, the bilinguals in their study demonstrated better attention control in the language in which they were more skilled than a weaker language (Taube-Schiff & Segalowitz, 2005b). Our results add to this line of findings, as our bilinguals were fluent in both L1 and L2, and switch costs for the relational and semantic conditions did not differ from each other in either of the language blocks. The bilinguals in the current study were "experts" in both their L1 and L2. However, it is unclear what underlies the differences in performance between our three groups, and specifically, why older adults and young bilinguals seem to be better at switching between relational elements of language than monolingual younger adults. We suggest that the benefit seen in the older adults and younger bilinguals could be driven by two different mechanisms, but have in common that they are due to unique experiences with language. In the case of the older adults, the unique experience would be their increased years of language use, while for bilinguals it would be the need to simultaneously manage two different language systems.

We found that older adults were equally efficient at switching between relational elements of language as they were at switching between semantic elements, whereas younger adults had significantly larger raw switch costs for relational elements than semantic. Our correlational analysis indicated that working memory, attention control, and inhibition were not related to linguistic attention control for the older adults. This suggests that attention control during this task was not related to other cognitive abilities, and perhaps that older adults need not be hindered by their declining cognitive abilities when processing relational elements of language. At the same time, it is important to note that our older adult group was particularly high functioning. Although this means that our results cannot necessarily be generalized, it is one of the most interesting findings is that although they differed from the young adult group on working memory on the LNS, and attention shifting on the CTMT, they were not as burdened as the younger adults when switching attention between relational elements of language (as compared to semantic elements).

To discuss the results of Study 2, it is important to recall that language proficiency involves, among other things, the ability to focus and refocus attention on the mental representation being built of the incoming message. Bilinguals must be able to do so in two language systems, which often differ in the way that the relational elements are used (Slobin, 1996). According to Slobin, relational elements are more difficult to master in the L2 than lexical elements, because of their structural (rather than conceptual) role. Relational elements are not, and cannot be, "experienced directly in our perceptual, sensorimotor, and practical dealings with the world" (1996, p. 91) in the same manner as semantic elements. Additionally, relational elements do not correspond directly between languagesWe hypothesize that for a proficient bilingual, the experience of having to deal with different systems of relational elements in their two languages affords them increased attention control specific to language. The present study showed that bilinguals did not experience an increased burden on their attention control when processing relational elements, as compared to semantic elements, whereas monolinguals did.

The current findings add to the research examining the dissociation of the open- and closed- class system of language. Research on the separableness of the two language-systems has focused on the ability to read closed-class words in isolation (in agrammatic aphasics; Biassou, Obler, Nespoulous, Dordain, & Harris, 1997; Froud, 2001; Swinney, Zurif, & Cutler, 1980; and normal controls; Friederici, Opitz & von Cramon, 2000;

Friederici, Ruschemeyer, Hahne, & Fiebach, 2003; Munte, Wieringa, Weyertes, Szentkuti, Matzke & Johannes, 2001; Neville, Mills & Lawson, 1992; Nobre & McCarthy 1994; Van Petten & Kutas, 1991) as compared to reading open-class words. Such studies provide evidence that the two systems may be functionally and structurally separate. The current studies focused on attention control for open- and closed-class elements within sentences, and suggest that with increased experience, attention control for relational elements within the closed-class system becomes similar to that for open-class words.

Taken together, the findings of the two studies presented herein have important implications. They suggest that the task switching paradigm can be successfully used to examine the relationship between attention control and language. Additionally, they reinforce the important distinction between domain-relevant knowledge and the ability to control attentional resources, and, in doing so, highlight the importance of examining the role of attention control in skilled performance. Specifically, the current findings suggest that language-specific attention control is more efficient in more experienced language users. Future studies are required to clarify which aspects of language experience specifically contribute to enhanced language-specific attention control, and how this relates to other areas of language comprehension.

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Appendix A

The Language-Specific Attention Control Task

Table A-1.

Sentence Elements from the Language-Specific Attention Control Task

Condition	L1	L2
	Semantic	
CUE:	SIZE	TAILLE
Key Reminder	1) Small	1) Faible taille
	Little	*Petit(e)*
	Tiny	*Minuscule*
Key Reminder	1) Big	1) Taille importante
	Fat	*Gros*
	Large	*Grand*
CUE:	CATEGORY	CATÉGORIE
Key Reminder	1) Animal	1) Animal
	Dog	*Chien*
	Pig	*Cochon*
Key Reminder	1) Object	1) Objet
	Glove	*Gant*
	Watch	*Montre*
	Relational	
CUE:	DISTANCE	DISTANCE
Key Reminder	1) Close	1) Proche
	Just	*Juste*
	A bit	*Un peu*
Key Reminder	1) Distant	1) Éloigné
	Way	Bien
	Far	Loin
CUE:	POSITION	POSITION
Key Reminder	1) Higher	1) Supérieure
	Above	*En haut*
	Over	*Au dessus*
Key Reminder	1) Lower	1) Inférieure
	Below	*En bas*
	Under	*Au dessous*

Table A -2.

L1 Sentences from the Language-Specific Attention Control Task

He found the fat dog far over the clock.
They discovered the fat pig far over the mirror.
The group located the fat dog way above the clock.
He discovered the fat pig way above the shelf.
He noticed the large pig way above the mirror.
They located the large dog far over the shelf.
The group saw the little watch far over the shelf.
The group located the large dog way over the shelf.
The group located the little watch way above the shelf.
He discovered the little glove far over the window.
They noticed the fat pig way over the mirror.
She saw the large pig way over the window.
Th3ey found the tiny glove far over the mirror.
They noticed the large dog far above the clock.
They found the little watch far above the clock.
They located the little glove far above the mirror.
They noticed the fat pig far above the clock.
She located the large pig far above the shelf.
The group located the tiny glove far above the shelf.
He discovered the large dog far above the window.
The group noticed the little watch far above the window.
They discovered the little glove far above the shelf.
They discovered the tiny watch far above the window.
He found the fat dog way over the shelf.
The group saw the fat pig way over the window.
They noticed the large pig way over the clock.
They found the tiny glove way over the clock.
She found the large pig far over the window.
He noticed the tiny glove far over the window.
She discovered the fat pig far over the shelf.
They saw the large pig far over the mirror.
They saw the large dog way over the mirror.
She noticed the little watch way over the mirror.
The group located the little glove way over the clock.
He saw the tiny watch far above the clock.
The group found the fat dog far above the mirror.
She noticed the tiny watch way over the mirror.
The group noticed the tiny glove way over the window.
They saw the little glove way above the window.

She found the tiny watch way above the shelf.
They found the tiny glove way above the mirror.
She found the large dog way above the clock.
The group noticed the tiny watch far over the shelf.
They found the fat dog far over the window.
She located the little watch way above the clock.
They found the little glove way above the mirror.
She discovered the tiny watch way above the clock.
They saw the fat dog way above the window.
He noticed the fat dog a bit under the clock.
The group discovered the fat pig a bit under the mirror.
He saw the little glove just below the shelf.
He located the tiny watch just below the window.
The group noticed the large pig a bit under the mirror.
They noticed the tiny glove a bit under the mirror.
The group noticed the large pig just below the shelf.
She located the tiny glove just below the shelf.
He found the little glove a bit under the mirror.
She located the tiny watch a bit under the clock.
The group found the tiny glove just under the mirror.
He discovered the large dog just below the clock.
The group saw the large dog a bit below the window.
The group found the little watch a bit below the window.
He saw the fat pig just under the mirror.
They noticed the large pig just under the mirror.
They saw the little glove a bit below the shelf.
She noticed the little watch just under the shelf.
The group saw the little glove just under the window.
He noticed the fat pig a bit below the clock.
She noticed the large pig a bit below the clock.
The group found the little watch a bit below the mirror.
The group discovered the little glove a bit below the clock.
The group located the tiny watch a bit below the mirror.
They saw the fat dog just under the shelf.
The group found the large dog a bit under the clock.
The group saw the little watch a bit under the clock.
They saw the fat pig just under the window.
They located the large pig just under the window.
They noticed the tiny glove just under the window.
She found the large dog just under the shelf.
The group saw the tiny glove a bit below the clock.
They saw the large dog a bit below the mirror.
He noticed the tiny watch just under the shelf.
They discovered the fat dog just under the clock.
The group noticed the tiny watch a bit below the window.
The group located the fat dog a bit below the mirror.

She discovered the little watch just below the clock.
He found the little glove just below the mirror.
He found the fat dog a bit under the window.
The group noticed the fat pig a bit under the shelf.
He found the tiny watch just below the clock.
The group found the fat dog just below the window.
She noticed the fat pig just below the shelf.
They noticed the large pig a bit under the shelf.
He located the tiny glove a bit under the shelf.
He located the large dog just below the window.
They saw the little watch just below the window.

Table A-3.

L2 Sentence Bank from the Language-Specific Attention Control Task

Ils ont trouvé le gros cochon bien en haut du miroir.
Le groupe a découvert le gros chien loin en haut de l'horloge.
Il a trouvé le gros cochon loin en haut de l'étagère.
Il a vu le grand cochon loin en haut du miroir.
Ils ont découvert le grand chien bien en haut de l'étagère.
Le groupe a retrouvé la petite montre bien en haut de l'étagère.
Le groupe a découvert le grand chien loin au dessus de l'étagère.
Le groupe a découvert la petite montre loin en haut de l'étagère.
Il a trouvé le gant minuscule bien en haut de la fenêtre.
Ils ont vu le gros cochon loin au dessus du miroir.
Elle a retrouvé le grand cochon loin au dessus de la fenêtre.
Ils ont trouvé le petit gant bien en haut du miroir.
Ils ont vu le grand chien bien au dessus de l'horloge.
Ils ont trouvé la montre minuscule bien au dessus de l'horloge.
Ils ont découvert le petit gant bien au dessus du miroir.
Ils ont vu le gros cochon bien au dessus de l'horloge.
Elle a découvert le grand cochon bien au dessus de l'étagère.
Le groupe a découvert le gant minuscule bien au dessus de l'étagère.
Il a trouvé le grand chien bien au dessus de la fenêtre.
Le groupe a vu la petite montre bien au dessus de la fenêtre.
Ils ont trouvé le gant minuscule bien au dessus de l'étagère.
Ils ont trouvé la montre minuscule bien au dessus de la fenêtre.
Il a trouvé le gros chien loin au dessus de l'étagère.
Le groupe a retrouvé le gros cochon loin au dessus de la fenêtre.
Ils ont vu le grand cochon loin au dessus de l'horloge.
Ils ont trouvé le petit gant loin au dessus de l'horloge.
Elle a trouvé le grand cochon bien en haut de la fenêtre.
Il a vu le gant minuscule bien en haut de la fenêtre.
Elle a trouvé le gros cochon bien en haut de l'étagère.
Ils ont retrouvé le grand cochon bien en haut du miroir.
Ils ont retrouvé le grand chien loin au dessus du miroir.
Elle a vu la petite montre loin au dessus du miroir.
Le groupe a découvert le gant minuscule loin au dessus de l'horloge.
Il a retrouvé la montre minuscule bien au dessus de l'horloge.
Le groupe a trouvé le gros chien bien au dessus du miroir.
Elle a vu la montre minuscule loin au dessus du miroir.
Le groupe a vu le petit gant loin au dessus de la fenêtre.
Ils ont retrouvé le gant minuscule loin en haut de la fenêtre.
Elle a trouvé la montre minuscule loin en haut de l'étagère.
Ils ont trouvé le petit gant loin en haut du miroir.
Elle a trouvé le grand chien loin en haut de l'horloge.
Le groupe a vu la montre minuscule bien en haut de l'étagère.

Ils ont trouvé le gros chien bien en haut de la fenêtre.
Elle a découvert la montre minuscule loin en haut de l'horloge.
Ils ont trouvé le petit gant loin en haut du miroir.
Elle a trouvé la montre minuscule loin en haut de l'horloge.
Ils ont retrouvé le gros chien loin en haut de la fenêtre.
Il a vu le gros chien un peu en bas de l'horloge.
Le groupe a découvert le gros cochon un peu en bas du miroir.
Il a retrouvé le gant minuscule juste en bas de l'étagère.
Il a découvert la montre minuscule juste en bas de la fenêtre.
Le groupe a vu le grand cochon un peu en bas du miroir.
Ils ont vu le petit gant un peu en bas du miroir.
Le groupe a vu le grand cochon juste en bas de l'étagère.
Elle a découvert le gant minuscule juste en bas de l'étagère.
Il a trouvé le petit gant un peu en bas du miroir.
Elle a découvert la montre minuscule un peu en bas de l'horloge.
Le groupe a trouvé le gant minuscule juste au dessous du miroir.
Il a retrouvé le grand chien juste en bas de l'horloge.
Le groupe a retrouvé le grand chien un peu au dessous de la fenêtre.
Le groupe a trouvé la petite montre un peu au dessous de la fenêtre.
Il a retrouvé le gros cochon juste au dessous du miroir.
Ils ont vu le grand cochon juste au dessous du miroir.
Ils ont retrouvé le gant minuscule un peu au dessous de l'étagère.
Elle a vu la petite montre juste au dessous de l'étagère.
Le groupe a retrouvé le gant minuscule juste au dessous de la fenêtre.
Il a vu le gros cochon un peu au dessous de l'horloge.
Elle a vu le grand cochon un peu au dessous de l'horloge.
Le groupe a trouvé la petite montre un peu au dessous du miroir.
Le groupe a découvert le gant minuscule un peu au dessous de l'horloge.
Le groupe a découvert la montre minuscule un peu au dessous du miroir.
Ils ont retrouvé le gros chien juste au dessous de l'étagère.
Le groupe a trouvé le grand chien un peu en bas de l'horloge.
Le groupe a retrouvé la petite montre un peu en bas de l'horloge.
Ils ont retrouvé le gros cochon juste au dessous de la fenêtre.
Ils ont découvert le grand cochon juste au dessous de la fenêtre.
Ils ont vu le gant minuscule juste au dessous de la fenêtre.
Elle a trouvé le grand chien juste au dessous de l'étagère.
Le groupe a retrouvé le petit gant un peu au dessous de l'horloge.
Ils ont retrouvé le grand chien un peu au dessous du miroir.
Il a vu la montre minuscule juste au dessous de l'étagère.
Ils ont trouvé le gros chien juste au dessous de l'horloge.
Le groupe a vu la montre minuscule un peu au dessous de la fenêtre.
Le groupe a découvert le gros chien un peu au dessous du miroir.
Elle a trouvé la montre minuscule juste en bas de l'horloge.
Il a trouvé le petit gant juste en bas du miroir.
Il a trouvé le gros chien un peu en bas de la fenêtre.
Le groupe a vu le gros cochon un peu en bas de l'étagère.
Il a trouvé la montre minuscule juste en bas de l'horloge.
Le groupe a trouvé le gros chien juste en bas de la fenêtre.
Elle a vu le gros cochon juste en bas de l'étagère.

Ils ont vu le grand cochon un peu en bas de l'étagère.
Il a découvert le gant minuscule un peu en bas de l'étagère.
Il a découvert le grand chien juste en bas de la fenêtre.
Ils ont retrouvé la montre minuscule juste en bas de la fenêtre.

Appendix B

Health and Language Questionnaire

History Questionnaire

We are interested in your personal history because it may help us to better understand the results of our study. Your answers to a few short questions will aid us in this effort. All answers will be kept strictly confidential. Thank you for your help.

Demographics:

- Date of Birth (D/M/Y):______________ 2. Age:___________

3. Gender: *(circle response)* (1) Male (2) Female
4. Handedness: *(circle response)* (1) LEFT (2) RIGHT (3) BOTH
5. Present marital status: *(circle response)* (1) Single – never married
   (2) Married
   (3) Separated
   (4) Divorced
   (5) Widowed
   (6) Cohabit

Language

7. Place of Birth:____

8. If not Canada, how long have you been in Canada?

____

9 Languages Spoken (in order of fluency):____

10. Primary Language/Language of choice:____

11. Language at home:________________________ 10. At work:________________________

12. At what age did you first learn English/French? ______________________

13. At what age did you become fluent in it ? ______________________

14. How would you rate, from 1 to 5[1], your level of proficiency in the languages you speak? What percentage of time do you speak it?

[1] 1: No ability at all; 2: Very little; 3: Moderate; 4: Very good; 5: Native-like ability

Language Rating (**L**istening, **R**eading, **S**peaking, **W**riting):

1. ____________________ L:____ R:____ S:____ W:____ %:____
2. ____________________ L:____ R:____ S:____ W:____ %:____
3. ____________________ L:____ R:____ S:____ W:____ %:____
4. ____________________ L:____ R:____ S:____ W:____ %:____

These questions are to be administered for studies interested in language and/or biling

6. Parents' places of birth and native languages:

mother: ________________________ father: ________________________

Have you ever spent a long period of time in another country in which you had to communicate in a language other than your native language? Indicate these cities, languages, and the age at which you lived there:

What is your primary language or language of choice? ____________________

Which languages do you speak… (and if more than one, which is primary?)

- at home? __________________
- with close family (parents/siblings)? __________________
- with extended family (grandparents)? __________________
- with friends? __________________
- with yourself (e.g. when you dream)? __________________

In what language(s) do you listen to the radio? Watch tv? __________________

Which language(s) do you use at work (estimate percentage for each)?

____

In which language was your education?

primary__________ secondary__________ cegep__________ university__________

How did you learn your second language?

____

____

15 . How many years of education do you have at this time? (i.e., what is the highest level achieved?)

1 2 3 4 5 6	7 8 9 10 11	12 13	14 15 16	17 18 19 20	21 22 23 24 25
Elementary	Secondary	Cegep	Undergrad	Graduate	Professional

16. In what field did you complete your degree? ______________________________

17. Did you skip or repeat a grade?
   A) NO / YES
   B) Which one (s):____

18. Did you have any particular difficulty with any subject in school?
   A) NO/YES
   B) Which one (s):

____

19. What is or was your main occupation?

____

20. What was your longest held occupation?

____

21. When did you retire? _________________

22. How many hours per week do you engage in physical exercise? _______________

23. How many hours per week do you engage in a social activity (this can include interacting with members of your household)?_____________

FOR YOUNG ADULTS:

How many years of education does your mother have, or what is the highest level that she completed? (see scale above if necessary) _________________

What is her main occupation? ________________________________

How many years of education does your father have, or what is the highest level that he completed? (see scale above if necessary) _________________

What is his main occupation? ________________________________

FOR OLDER ADULTS (AND YOUNG ADULTS WHO ARE MARRIED):

How many years of education does/did your spouse have, or what was the highest level that he/she completed? (see scale above if necessary) _________________

What was/is his/her main occupation? ______________________________

Medical History

24. Do you have now, or have you had in the past -*(please circle your response)*

- Visual problems:
  - A) Nearsighted / Farsighted
  - B) Glasses / Contact lenses[2]
  - C) Cataract: Left / Right
  - D) Colour blind: NO / YES

- Trouble hearing:
  - E) NO / YES
  - F) Hearing Aid: Left / Right

25. Have you ever been unconscious[3], had a head injury or had blackouts[4]?
    - A) NO / YES
    - B) Cause:______________________________
    - C) Duration:______________________________
    - D) Treatment:______________________________
    - E) Outcome:______________________________

26. Have you been seriously ill or hospitalized in the past 6 months?
    - A) NO / YES
    - B) Cause:______________________________
    - C) Duration:______________________________

Do you have now, or have you had in the past (conditions susceptible or influencing cognitive functions)...

27. a) A stroke? b)[s] Transient ischemic attack (mini-stoke[5])?	NO / YES NO / YES	
28[s]. Bypass surgery?	NO / YES	
29[S] Heart disease?	NO / YES	Nature (myocardial infarction [MI], angina, narrowing of

[2] If participant usually wear contact lenses, he/she will have to wear glasses on ERP testing sessions (to prevent blinking).

[3] Falling unconscious ≠ Fainting

[4] Exclude: Substantial head injury relatively recently, several concussions, & coma.

[s] Risk factors for stroke. Exclusion criterion: More than one of those factors, if older participants.

[5] Mini-stroke: symptoms less than 24 hours.

[s] Risk factors for stroke. Exclusion criterion: More than one of those factors, if older participants.

		arteries):
30 [S] High blood pressure?	NO / YES	Is it controlled? NO / YES What medication? ________
31 [S]. High cholesterol?	NO / YES	Is it controlled? NO / YES What medication? ________
32 [S]. a) Diabetes? b) Insulin dependent?	NO / YES	Type 1 / Type 2 Age of onset: ________ Treatment: ________
33. Other Surgery?	NO / YES	
34. Seizures?	NO / YES	Age Onset: ________ Frequency: ________ Cause: ________ Treatment: ________
35. Epilepsy?	NO / YES	
36. Thyroid disease?	NO / YES	
37. Frequent headaches?	NO / YES	Tension / migraine
38. Dizziness?	NO / YES	
39. Trouble walking Unsteadiness?	NO / YES NO / YES	
40. Arthritis?	NO / YES	
41. Any injuries to the lower limb? (e.g. hip, knee, ankle)	NO / YES NO / YES	
42. Serious illness (e.g. liver disease)?	NO / YES	
43. Neurological disorders[6]? (e.g. lupus, MS, Parkinson's)	NO / YES	
44. Exposure to toxic chemicals (that you know of)?	NO / YES	
45. Depression?	NO / YES	Did you seek assistance or feel the to do so? ________ Is it controlled? ________
46. Anxiety?	NO / YES	Did you seek assistance or feel the to do so? ________ Is it controlled? ________
47. Other psychological difficulties?	NO / YES	
48. Hormone replacement?	NO / YES	
49. Steroids?	NO / YES	

[6] Automatic exclusion

50. Medication: Please list the medication you are currently taking and any other medication that you have taken in the past year.

Type of medicatio		Reason for consumption	Duration of consumption and
A			
B			
C			
D			
E			
F			

51. Do you drink alcohol? a) YES, frequently.
b) YES, but infrequently.
c) NO.
If YES, approximately how many drinks[7] of alcohol do you have per week? ______________________

52. Do you use non-prescription drugs such as homeopathic medications, vitamins, laxatives, syrups ?
NO / YES
If YES, which one (s): ____
How many times per week?
a) Occasionally b) 1 - 3 c) 4 - 6 d) more than 6

53. Do you use non-prescription drugs for recreational purposes?
NO / YES

If yes, do you use marijuana/hashish?
NO / YES
If YES, How many times per week?
a) Occasionally b) 1 - 3 c) 4 - 6 d) more than 6

[7] 1 drink = 1 beer, 1 glass of wine, 1 oz of liquor. 2 drinks/day is considered moderate drinking.

Do you use any other non-prescription drugs for recreational purposes?
NO / YES

If YES, How many times per week?

a) Occasionally b) 1 - 3 c) 4 - 6 d) more than 6

If yes, which one (s): (*participant not obliged to answer*)

____

Ask participant to not use drugs prior to testing (~48hr)

54. Do you smoke[S]?

NO / YES

If YES, How many packs a day (or average quantity)? ____________

55. Current problems: Are you currently troubled by any of the following[8]?

a) Concentration / Attention problems?

NO / YES

Nature: ________________________________

b) Memory problems?

NO / YES

Nature: ________________________________

c) Difficulties finding words?

NO / YES

Nature: ________________________________

56) How would you rate your health? *(circle response)*

1) poor 2) fair 3) good 4) very good 5) excellent

[8] Please remind potential older participants who are interested in participating to research because of memory concerns that we do NOT provide full clinical assessments

Participant contact information:

Name: ____

Phone Number: ______________________________

Email: ______________________________

Address ***(remind participant that this section is optional)***:

____

____

____

Are you willing to be contacted by researchers in Dr. Phillips' lab for future studies?
NO / YES

What year will you graduate? ________________________

Can we give your contact information to other Concordia researchers (name, tel. #, email address)?
NO / YES

Source: ____

Eligibility:

- You are not eligible for this study due to ________ reasons, but you may be eligible for other studies, so we'll keep your information on file
- I need to discuss some issues with my colleagues, and I will contact you to let you know if you are eligible to participate.
- If they ask why they are ineligible:
  - We are interested in cognitive processing and certain conditions, medications, and habits interfere with cognitive processing, therefore we cannot test people who meet those criteria

Appendix C

Consent Form

CONSENT FORM TO PARTICIPATE IN RESEARCH

This is to state that I agree to participate in a program of research being conducted by Dr. Natalie Phillips (tel: *514.848.2424, x.2218;* email: Natalie.phillips@concordia.ca) and Ms. Hilary D. Duncan (tel: *514.848.2424, x.7546*, email: hilaryddunc an@gmail.com) of the Department of Psychology, Concordia University.

A. PURPOSE

I have been informed that the purpose of this research is to examine the effects of age on a switching task in order to increase our present understanding of age-related changes in language-specific attention control and how these changes may differ in monolingual and bilingual individuals.

B. PROCEDURES

The study will take place in the Cognitive Psychophysiology laboratory of the Department of Psychology at Concordia University. The study will be conducted in a small testing room. I will be seated in a comfortable chair and will be presented with sentences on a computer monitor. I will be asked to read each sentence and then make a decision about the sentence by pressing a button, as quickly and accurately as possible. I understand that I may make errors but the most important thing is that I will try to do my best. I will also be asked to complete other brief tasks, including a colour naming task, in which I will be asked to name colours and read colour words, a living/nonliving judgement task in which I will be asked to judge whether words refer to living or nonliving objects, in French and English, and a short reaction time task called the Simon Task. Three other paper and pencil tasks will be used to assess my cognitive performance, these include the Montreal Cognitive Assessment, the digit-symbol coding subtest of the Wechsler Adult Intelligence Scale, 3rd edition, and the Comprehensive Trail-Making Test.

I will be asked to visit the Laboratory at Concordia University on one occasion and the testing session will last approximately 2 ½ hours. I have been informed that certain demographic information (age, sex, education, language, and health status) will be recorded. I understand that this test is for research purposes only and that it is not diagnostic, meaning that it will not yield any results about my health. I understand that my individual results will not be provided to me; however, I will be informed of the general findings of the study.

C. CONDITIONS OF PARTICIPATION

I understand that I am free to withdraw my consent and discontinue my participation at anytime without negative consequences.

I understand that my participation in this study is CONFIDENTIAL (i.e., the researcher will know, but will not disclose my identity).

I understand that the data from this study may be published but that I will not be identified as an individual in the study.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT.

I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

____

Date

____________________ ____________________

Signature of Subject Print Name

____________________ ____________________

Signature of Investigator Print Name

____________________ ____________________

Signature of Person explaining Print Name

If at any time you have questions about your rights as a research participant, please contact Adela Reid, Research Ethics and Compliance Officer, Concordia University, 514.848.2424, x.7481, or by email, at Adela.Reid@Concordia.ca

Appendix D

Task Order of Administration

Tasks' Order of Administration

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1) Health and language questionnaire during a phone interview prior to the testing session

2) Montreal Cognitive Assessment test

3) Computerized Animacy Judgment task

a) Neutral
b) Language 1*
c) Language 2*

4) Computerized Language-Specific Attention Control task
    a) Language 1* (bilinguals only)
    b) Condition 1**

5) WAIS-III Vocabulary test

6) Computerized Language-Specific Attention Control task (bilinguals only)
    a) Language 1*
    b) Condition 2**

7) WAIS-III Letter-Number Sequencing test

8) Simon task

9) Computerized Language-Specific Attention Control task (bilinguals only)
    a) Language 2*
    b) Condition 1**

10) Computerized colour-naming Stroop task

11) Comprehensive Trail-Making test

12) Computerized Language-Specific Attention Control task
    a) Language 2* (bilinguals only)
    b) Condition 2**

---

* L1 or L2
**Semantic or Relational

Appendix E

The Language-Specific Attention Control Task RT Data for all Trials

Table E-1

Mean and Standard Error for RT Data for All Trials for Younger and Older Adults.

	Relational							
	Younger		Older		Younger		Older	
	Proximity				Verticality			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	2888.7	*326.1*	3982.5	*296.2*	2468.0	*240.9*	3672.4	*283.6*
Switch	3107.5	*281.0*	4331.1	*342.1*	3224.4	*295.1*	4098.9	*264.3*
	Semantic							
	Size				Category			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	1981.4	*198.2*	3391.5	*302.9*	2017.2	*272.2*	3691.8	*431.6*
Switch	2137.8	*239.1*	3825.1	*376.9*	2277.7	*203.7*	4025.6	*440.3*

Table E-2

Mean and Standard Error for RT Data for L1 and L2 Blocks for Bilingual Participants

	Relational							
	L1		L2		L1		L2	
	Proximity				Verticality			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	2208.88	*243.00*	3349.91	*441.95*	2146.66	*257.98*	3278.93	*476.37*
Switch	2458.38	*213.02*	3672.45	*478.68*	2539.32	*278.56*	3797.95	*507.87*
	Semantic							
	Size				Category			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	1866.48	*260.97*	2333.35	*312.35*	1919.78	*297.22*	2107.92	*289.92*
Switch	2075.73	*303.36*	2390.99	*296.78*	2229.35	*292.61*	2594.82	*369.06*

Table E-3

Mean and SE for RT Data for L1 Block for Bilingual and Monolingual Participants

	Relational							
	Monolingual		Bilingual		Monolingual		Bilingual	
	Proximity				Verticality			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	2888.7	*326.1*	2208.88	*243.00*	2146.66	*257.98*	3672.4	*283.6*
Switch	3107.5	*281.0*	2458.38	*213.02*	2539.32	*278.56*	4098.9	*264.3*
	Semantic							
	Size				Category			
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Repeat	1981.4	*198.2*	1866.48	*260.97*	1919.78	*297.22*	3691.8	*431.6*
Switch	2137.8	*239.1*	2075.73	*303.36*	2229.35	*292.61*	4025.6	*440.3*