A Language-Specific Form of Attention that Underlies Second Language Proficiency

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ABSTRACT

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This research investigated the role of a specific form of attention that may be implicated in the acquisition of second language (L2) proficiency, based on cognitive linguistic considerations. It was hypothesized that L2 proficiency would be positively correlated with efficiency of attention control for L2 grammaticized elements (pronouns, prepositions, conjunctions and verb forms), after controlling for effects attributable to attention control for non-grammaticized elements (concrete and abstract nouns). Twenty-four bilingual undergraduates (L1=English; L2=French) performed a proficiency task (operationalized as efficiency of accessing word meaning in a lexical living or nonliving categorization task) and an attention task (operationalized as efficiency of attention shift judgments in a nonmatching-to-sample task using grammaticized words [GRAM], concrete nouns [CONC], abstract nouns [ABST]). For both the proficiency and attention tasks, coefficient of variation (CV) of reaction time was the measure of processing efficiency. L2-specific measures were obtained by partialling out L1 from L2 CVs. The baseline for attention performance (i.e., no attention shift) was measured using a matching-to-sample task. Attention control indices were computed by partialling out match CVs from non-match CVs. Hierarchical multiple regression analyses

(Step 1 = CONC & ABST; Step 2 = GRAM) revealed that efficiency of attention control for L2 grammaticized elements accounted for a significant amount of unique variance of L2 proficiency whereas attention control for nongrammaticized elements did not. Because all L2 measures had been residualized against L1, the results could be interpreted as reflecting a language specific form of attention and not general processing abilities.

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Introduction

Over the last century, research in cognitive science has explored some of the mechanisms underlying complex skill acquisition from psychophysical, neurophysiological, and computational perspectives (e.g., Anderson & Lebiere, 1998; Ericsson & Charness, 1994; Fischler & Raney, 1991; Posner & Boies, 1971; Raichle et al., 1994; Rogers & Monsell, 1995; Schneider & Shiffrin, 1977; Segalowitz, 2002). Complex cognitive skills (e.g., learning a second language, playing a musical instrument, and making medical diagnoses) involve a variety of automatized processes and attention related mechanisms (Segalowitz, 2000). In recent years, automatic processing (automaticity) and attention control have become major topics of interest in the skill acquisition literature (e.g., DeKeyser, 2001; Favreau & Segalowitz, 1983; Posner et al, 1989; Robinson, 1997).

Research on these two aspects of cognitive processing has contributed to our understanding of their role in complex learning and also how to optimize learning environments for development of high-level performance. Of special interest are questions about why and how individuals vary in their achievement of high-level skilled performance and, in the case of bilingualism, why individuals seem not to master their second language to the same high level as their first language. Now, in the case of language proficiency, it is evident that some aspects are relatively automatic (e.g., word recognition) and some are under attention control (e.g., abstracting the underlying meaning of sentences). Second language performance provides a promising domain in which to study how the brain executes complex cognitive skills and studies in this area have relevance for many other high-level skill activities that characterize daily life.

Basic Research on Automaticity

As mentioned previously, it is believed that many aspects of mental and motor functioning can be characterized as being either relatively automatic or as involving attention control processes. Processes that are automatic can be carried out simultaneously with other tasks because they require little or no attention, whereas processes carried under attention control cannot be performed with other tasks at the same time as they usually require full attentional resources. The task of driving a car provides a good example of automaticity and its development. A novice driver may have difficulty talking to someone while driving because the acts of steering, checking for traffic lights, and stopping at red lights involve attention control. However, these acts can become automatic through practice. After gaining some experience, this driver will be able to automatically check for traffic signs and stop at stop signs while at the same time continue speaking to someone. A major goal of psychological research into skill development concerns documenting and explaining how this shift from performance that is relatively non-automatic and under attention control to performance that is relatively automatic takes place.

One significant study in this domain is Schneider and Shiffrin's (1977) research on controlled and automatic human information processing and the conditions under which processing that starts out under attention control becomes automatic. Using both reaction time and accuracy measures, they noted that under certain practice conditions the search time for a target in a display of distractors can become independent of the amount of information being processed, that is, the target seems to pop out of the background. For instance, in a visual search task, participants search through presented four-item frames for memory set items (e.g., 4, 7, 8, 1). These memory set items serve as targets only throughout the experiment and never appear as distractors. In this case, after practice, the visual search has become effortless and automatic, suggesting that practice somehow speeds up memory search because the search time per item decreases substantially; after much training, the targets seem to just pop out of the background of distractors, regardless of how many distractors there are. It is thought that processing shifts from being serial to parallel, hence decreasing dependency of performance on the number of items in the display (see Nakayama & Joseph, 1998, for a different interpretation).

In contrast to this pop-out effect, under other conditions of practice, the search time for a target remains dependent of the number of distractors. For example, suppose that memory set stimuli 4, 7, 8, 1 appear on some trials as a target and on other trials as distractors. In this condition, although overall reaction time does decrease after practice, the dependency of search time on the number of items does not decrease. This processing remains non-automatic in the sense that pop-out effects do not emerge over time.

In addition to these findings, Schneider and Shiffrin (1977) found that when participants practiced with consistent mapping of stimuli to responses (i.e., there was a consistent relationship between stimulus and response because of consistency in using a given stimulus as a target or a distractor but never both), visual search seemed to become increasingly automatized in processing. For example, automatic detection can occur when participants are required to always search for the same number, such as an "8" in a visual search task. Given that they consistently press a particular key on the computer keyboard whenever they see an "8", this stimulus-response mapping can become automatic. However, when participants practiced with varied mapping (i.e., where stimuli could occur on some occasions as targets and on others as distractors), serial controlled search was performed because the number 8 for which they searched a moment before may now appear but no longer be a target. These researchers also proposed that the change from attention control to automatic processing is a progressive one, implying that automaticity should be viewed in terms of degree, rather than in an all-or-none manner.

Applying these concepts to the example of driving, the stimulus provided by a stop sign can be said to be consistently mapped onto the response of making the car stop. Because of the consistency in this mapping (there is never a context when a stop sign signals go) the stopping behaviour becomes automatic over time. However, when a yield sign appears the driver has to decide consciously and deliberately whether to stop if there is other traffic coming or to continue without stopping if no traffic is coming. A yield sign is thus mapped onto various responses and practice with this varied mapping does not promote automaticity of stopping at yield signs.

Based on this view, it is thought that consistent practice and extended repetition of items are necessary for the development of automaticity. When several underlying mechanisms of the performance become automatic, the amount of resources for attention and skill reduce accordingly. Individuals are less likely to be disturbed by other activities during the performance. In addition, it seems that they perform the task more quickly, with fewer mistakes, and with less variable response times, that is, not only is performance faster but it is also more stable. This suggestion may have important applications for the study of second language acquisition. For instance, if word recognition, pronunciation, syntax, and the like can be automatically processed, then more native-like proficiency can be achieved as a result because the fast, accurate, and fluid (uninterrupted) characteristics of automaticity will help bring performance to a native-like level of fluidity.

The next section reviews automaticity in the context of a theoretical framework of skill acquisition as well as research on the characteristics of automaticity.

Theoretical Framework of Skill Acquisition

One useful framework of skill acquisition is Anderson's adaptive control of thought (Anderson, 1983; Anderson & Lebiere, 1998). In this framework, skill acquisition is thought to involve a transition from declarative knowledge to procedural knowledge. Declarative knowledge is knowledge "that", which means this kind of knowledge is describable, conscious, skill-related, and explicit. Examples of this type of knowledge are when a novice driver stops at a stop sign or an individual forms a particular grammatical construction in a second language. Procedural knowledge is knowledge "how". This procedural knowledge is non-describable, unconscious, and implicit. Examples of this type are when a skilled driver steers and brakes at red lights or a native speaker forms correct grammatical constructions in her first language. To use the example of driving, when novice drivers see a stop sign they retrieve and use their declarative knowledge to decide consciously and deliberately which pedal to push to stop the car. The execution of such a cognitive skill involves applying production rules on the declarative knowledge. When these production rules are applied repeatedly following consistent mapping of stop signs to stopping responses, declarative knowledge is transformed into procedural knowledge. That is, the repeatedly applied production rules become chunked, routinized, or "compiled" (to use a computer model metaphor). Thus, according to Anderson, automaticity occurs when the execution of a given skill becomes implicit, fast, and coordinated due to a routinization of production rules.

Perhaps one of the best demonstrations of automaticity in language processing is Neely's (1977) study. Neely showed that word recognition appeared to be automatic at the earliest stage of word recognition. His study demonstrated that participants were unable to inhibit the processing of a word's primary meaning after seeing the word within the first few hundred milliseconds, even though they had been trained to interpret the word differently and could do so given a few hundred more milliseconds to do so. His results suggested that this processing of the meaning of words in skilled native readers of English was ballistic (unstoppable). While this well-learned word recognition ability requires so little attention, it may lead to interference with processing when the task is changed. Thus, the inflexibility of automaticity can become problematic if the situation requires flexibility of response (as was the case in Neely's design). In addition to Neely's finding, Posner and Boies (1971) also observed that letter recognition became automatic and non-attentional. They showed that the recognition of a simple letter was a well-trained skill and thus it did not require attentional resources insofar as letter recognition did not interfere with the performance of a secondary, attention-demanding task.

Thus we see that basic first language skills, such as word recognition and letter recognition, involve highly efficient or automatic processing. The same can be said about second language functioning, as will be discussed below. However, in the case of second language functioning, we can expect to see considerable inter-individual variation because not all speakers of a second language are equally proficient.

Second Language Acquisition

With respect to second language acquisition, automaticity refers to the speed, accuracy, and fluidity of language application (Segalowitz, 2000). To illustrate the development of automaticity, consider the task of reading a second language. Reading involves many sub-tasks, such as recognizing and understanding words, combining the words into sentences, and then going from sentences to the underlying thoughts or ideas. Readers must be able to break a string of words into appropriate chunks and apply rules and strategies to try to derive the appropriate meaning.

When first learning to read a second language, individuals have difficulty combining all these things concurrently. When they read a word, they may have to think consciously about the meaning of this word (e.g., try to remember a previous context in which they encountered the word, or search for an associated translation equivalent). However, with practice, these readers become skilled and no longer need to read in such a controlled manner; words become recognized automatically. Thus one feature of skilled or highly proficiency second language use will be automatic word recognition. In addition to automaticity, however, Segalowitz has also suggested that proficiency in a second language also requires a certain level of efficiency in cognitive control. To employ the example of reading again, readers try to understand sentences as soon as they have processed the first words. That is, they retrieve the meaning of the first word of the sentence from their mental lexicon and use this to guide subsequent retrieval of word meanings and the construction of a representation for the sentence as a whole. If the first word is <u>the</u>, then the reader can expect that the next word will probably be a noun or adjective. If <u>the</u> is followed by <u>clutch</u>, then readers may face difficulty deciding whether the correct meaning involved is a tight hold, an apparatus in a car, or a number of eggs laid by a hen at one time. This is because lexical access during sentence understanding is an autonomous process in which all possible meanings of a word are initially activated (Swinney, 1979). Even though the appropriate meaning of the word will emerge later in the sentence, readers need to select a meaning and then backtrack if it is wrong. Some form of attention control is necessary for performing such a selection by inhibiting other possible word meanings that may interrupt the flow of comprehension processes.

The next section examines research on the relationship between automaticity and fluent performance and then introduces a method for assessing automaticity. Following next section is research on attention and its implications for second language proficiency.

<u>Automaticity</u>

To examine whether automaticity underlies proficiency, Favreau and Segalowitz (1983) compared participants' performance on single word recognition task conducted in their first language with their performance on the same task conducted in their second language. The bilingual participants were either very fluent in their second language or somewhat less fluent. The very fluent bilinguals were able to read texts to full comprehension as quickly as they could read comparable texts in their first language. The less fluent bilinguals required more time to read texts to full comprehension than in their first language. Those participants who were in the very fluent group demonstrated automaticity in both languages, whereas those participants who were somewhat less fluent in their second language showed automaticity in their first language only. Automaticity in this study was operationally defined in the way Neely (1977) defined it, in terms of ballistic processing of a word's primary meaning despite an intention to think about the word in a different way. Such data led Favreau and Segalowitz to propose that automaticity was associated with proficiency of a second language.

While Favreau and Segalowitz (1983) focused on the "ballistic" nature of automatic processing, the most prominent characteristic of automaticity referred to in the literature on this topic is the fast processing speed said to characterize automatic processing. However, although automatic processes are indeed generally faster than non-automatic processes, fast processing does not necessarily indicate automatic processing because "fast" is a relative term but not an absolute one. As Segalowitz and Segalowitz (1993) have suggested, one can still speak of faster and slower control (nonautomatic) processing, so speed of processing cannot be the principal characteristic of automatic processing. Segalowitz and Segalowitz proposed that the coefficient of variation (CV) of response time, which is defined by the standard deviation of the individual's reaction times divided by this individual's mean reaction time, can be used to evaluate the existence of automaticity in the process being studied. According to them, this parameter can discriminate between improvement (faster responding) with versus without the development of automaticity. These researchers suggested that when the underlying component processes that determine the overall response time operate faster as a result of practice but do so without increased automaticity, then both the overall reaction time and the standard deviation of that reaction time will be decreased. This is because as the execution time of each component process is reduced so is the standard deviation of that component's execution time, and by at most in proportion to the reduction in the response time. Thus, for example, if overall response time is cut in half, then the standard deviation of that individual's response time will at most be reduced by half as well. Thus, the CV that is the ratio of the standard deviation to the reaction time will itself not become decreased.

However, when the improvement (faster responding) is due to increased automaticity, the coefficient of variation (CV) will decrease for the following reason. As performance improves with practice, some of the slower and more highly variable control processes will drop out of the sequence of underlying events that determine the overall response time. Thus not only will overall response time become faster because these processes have been eliminated, but the overall variability will become even more reduced because highly variable processes will have been selectively removed. Thus the overall standard deviation of response time will be more than proportionally reduced. In other words, the CV will decrease with decreasing response time.

Segalowitz and Segalowitz (1993) thus proposed that this decrement in the CV reflects a qualitative modification in performance because of the absence of components that formerly contributed largely to the variability. This qualitative difference may be produced by the reorganization of the underlying mechanisms that are involved in performing a task. Hence, the CV can be a useful index of automaticity insofar as a change in the CV allows one to reject the hypothesis that faster responding is due simply to a generalized speed-up of underlying processes in favour of the hypothesis that there has been a selective elimination of and/or re-organization of those processes. In the research reported below, the CV will be used as an index of processing efficiency, where a lower CV indicates more efficient (in this sense, more automatic) processing.

While the coefficient of variation (CV) can be used as just described as an index of processing efficiency, what is needed is an index of processing efficiency that is specific to the second language, one that takes into account or controls for the bilingual's more general processing abilities and processing efficiency. To accomplish this, in the research reported here, the procedure used was to partial out CVs obtained in the first language from CVs obtained in the second language and use the residuals as indicators of relative efficiency or automaticity in the second language. This procedure was used successfully by Segalowitz and Freed (in press) who found that such residualized measures were found to be related to oral fluency measures.

Statistically, the coefficient of variation (CV) in the first language serves as a baseline against which the CV in the second language is regressed. This residualized CV reflects some components of word recognition specific to second language without including many other aspects of general language ability (e.g., semantic knowledge, knowledge of syntactic and phrase structures, world knowledge in sentence comprehension, ability to combine or integrate a variety of sources of information, etc.). Therefore, this index has built into it a control for individual differences in word recognition as well as a general language ability that may be functioning in both language conditions.

Based on the materials just reviewed, automaticity is believed to be just one of the components to promote the development of proficiency of a language. Another major area of research on second language proficiency is the study of the role of attention in the coordination and control of language processing.

Attention

Attention has been considered an important topic in consciousness and cognitive science since Hermann von Helmholtz wrote on the subject (Helmholtz, 1896). A general view of attention is that mental resources are of limited capacity but may be allocated flexibly according to task demands (Kahneman, 1973). Interest has been maintained in understanding the role played by attention control processes in complex skill development. For example, Gopher (1993) investigated the development of attention control strategies for coordinating the interplay between highly interactive components in a complex skill task. His study showed the presence of behavioural control over the allocation of attention and that with appropriate training attention control can be taught to improve. In this sense, attention control can be regarded as a basic skill element. He suggested that individuals need to determine attention tactics and allocating processing in controlling and using their limited attentional resources among changing task components at the same time.

Of immediate interest to the present study is the issue of attention focusing, which can be seen to reflect, in some ways, Kahneman's (1973) concern with allocation of resources. Shifting attention from one element of focus to another is crucial for successfully carrying out any complex cognitive task because the needs of such tasks change from moment to moment and often the environment in which such tasks are performed changes in unpredictable ways. The ability to carry out such shifts in attention focus rapidly and fluidly (i.e., efficiently) is perhaps central to fluent performance. In the present research we are concerned with the question of this efficiency of one's ability to shift the focus of attention appropriately as the demands of the moment require it.

James (1890) suggested that attention permits individuals to see, think, differentiate, and retrieve better than they otherwise could. He also stated that attention can be voluntary and effortful under one condition but under different conditions it can be involuntary and effortless. That means attention can be drawn voluntarily to any feature of the environment but it can be attracted automatically by some components of stimuli in the environment such as sudden changes in brightness or pitch. This automatic aspect of attention can determine individuals' behaviour especially when their attentional resources are exhausted because of fatigue or stress.

In the case of second language learning, when English speakers of French are tired or under stress, they may have difficulty observing certain important grammatical conventions of the language, especially when these depart from the conventions observed in English. For example, in French, French possessive pronouns such as sa (feminine form) and son (masculine form) must agree with the noun designating the possessed object. This contrasts with English, where the possessive pronouns his and her refer to the possessor. This can be seen in the following situation -- Tom talks to his mother -- where his is equivalent to Tom's in this case. However, to translate this sentence into French, a feminine possessive form is used -- Tom parle à sa mère -- because in French the possessive pronoun follows the gender of the possessed noun. English speakers of French may be directed automatically by the grammatical components of their first language when the attentional resources allocated to choosing the correct form of grammar have been depleted.

The next section discusses the role of attention in language. Following the next section is a discussion of research on attention control in second language proficiency.

Attention and Language

Effective use of language requires the coordination of a variety of cognitive skills. For instance, an individual must be capable of focusing attention on important relevant information on the one hand; she must also be alert to significant, unexpected changes in the linguistic environment on the other hand, such as a change in the tone of voice, or the introduction of an unexpected idea. In other words, the individual must be able to selectively shift attention from one dimension of language to another to remain focused on goal-related information. Such attention flexibility is necessary to enable an individual to engage effectively in actions to achieve a communicative goal.

Beyond this, however, language directs and controls what individuals attend to in a special way. First, words direct attention to specific objects, events and their attributes. For example, in the sentence -- The boy was holding a red ball -- the words boy, hold, red and ball direct the listener's or reader's attention to conceptual representations corresponding to the objects boy, ball, the action event hold and the perceptual attribute red. Second, and this is especially important for the research reported here, words and sentence structure also direct attention to relationships between items named. In the example sentence the elements The, a, was …-ing do not have perceptual referents in the same sense as nouns, verbs and adjectives. The/a refer to the definiteness and indefiniteness of the modified noun, that is, whether the noun is related to some previously mentioned or known object (the referent of boy must already be known to the reader; the referent of ball is new information being introduced for the first time by this sentence). The construction was …-ing indicates something about how the action specified by hold unfolds (contrast this with held the ball, had held the ball, etc.).

It is especially this second type of attention directing activity of language that can differ markedly from one language to another. Accordingly, the way one's first language directs attention to the quality and content of mental representations may lead learners to ignore important linguistic characteristics of a second language that do not receive verbal expression in their first language (Slobin, 1996). For example, the definiteness difference between _a_ and _the_ can only be signaled to a person through syntactic devices in a language because these grammaticized notions cannot be sensed directly by our sensorimotor and perceptual systems. Slobin suggested that the function of grammaticized words is to direct one's attention to such relational or grammaticized notions. In contrast, the function of non-grammaticized words, such as concrete and abstract nouns, adjectives and verbs that can be experienced directly as objects or events in the environment, is to fill in the content of a message. This definiteness example also shows the importance of grammaticized words that are critical components in directing one's attention to build an equivalent mental representation as the messenger. By being able to skillfully manipulate these grammaticized words, second language users can obtain much more information by paying attention to the subtle features of language and thus become more sensitive to linguistic and social cues.

In agreement with this line of reasoning, Segalowitz (2000) suggested that two complementary factors, attention and nonattentive processes, are involved in the acquisition of second language fluency or proficiency. A proficient second language user should be able to recognize letters or speech sounds automatically at one point and also be able to adjust to environmental changes so as to execute any appropriate activity that may be necessary. Therefore, this ability to shift attention easily and sensitively to changing features of the environment, also known as attention flexibility, requires highly efficient cognitive control of attention.

Research on Attention Control in Second Language Proficiency

In order to investigate if individual differences in attention control underlie individual differences in second language reading skill, Segalowitz, O'Brien, and Poulsen (1998) adapted a linguistic version of the Wisconsin Card Sorting Task to measure participants' attention flexibility in their first (English) and second (French) language. Bilingual participants performed four tests, which included an English attention shifting task, a French attention shifting task, a French control task, and a French reading speed test. On every trial of the attention shifting tasks, participants needed to figure out the matching rule by trial and error. For example, on one trial, the target word vast might be surrounded by the following four words -- large (synonym), tiny (antonym), fast (rhyme), and low (semantically and phonologically unrelated word) -- and participants would have to choose the one they thought matched the target word. The matching rule here might be to choose a synonym. They received accuracy feedback after each trial. The matching rule was counterbalanced and was randomly shifted after a period of four to twelve correct matched words (e.g., ran with one matching rule and then surprise shift after a run of 8 correct responses). The only difference between the French attention shifting task and French control task was that in the control task participants were given the matching rule so that they did not need to find the rule by trial and error as in the attention shifting tasks. The researchers believed that second language learners needed attention flexibility to adapt to linguistic environmental changes. Therefore, they hypothesized that second language attention flexibility would be correlated with second language reading speed. Their research finding supported this hypothesis by showing that attention flexibility underlay individual differences in second language reading skill. However, a methodological shortcoming of this procedure was that while the effect was obtained using reaction time measures, the number of trials for finding the new matching rule was not the same for each participant, due to individual differences in preservation. This meant that some subjects received more practice with the task than others and this could have affected reaction times.

This problem led Segalowitz and Frankiel (in preparation) to use Rogers and Monsell's (1995) alternating attention shift paradigm to further examine the relationship between second language proficiency and linguistic attention control. This alternating runs paradigm involved both switch and repeat trials within blocks (i.e., tasks AABBAA ...) in which performance on repeat trials served as baseline and costs of switching were computed by partialling out mean reaction time on these repeat trials from mean reaction time on switch trials. Stimuli were presented in one of four quadrants on a computer screen and their presentation rotated in clockwise manner on successive trials, with location on the screen (i.e., which quadrant) indicating which of two tasks had to be performed. This resulted in regular, predictable alternation between the tasks. The first trial of each task demanded a task switch from the previous trial and the second trial required only a repetition of the task performed on the previous trial.

The paradigm was conducted in separate blocks of English (first language measures used as baseline) and French (second language), to allow a measure of switch cost in each language. A measure of proficiency specific to second language was obtained by partialling out reaction times on English from French on a lexical classification task (living-nonliving). The stimuli used in the attention switching task were time words (now, next, promptly, shortly; or afterward, later, tomorrow, never) and causal connection words (because, consequently, due to, therefore; or although, but, despite, however). The design permitted assessment of the ability to shift focus of attention in responding to these time and causal connection words. This ability to shift attention flexibly was hypothesized to be correlated with second language proficiency. Participants were required to switch between the time and causal connection words after a repeat trial (e.g., time, time, cause, cause, time, time, etc. which involves switch repeat switch repeat switch repeat etc.). They judged one word at a time. When they saw a time word, they decided whether this time word referred to a moment that was either nearer to or further away from the present by pressing the left or right button. For example, the time word promptly can be thought of as indicating that the action it modifies occurs very close to the present moment on a hypothetical mental representation of a time line whereas the word tomorrow would represent the action as more distant from the present moment. When participants saw a causal connection word, they had to decide whether this word referred to the presence or absence of mention of a causal connection (e.g., compare because in John did well in his exams because he studied all night with despite in John did well in his exams despite partying all night). The researchers found that the reaction time on switch trials was significantly longer than the reaction time on repeat trials, that is, a switch cost.

This switch cost became an index of attention control that reflected the degree of difficulty for shifting focus of attention from one category to the other. Segalowitz and Frankiel (in preparation) found that there was a significant correlation between the second language attention control and second language proficiency. According to them, this second language-specific cognitive control of attention is essential for developing proficiency in a second language.

Recently, Houde (2001) in Segalowitz's laboratory, conducted a study to test an hypothesis that was related more directly to Slobin's (1996) suggestion. As mentioned earlier, Slobin proposed that grammaticized words (those whose referents cannot be directly experienced by the perceptual and sensorimotor systems) play a significant role in directing attention. In his study, Houde explored the relationships among words, reading proficiency, and language-specific attention control in second language performance. Similar to other studies, he employed a speeded word classification task for measuring participants' English and French reading proficiency. The researcher requested participants to classify words either into living (e.g., flower, grandfather, lion) or nonliving (e.g., table, hat, train) category by pressing the right or left button. An index of reading proficiency was used based on the coefficient of variation (CV) of the word recognition reaction time. For a measure of reading proficiency specific to second language, the CV of first language reading proficiency was partialled out from the CV of second language.

In addition to the speeded word classification task, a category switch task was performed to measure cognitive control of attention. Houde (2001) used concrete (e.g., apple, leg, house), abstract (e.g., idea, answer, law), and grammaticized (e.g., me, in, during) words. The category switch task was conducted in both English and French in separate sessions. On the first trial, four words were presented across the top of the screen and participants could choose any one of these words (e.g., apple) by pressing a button that corresponded to the chosen word's location on the screen. However, on the following trial, participants had to choose a word that belonged to a different group from apple (e.g., house) and not a word (e.g., banana) that came from the same group again. Houde used the concrete word condition as a baseline against which to contrast performance in the abstract and grammaticized word conditions. This baseline controlled for the participants' basic ability in switching category tasks, regardless of their speed in word reading. For instance, an index of second language grammaticized-attention control was computed by first residualizing reaction times in the French grammaticized word condition against the French concrete word condition, then continuing the same procedure in English, and finally residualizing the French scores against the English scores. The researcher found that attention control varied as a function of reading proficiency but only for grammaticized words. Thus, he suggested that high proficiency in the second language is associated with flexible and rapid ability to shift attention among grammaticized components in communication.

However, the category shift task employed in Houde's (2001) study involved working memory, because the participant had to remember which word had been chosen on the previous trial. Thus, poor performance on this task could also have been due to a deficit in working memory as opposed to or in addition to a deficit in attention shifting. Accordingly, issues of memory could not be separated from issues of control or flexibility of attention shifting. In addition to this shortcoming, the use of the concrete word condition as a baseline made it impossible to independently assess the ability to shift focus of attention in the concrete word condition (there was no baseline for this condition).

The Present Study

With the aim to better understand some of the cognitive mechanisms that may be involved in acquiring a second language, the goals of the present study were to assess second language proficiency in relation to attention control processes. The present study was designed to use a simultaneous nonmatching-to-sample procedure to examine attention control, with a matching-to-sample procedure providing baseline measures. The matching and nonmatching-to-sample tasks involved the presentation of a Sample item and four Test items, in which the Sample item remained visible while the nonmatching or matching decision was made. Without making demands on working memory as was the case Houde's (2001) investigation, the present study investigated the ability of people to shift attention from one category of words to another. Conditional discrimination was required because the particular Test stimulus that matched the Sample stimulus on a matching block was incorrect on a nonmatching block. While the matching task involved judgments of the taxonomic relations in categorization between the Sample word and the correct Test word, the nonmatching task demanded selection based on differences in taxonomic relations among the stimuli displayed. Poor performance on the nonmatching-to-sample task thus suggested limitations in flexible thinking.

Second language proficiency was assessed in this study using a modified version of the living-nonliving lexical categorization task. The modification was the inclusion of semantically primed and unprimed trials. Primed trials were those in which the immediately preceding trial involved a word that was a high semantic associate of the stimulus on the present trial (e.g., … cat … dog …). This provided two indices of proficiency. First, it was expected that generally speaking, more proficient bilinguals would be faster compared to low proficient bilinguals. Second, it was expected that higher proficient bilinguals would show stronger semantic priming effects compared to lower proficient bilinguals, following the results of Favreau and Segalowitz (1983). The dependent measure of critical interest from the lexical categorization task was the measure of processing efficiency or degree of automatization, not the measure of simple speed. The coefficient of variation (CV) of the response time provided this measure of efficiency or automaticity, as described earlier.

To summarize, the present study investigated the role of attention control in adult second language proficiency. Participants were English-French bilinguals whose levels of proficiency in the second language were evaluated by a living/nonliving word classification task. To examine the cognitive control mechanism specific to the second language, a simultaneous matching/nonmatching task with concrete, abstract, and grammaticized words was constructed. Second language-specific proficiency and attention control were assessed by partialling out performance in the first language from performance in the second language. It was hypothesized that second language proficiency would be predicted by efficiency of attention shifting with grammaticized elements, but not with concrete and abstract nouns, and that this relationship would hold for second language-specific measures of proficiency and attention shifting ability.

Method

Participants

Participants were 24 university students (7 men and 17 women) aged 19 to 46 years (mean age = 23 years). They were recruited on a voluntary basis through personal contact. They were either given 14 dollars or received course credit for their participation. Their first language was English and second language was French. Participants rated their speaking, reading, and writing abilities in English and French ranging from no ability to native-like ability measured by a five-point Likert scale of a questionnaire. Only participants scoring at least two on the ability scales in French for speaking, reading, and writing were retained for the present study. They were required to have normal or corrected-to-normal visual acuity and no reading disability.

Apparatus

Stimuli were presented in uppercase 24-point Palatino font for the living/nonliving word classification task and in lowercase 24-point Palatino font for the matching and nonmatching-to-sample tasks on a 10-inch color Apple screen set to 640 x 480 pixel resolution. Stimulus presentation and data collection were programmed in HyperCard Version 2.3 software and run on an Apple Macintosh 7100 computer. The screen was viewed from a distance of 60 cm. Observations were binocular.

Materials

Living/Nonliving word classification task. For the living/nonliving word classification task, there was a block of training trials designed to familiarize the participants with the task procedures, and two blocks of experimental trials, one in English and one in French. The trials for the training block were constructed using 8 letters (F, J, K, P, T, V, X, Z) and 8 digits (2, 3, 4, 5, 6, 7, 8, 9), for a total of 106 training trials, which were excluded from all analyses. Stimuli that were either letters or digits were drawn from the set in pseudo-random order, with the restriction that no stimulus be repeated on two successive trials.

For experimental blocks, a total of 136 English words and 136 French words, mostly translation equivalents to the English words, were used. For each language condition, the 136 words were composed of names for 68 living and 68 nonliving objects. These 136 words were presented twice each for a total of 272 trials (22 warm-up trials and 250 experimental trials). On 120 trials, 60 different words each appeared twice. In these trials, each word appeared once on a primed trial in which the immediately preceding word was as strong semantic associate (e.g., the knife followed by the fork) as determined by the University of South Florida word association, rhyme, and word fragment norms (Nelson, McEvoy, & Schreiber, 1994) and once preceded by a non-associate (e.g., the fork followed by the bank;

see Appendix A-1 & 2). On 152 of these trials, 76 different words served as fillers, each appearing twice. The first 11 trials of each block used filler words and were considered as warm-up trials and, along with the other filler trials, were excluded from all analyses. This left 120 experimental trials per condition (60 primed and 60 unprimed). First and second occurrences of each word were separated by at least 15 trials. Trials were sequenced such that there were never more than four successive left or right button press responses required. Using a computer keyboard with the C key relabeled as a left key and the N key relabeled as a right key, participants were requested to press the right button for either letters or living objects and to press the left button for either digits or non-living objects.

Matching and nonmatching-to-sample tasks. For the matching and nonmatching-to-sample tasks, the training blocks used neutral symbols as stimuli, which were drawn from the categories shapes, digits, letters, and nonalphanumeric symbols (see Appendix B-1). Two blocks (one matching-to-sample and one nonmatching-to-sample) of 56 trials each were created for the training phase, for a total of 112 training trials.

For experimental blocks, three sets of 16 English words and three sets of 16 French words were constructed. The three sets of words were (a) concrete nouns, which consisted of words drawn from the categories fruit, building, body part, and animal (see Appendix B-2); (b) abstract nouns, which were words drawn from the categories mental activity, time unit, verbal activity, and type (see Appendix B-3); and (c) grammaticized words, which were forms of the verb "to be", conjunctions, prepositions, and pronouns (see Appendix B-4). Twelve blocks of 56 trials were created for the English (3 matching-to-sample and 3 nonmatching-to-sample blocks) and French (3 matching-to-sample and 3 nonmatching-to-sample blocks) conditions. The first 16 trials of each block were considered warm-up trials and were excluded from all analyses. This left 40 experimental trials per block for a total of 240 experimental trials per language condition. The order of block presentations was counterbalanced across participants. Stimulus trials were counterbalanced across the block such that targets appeared an approximately equal number of times and occurred in each possible screen position (1st, 2nd, 3rd, 4th). The Sample and Test stimuli were sequenced in pseudo-random order, with the restriction that no Sample and Test stimuli were repeated on two successive trials. On each trial, five stimuli were presented on the computer screen - one Sample and four Test words. Two of the Test words were drawn from the same category as the Sample. The remaining two Test words were drawn from two other categories. For example, on a matching trial, the Test stimuli might have consisted of four words drawn from three categories (e.g., cat, peach, leg, pear) and the Sample word (e.g., apple). The Sample word apple was associated with the two Test words peach and pear as these words were drawn from the same category (fruit) in the study list, and thus either peach or pear would be an appropriate response. However, on a nonmatching trial, the correct responses would be either cat or leg as these words were drawn from a different category than the Sample.

Using a computer keyboard with the C key relabeled as a position 1, the V key relabeled as a position 2, the B key relabeled as a position 3, and the N key relabeled as a position 4, participants selected a Test word by pressing on the key that corresponded to the position of the word on the screen.

Design

All participants performed the living-nonliving lexical classification task that provided a measure of second language proficiency, and the matching-to-sample and nonmatching-to-sample tasks that provided measures of attention control. The order of languages tested (first language before second language or vice versa) was counterbalanced across participants.

Second language proficiency. The measure of second language proficiency, based on lexical access, was derived from performance in the living-nonliving lexical classification task. This task conformed to a 2 (first language, second language) x 2 (primed, unprimed) within-subject factorial design.

Second language attention control. The measure of second language attention control was based on performance in the nonmatching-to-sample task corrected for baseline performance as obtained in the matching-to-sample task. Both the nonmatching-to-sample task and the matching-to-sample task conformed to a 2 (first language, second language) x 3 (concrete noun, abstract noun, grammaticized word) within-subject factorial design.

Procedure

Participants were tested individually. They read and signed consent forms describing the general purpose and procedures of the experiment and explaining participant confidentiality and rights (see Appendix C). They were told that the whole session lasted approximately one hour and a half. Participants filled in participant questionnaires in which they reported their linguistic background and level of speaking, reading, and writing abilities in English and French (see Appendix D).

Before doing the living/nonliving word classification test, participants read instructions (see Appendix E-1 & 2) about the testing procedure. The experimenter went over the instructions with them and told them that reaction times would be recorded automatically by the computer. Participants were requested to respond as quickly as possible to each stimulus without sacrificing accuracy.

Participants were seated throughout the experiment in front of a computer where the stimuli were presented. Each block of trials began with the message "Press either key when ready to start". Approximately 450 ms later, the first stimulus was presented and remained in the center of the screen until the participant responded or until a deadline of 5000 ms passed. The interval between the participant's response and presentation of the next stimulus was approximately 450 ms. If the response was incorrect, a computer-generated "boing" tone was played and an extra 1.5 s was added to the response-stimulus interval (RSI) to allow the participant time to recover from the error.

For the training condition, participants classified a stimulus as a letter or digit. For the English and French conditions, participants classified a word as a living or non-living object. Throughout the block, instructions for left and right button press assignments appeared as a reminder at the bottom of the screen.

After the living/nonliving word classification test, participants read instructions (see Appendix F-1 to 4) for the matching and nonmatching-to-sample task. The experimenter reminded the participants to respond as quickly as they could without sacrificing accuracy. To become familiar with the way the stimuli had been categorized for this task, participants completed a training session for each block before testing. During each training session, participants studied a list of 16 stimuli, which were classified into four (easy-to-remember and intuitively obvious) categories (see Appendix G-1 to

8). Then, they sorted twice a pack of cards that contained all of these stimuli into the four categories they had just studied without looking at the study list.

In the testing phase, participants were seated in front of a computer. Each block of trials began with the message "Press any key when ready". Approximately 450 ms later, the first four Test stimuli and a Sample stimulus were presented and remained on the screen until the participant responded or until a response time limit of 5 s had passed. The Sample item remained visible while the matching decision was made and so did not necessitate memory. The interval between the participant's response and presentation of the next stimulus was approximately 450 ms. Trials on which participants committed errors and trials immediately following an error were excluded from all analyses. At the end of each block of trials, participants were shown their testing results, including points earned, the total number of errors, and bonus points for speed for that block. On each trial, four Test stimuli were presented at the top of the screen and a bolded Sample stimulus appeared in a 7.5 cm by 4 cm rectangle in the center of the monitor. Throughout the matching block, instructions for same category choice assignments were presented as a reminder at the bottom of the rectangle. Participants were requested to choose a Test word belonging to the same category as the Sample stimulus throughout the block. However, throughout the nonmatching block, instructions appeared for participants to choose a Test word belonging to a different category from the Sample stimulus.

Results

Participant Questionnaire Measure

On the questionnaire, participants were requested to evaluate their speaking, reading, and writing skills in both English and French using a Likert scale ranging from 1 (no ability at all) to 5 (native-like ability). The means of ability ratings in English for speaking, reading, and writing were 4.79 (SEM = .104), 4.83 (SEM = .078), and 4.79 (SEM = .104) respectively (range = 4.0 to 5.0). The means of ability ratings in French for speaking, reading, and writing were 3.46 (SEM = .170), 3.71 (SEM = .195), and 3.08 (SEM = .180) respectively (range = 2.0 to 5.0). The minimum responses to remain in the present study were two on these ability ratings.

Participants were also requested to estimate the frequency of using these speaking, reading, and writing skills over one week period in both English and French using a Likert scale ranging from 1 (never/almost never) to 5 (main language used). The means of time ratings in English for speaking, reading, and writing were 5, 5, and 5 respectively (SEM = 0). The means of time ratings in French for speaking, reading, and writing were 3.04 (SEM = .259; range = 1.0 to 5.0), 2.21 (SEM = .190; range = 1.0 to 4.0), and 1.42 (SEM = .158; range = 1.0 to 4.0) respectively.

Second Language Proficiency Measure

The mean reaction times in the first language was 647 ms (SEM = 20.60) and mean reaction times in the second language was 740 ms (SEM = 21.13). A paired samples two-tailed t-test revealed that participants were significantly slower to respond in the second language than in the first language, $t(23) = -7.03$, $p < .001$.

The coefficient of variation (CV) on the living/nonliving word classification task formed the basis of the computations for second language-specific proficiency. Using the CV in the first language as a baseline against which the CV in the second language was regressed, the residualized CV was used as an index of stimulus recognition skills or proficiency, reflecting automaticity or efficiency of lexical access in the second language.

For the living/nonliving word classification task, the data were analyzed in the following three different ways: using data from all primed and unprimed trials; from primed trials alone, and from unprimed trials alone. The data in each analysis were aggregated to obtain a residualized coefficient of variation (CV) by partialling out CV in the first language (English) from the CV in the second language (French).

The residualized coefficients of variation (CVs) were sorted in order such that the first 12 participants (with the largest CVs) formed the "lower" proficiency group and the last 12 participants (with the smallest CVs) formed the "higher" proficiency group. For the lower proficiency group, the mean CV in the first language was .428 (SEM =

.039) and mean CV in the second language was .525 (SEM = .029). A paired samples two-tailed t-test revealed that participants in the lower proficiency group were significantly slower to respond in the second language than in the first language, $t(11) = -4.43$, $p = .001$. For the higher proficiency group, the mean CV in the first language was .395 (SEM = .043) and mean CV in the second language was .333 (SEM = .028). A paired samples two-tailed t-test showed that participants in the higher proficiency group were not significantly slower to respond in the second language than in the first language, $t(11) = 1.63$.

The second language coefficients of variation (CVs) were residualized against the first language CVs as described earlier to obtain second language-specific CVs. The correlations between the second language-specific CVs and second language-specific reaction times in the living/nonliving classification tasks for all participants were significant for all trials as well as unprimed trials, $r = .45$, $p < .05$ ($n = 24$) and $r = .74$, $p < .0001$ ($n = 24$), respectively. These results indicate that participants who responded faster were doing so because they were processing in a more efficient manner than the slower participants (i.e., the speed-up hypothesis that processing by the faster responders were simply faster but not otherwise different could be rejected). The correlation was not significant for primed trials, $r = .16$ ($n = 24$).

Attention Control Measure

Table 1 displays the mean reaction times and mean coefficients of variation in the first and second languages for the measures of attention control variables in the matching and nonmatching-to-sample tasks. The data show a pattern of matching-nonmatching shifting costs on the reaction times, suggesting that participants were significantly slower to respond in the nonmatching task than in the matching task.

The coefficients of variation (CVs) obtained from the matching/nonmatching-to-sample task on concrete, abstract, and grammaticized trials formed the basis of the computations for efficiency of attention shifting with concrete elements (attention control concrete CV), abstract elements (attention control abstract CV), and grammaticized elements (attention control grammaticized CV). Each measure of attention shifting involved a residualized score obtained by partialling out CV on matching trials from CV on nonmatching trials. This procedure thus removed variance associated with individual differences in single word reading proficiency as well as in button pressing speed. These CVs of the three attention shifting tasks were calculated in both language conditions and represent the participants' abilities to make the category shift after other factors have been controlled for. To obtain a measure of attention control specific to the second language,

Table 1

Mean Reaction Times and Mean Coefficients of Variation for the Measures of Second Language-Specific Attention Control Variables in the Matching and Nonmatching-to-Sample Task (N = 24)

	Reaction Time				Coefficient of Variation			
	First Language		Second Language		First Language		Second Language	
Category	M	SEM	M	SEM	M	SEM	M	SEM
	Matching-to-Sample Task							
Concrete	1163	32.78	1306	37.39	.305	.013	.320	.012
Abstract	1661	64.14	1679	64.84	.374	.016	.385	.017
Grammaticized	1544	61.68	1741	61.50	.362	.015	.376	.013
	Nonmatching-to-Sample Task							
Concrete	1432	84.58	1467	72.81	.273	.016	.295	.014
Abstract	1886	80.20	1973	92.60	.350	.014	.331	.011
Grammaticized	1842	84.60	2040	97.17	.321	.013	.325	.010

the attention shifting CV in the first language was used as a baseline against which the attention shifting CV in the second language was regressed. This measure was computed by partialling out the English attention shifting CV from the French attention shifting CV and saving the residuals.

The main hypothesis was that second language-specific attention control with grammaticized elements would significantly predict second language proficiency, after taking into account attention control performance with concrete and abstract nouns. To test this hypothesis, hierarchical multiple regression was employed. The probability of a Type I error was set at p = .05 for all analyses.

Table 2 displays the correlation between second language-specific proficiency based on all trials (primed and unprimed) and the measures of second language-specific attention control variables (concrete nouns, abstract nouns, grammaticized words). Table 3 shows that after step 1, with measures of attention control for concrete and abstract nouns in the equation, R^2 = .061, F_{inc} (2, 21) = .676. This result indicates that these attention control measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific proficiency. After step 2, with measures of attention control for grammaticized words added to

Table 2

Intercorrelations Between Second Language-Specific Proficiency Based on All Trials and the Measures of Second Language-Specific Attention Control CV Variables

	1	2	3	4
(n = 24)				
1. Proficiency: All trials	--	.241	-.073	.272
2. Attention control for concrete nouns		--	-.097	-.458
3. Attention control for abstract nouns			--	.144
4. Attention control for grammaticized words				--

Table 3

Summary of Hierarchical Multiple Regression Analysis for CV Variables Predicting Second Language-Specific Proficiency Based on All Trials (N = 24)

Variable	B	SE B	β
Step 1			
Attention control for concrete nouns	.454	.409	.236
Attention control for abstract nouns	-.134	.571	-.050
Step 2			
Attention control for concrete nouns	.882	.419	.458*
Attention control for abstract nouns	-.269	.525	-.100
Attention control for grammaticized words	1.182	.521	.496*

Note. R^2 = .061 for Step 1 (p = .519); ΔR^2 = .192 for Step 2 (p = .035).

*p < .05.

prediction of second language-specific proficiency by measures of attention control for concrete and abstract nouns, R^2 = .253 (sr^2 = .192), F_{inc} (1, 20) = 5.141, p = .035. Therefore, addition of measures of attention control for grammaticized words to the equation with measures of attention control for concrete and abstract nouns resulted in a significant increment in R^2. Altogether, 25.3% of the variability in index of proficiency was predicted by knowing scores on the measures of attention control for concrete, abstract, and grammaticized variables.

As mentioned previously, participants were split into two proficiency groups. Tables 4 and 5 display the correlations between second language-specific proficiency based on all trials (primed and unprimed) and the measures of second language-specific attention control variables (concrete nouns, abstract nouns, grammaticized words) for the 12 most proficient participants and 12 least proficient participants, respectively. Table 6 shows that for the higher proficiency group, after step 1, with measures of attention control for concrete and abstract nouns in the equation, R^2 = .084, F_{inc} (2, 9) = .414. This result indicates that these attention control measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific proficiency in this group. After step 2, with measures of attention control for grammaticized words added to

Table 4

Intercorrelations Between Second Language-Specific Proficiency Based on All Trials and the Measures of Second Language-Specific Attention Control CV Variables for Higher Proficiency Group

	1	2	3	4
	(n = 12)			
1. Proficiency: All trials	--	.109	-.290	.532
2. Attention control for concrete nouns		--	-.432	-.583
3. Attention control for abstract nouns			--	.198
4. Attention control for grammaticized words				--

Table 5

Intercorrelations Between Second Language-Specific Proficiency Based on All Trials and the Measures of Second Language-Specific Attention Control CV Variables for Lower Proficiency Group

	1	2	3	4
(n = 12)				
1. Proficiency: All trials	--	.152	-.138	.024
2. Attention control for concrete nouns		--	.187	-.396
3. Attention control for abstract nouns			--	.047
4. Attention control for grammaticized words				--

Table 6

Summary of Hierarchical Multiple Regression Analysis for CV Variables Predicting Second Language-Specific Proficiency Based on All Trials for Higher Proficiency Group (N = 12)

Variable	B	SE B	β
Step 1			
Attention control for concrete nouns	-.032	.577	-.020
Attention control for abstract nouns	-.556	.660	-.298
Step 2			
Attention control for concrete nouns	.850	.492	.521
Attention control for abstract nouns	-.447	.466	-.240
Attention control for grammaticized words	1.410	.442	.883*

Note. R^2 = .084 for Step 1 (p = .673); ΔR^2 = .512 for Step 2 (p = .013).

*$p < .05$.

prediction of second language-specific proficiency by measures of attention control for concrete and abstract nouns, R^2 = .596 (sr^2 = .512), F_{inc} (1, 8) = 10.149, p = .013. Thus, addition of measures of attention control for grammaticized words to the equation with measures of attention control for concrete and abstract nouns resulted in a significant increment in R^2. A total of 59.6% of the variability in index of proficiency for the higher proficiency group was predicted by knowing scores on the measures of attention control for concrete, abstract, and grammaticized variables. For the lower proficiency group, none of the measures of attention variables predicted second language-specific proficiency significantly and the total amount of variance accounted for was only 6.5%, F(3, 8) = .19.

Table 7 displays the correlation between second language-specific proficiency based on primed trials and the measures of second language-specific attention control variables (concrete nouns, abstract nouns, grammaticized words). Table 8 shows that after step 1, with measures of attention control for concrete and abstract nouns in the equation, R^2 = .134, F_{inc} (2, 21) = 1.619. This result indicates that these attention control measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific proficiency. Step 2, however, revealed that the measures of

Table 7

Intercorrelations Between Second Language-Specific Proficiency Based on Primed Trials and the Measures of Second Language-Specific Attention Control CV Variables

	1	2	3	4
(n = 24)				
1. Proficiency: Primed trials	--	.195	-.327	.254
2. Attention control for concrete nouns		--	-.097	-.458
3. Attention control for abstract nouns			--	.144
4. Attention control for grammaticized words				--

Table 8

Summary of Hierarchical Multiple Regression Analysis for CV Variables Predicting Second Language-Specific Proficiency Based on Primed Trials (N = 24)

Variable	*B*	*SE B*	β
Step 1			
Attention control for concrete nouns	.258	.319	.165
Attention control for abstract nouns	-.679	.446	-.311
Step 2			
Attention control for concrete nouns	.593	.326	.379
Attention control for abstract nouns	-.784	.409	-.359
Attention control for grammaticized words	.928	.406	.480*

Note. R^2 = .134 for Step 1 (p = .222); ΔR^2 = .179 for Step 2 (p = .033).

*$p < .05$.

attention control for grammaticized words added significantly to prediction of second language-specific proficiency, R^2 = .313 (sr^2 = .179), F_{inc} (1, 20) = 5.226, p = .033. Thus, addition of measures of attention control for grammaticized words to the equation with measures of attention control for concrete and abstract nouns resulted in a significant increment in R^2. Altogether, 31.3% of the variability in index of proficiency was predicted by knowing scores on the measures of attention control for concrete, abstract, and grammaticized variables.

For the higher proficiency group, the hierarchical multiple regression analysis also showed that measures of attention control for grammaticized words contributed significantly to prediction of second language-specific proficiency to primed words as well as to unprimed words. Table 9 displays the correlation between second language-specific proficiency based on primed trials and the measures of second language-specific attention control variables (concrete nouns, abstract nouns, grammaticized words) for the 12 most proficient participants. Table 10 shows that for the higher proficiency group, after step 1, with measures of attention control for concrete and abstract nouns in the equation, R^2 = .098, F_{inc} (2, 9) = .488, indicating that the attention control measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific

Table 9

Intercorrelations Between Second Language-Specific Proficiency Based on Primed Trials and the Measures of Second Language-Specific Attention Control CV Variables for Higher Proficiency Group

	1	2	3	4
	(n = 12)			
1. Proficiency: Primed trials	--	.143	-.309	.520
2. Attention control for concrete nouns		--	-.317	-.583
3. Attention control for abstract nouns			--	.237
4. Attention control for grammaticized words				--

Table 10

Summary of Hierarchical Multiple Regression Analysis for CV Variables Predicting Second Language-Specific Proficiency Based on Primed Trials for Higher Proficiency Group (N = 12)

Variable	B	SE B	β
Step 1			
Attention control for concrete nouns	.062	.411	.050
Attention control for abstract nouns	-.540	.615	-.293
Step 2			
Attention control for concrete nouns	.617	.320	.501
Attention control for abstract nouns	-.659	.415	-.358
Attention control for grammaticized words	1.069	.310	.875*

Note. R^2 = .098 for Step 1 (p = .629); ΔR^2 = .54 for Step 2 (p = .009).

*$p < .05$.

proficiency. After step 2, with measures of attention control for grammaticized words added to prediction of second language-specific proficiency by measures of attention control for concrete and abstract nouns, R^2 = .638 (sr^2 = .540), F_{inc} (1, 8) = 11.922, p = .009. Therefore, addition of measures of attention control for grammaticized words to the equation with measures of attention control for concrete and abstract nouns resulted in a significant increment in R^2. The total amount of 63.8% of the variability in index of proficiency for the higher proficiency group was predicted by knowing scores on the measures of attention control for concrete, abstract, and grammaticized variables.

For unprimed words, Table 11 displays the correlation between second language-specific proficiency based on unprimed trials and the measures of second language-specific attention control variables (concrete nouns, abstract nouns, grammaticized words) for the 12 most proficient participants. Table 12 shows that for the higher proficiency group, after step 1, with measures of attention control for concrete and abstract nouns in the equation, R^2 = .098, F_{inc} (2, 9) = .489. These attention control measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific proficiency. After step 2, with measures of

Table 11

Intercorrelations Between Second Language-Specific Proficiency Based on Unprimed Trials and the Measures of Second Language-Specific Attention Control CV Variables for Higher Proficiency Group

	1	2	3	4
(n = 12)				
1. Proficiency: Unprimed trials	--	.309	-.080	.437
2. Attention control for concrete nouns		--	-.088	-.368
3. Attention control for abstract nouns			--	.294
4. Attention control for grammaticized words				--

Table 12

Summary of Hierarchical Multiple Regression Analysis for CV Variables Predicting Second Language-Specific Proficiency Based on Unprimed Trials for Higher Proficiency Group (N = 12)

Variable	B	SE B	β
Step 1			
Attention control for concrete nouns	.387	.404	.304
Attention control for abstract nouns	-.084	.506	-.053
Step 2			
Attention control for concrete nouns	.698	.342	.549
Attention control for abstract nouns	-.381	.417	-.240
Attention control for grammaticized words	.981	.388	.709*

Note. R^2 = .098 for Step 1 (p = .628); ΔR^2 = .400 for Step 2 (p = .035).

*$p < .05$.

attention control for grammaticized words added to prediction of second language-specific proficiency by measures of attention control for concrete and abstract nouns, R^2 = .498 (sr^2 = .400), F_{inc} (1, 8) = 6.385, p = .035. Thus, addition of measures of attention control for grammaticized words to the equation with measures of attention control for concrete and abstract nouns results in a significant increment in R^2. Altogether, 49.8%of the variability in index of proficiency for the higher proficiency group was predicted by knowing scores on the measures of attention control for concrete, abstract, and grammaticized variables.

Finally, analogous analyses were carried out using the reaction time (RT) data instead of the coefficient of variation (CV) data to see if similar relationship would hold. Except for one case, all the changes in R^2 were not significant ($p > .10$). The one case was for the higher proficiency group based on the primed trials RT index of proficiency. Table 13 shows that after step 1, with RT measures of attention control for concrete and abstract nouns in the equation, R^2 = .155, F_{inc} (2, 9) = .825. This result indicates that these attention control RT measures based on concrete and abstract nouns did not contribute significantly to prediction of second language-specific proficiency. After step 2, with RT measures of attention control for grammaticized words added to prediction of

Table 13

Summary of Hierarchical Multiple Regression Analysis for RT Variables Predicting Second Language-Specific Proficiency Based on Primed Trials for Higher Proficiency Group (N = 12)

Variable	B	SE B	β
Step 1			
Attention control for concrete nouns	-.094	.074	-.430
Attention control for abstract nouns	.020	.053	.126
Step 2			
Attention control for concrete nouns	-.088	.059	-.403
Attention control for abstract nouns	-.092	.063	-.589
Attention control for grammaticized words	.153	.063	.925*

Note. R^2 = .155 for Step 1 (p = .469); ΔR^2 = .358 for Step 2 (p = .041).

*$p < .05$.

second language-specific proficiency by RT measures of attention control for concrete and abstract nouns, R^2 = .513 (sr^2 = .358), F_{inc} (1, 8) = 5.893, p = .041. Therefore, addition of RT measures of attention control for grammaticized words to the equation with RT measures of attention control for concrete and abstract nouns resulted in a significant increment in R^2. Altogether, 51.3% of the variability in RT index of proficiency was predicted by knowing scores on the RT measures of attention control for concrete, abstract, and grammaticized variables.

Discussion

The present research supports the idea that performance with the grammaticized elements predicted proficiency, and that performance with the concrete and abstract elements did not. This is consistent with Slobin's (1996) view of what is involved in second language proficiency, as well as the general cognitive linguistics point of view. Moreover, the present results were true only with the higher proficiency group (the more efficient participants). This suggests that efficiency of processing is especially important. In addition, the present findings were obtained after partialling out first language performance, hence the abilities involved here were acquired in the course of learning the second language, and not just general abilities. Finally, the present results did not obtain when analyzed in terms of reaction time (RT) instead of coefficient of variation (CV). This reinforces the conclusion that what we are dealing with here is not simple speed of processing, but the efficiency of cognitive control.

Given a correlation was found between the second language proficiency and the grammaticized words, this result is congruent with Slobin's (1996) view of first language thinking in second language speaking, implying that the grammaticized words of a second language are most difficult to master.

First Language Thinking in Second Language Speaking

According to Slobin (1996), the grammaticized components are not generally items of conceptual thought but items of "thinking for speaking" because each first language has trained its speakers to selectively attend to particular details of experience using its own set of grammatical distinctions and to ignore those aspects that do not receive verbal expression. Accordingly, users of a given particular first language may face difficulty in mastering certain aspects of a particular second language, especially when certain grammatical distinctions are lacking in their first language (e.g., English lacks the masculine and feminine articles of French). Contrarily, when the distinctions are similar to those in their first language, it becomes easier to make the proper conceptual distinction. This is because what grammaticized elements refer cannot be sensed directly in the world as can the referents of concrete nouns, verbs and adjectives, nor experienced indirectly through linguistic definitions as are abstract nouns. Such a suggestion is consistent with our finding showing a significantly positive relationship with second language proficiency only with second language grammaticized words but not with concrete and abstract nouns. The present data thus suggest that elements of conceptual thought such as concrete and abstract nouns that are unrelated to language structure did not significantly predict second language proficiency.

Higher Proficiency Group

The higher proficiency group in the present study were those participants who were able to recognize words in the second language in a particular efficient manner, after taking into account their first language word recognition efficiency. This was interpreted to mean that they were relatively good at processing the second language without disruption and interference from other ongoing mental processes. In this group, individual differences in performance reflect differences in processing efficiency. Therefore, it makes sense that their second language proficiency was positively correlated with the efficiency measure of attention control for second language grammaticized elements, even after controlling for effects attributable to attention control for concrete and abstract nouns. In contrast to this higher proficiency group, the lower proficient second language participants were presumably much less able to focus attention efficiently on meanings, affecting their reading proficiency. In this group, individual differences in performance reflected differences in the efficiency in the application of the knowledge (e.g., efficiency of lexical access or in attention shifting). As a result, the present findings were true only with the higher proficiency group.

All second language-specific measures had been residualized against first language, the present findings reflect a language-specific form of attention that underlies second language proficiency.

Language-Specific Form of Attention

To control for individual differences in general cognitive abilities, the present measures of second language-specific attention control were obtained after partialling out first language performance. This suggests that these attention control abilities must have been acquired through experience with the second language as opposed to reflecting some more general processing abilities that are common to both languages, or the fact that reading in the second language is generally slower than in the first language. Thus, the present study provides significant evidence for a language-specific form of attention for grammaticized elements that underlies second language proficiency.

Equally important, the present results did not obtain when analyzed in terms of reaction time instead of coefficient of variation.

Coefficient of Variation as Index of Proficiency

Hierarchical multiple regression analyses showed only one case that was significant when analyzed in terms of reaction time (RT). In this case, for the higher proficiency group based on the primed trials RT index of proficiency, performance with the grammaticized elements predicted proficiency. But none of the other results are significant whereas the coefficient of variation (CV) counterparts were significant. Often the $\underline{R}^2$ was very small with the reaction time data (total $\underline{R}^2 < .15$).

In the present study, the correlations between the second language-specific coefficients of variation (CVs) and reaction times in the living/nonliving classification tasks for all participants were positive, suggesting that individual differences in response time in this classification task reflected differential degrees of automaticity or processing efficiency (Segalowitz & Segalowitz, 1993). Hence, the CV data were used to evaluate relative variability in response time that referred to a qualitative change in performance. The present results provide further support to Segalowitz and Segalowitz's finding that used the CV as an index of automaticity.

The next section is a discussion of some of the cognitive mechanisms underlying complex skill task such as matching and nonmatching-to-sample tasks.

Mechanisms Underlying Matching/Nonmatching-to-Sample Tasks

The role of attention in language concerns the allocation of limited processing resources to the tasks involved in language understanding and meaning construction. Attentional resources, according to Chiarello et al. (1995), could be directed to various levels, including sensory and graphemic levels at a very early stage and semantic levels at a later stage. Cognitive skill tasks such as matching and nonmatching-to-sample tasks involve executive control over the allocation of attentional resources due to the fact that task difficulty can be viewed as a particular level of resource demand. The ability to allocate resources appropriately over the course of this task will depend on a number of factors, including the ability to categorize an object when making matches and nonmatches, and the participant's semantic knowledge of these categories. Hence, it requires taking into account different categorical relations involving the same object and shifting between them, suggesting attention control between matching and nonmatching modes of categorization.

In the nonmatching-to-sample task, it is necessary to inhibit more automatic associations to produce a nonmatching category response. Consistent with this view, the present study shows that the response time was slower on nonmatching trials than on matching trials, suggestive of a matching-nonmatching shifting cost on the response time.

In the simultaneous matching/nonmatching-to-sample tasks, the Sample word remained present while the Test words are presented. The participant is able to make a direct comparison between the Sample and Test words. Thus, retrospective working memory, which involves memory for the Sample stimulus that was presented previously, was not required in this study as it normally is in delayed matching/nonmatching-to-sample task (Domjan, 2000). However, the participant must remember what category the

Sample word represents in the semantic matching-to-sample categorization task used here.

The next section examines important implications for second language learning.

Second Language Learning

It is well known that individuals learn a second language differently from the way they acquire their first language, and that there exists much greater individual differences in outcome, reflecting the fact that there exists considerable variation in the situations learners find themselves in. Ericsson and Charness's (1994) study shows why practice is so important in second language acquisition. It is believed that after intensive and consistent practice, or after extended repetition of items, automaticity that requires only a minimal amount of attentional resources relative to non-automatic processing will be developed and promoted. In the case of reading, when word recognition and grammatical processing become automatic, the unused attentional resources can be allocated for other purposes such as to extract the meaning of the text being studied. According to Ericsson and Charness, to attain a professional or expert level of a given skill, approximately 10,000 hours of practice are necessary, which is about the same number of hours a four-year old girl will normally have practiced using her first language.

To promote second language learning, it is thought that the reorganization of the mechanisms underlying second language performance, such as increasing automatic processing and strengthening attention management, may lead to a qualitative modification in performance. Equally important, the present findings are congruent with the view that the development of attentive skills specific to grammaticized categories of the second language being learnt seems to be essential, namely second language-specific styles of thinking for speaking. To acquire the world knowledge of the second language being learnt, consistent practice and extended repetition of grammaticized categories that are not linguistic expressed in the first language are believed to be necessary. A program of training that focuses learners' attention on grammaticized elements explicitly would ultimately direct to the reorganization of attention to the particular features of experience that are expressed in that language.

In addition to these cognitive-linguistic views of attention and language, the behavioural differences found in the present study should be of interest to researchers concerned with automatized processes and attention related mechanisms at a neurological level. In recent years, research in neuroscience has begun to explore brain correlates involved in the execution of complex cognitive skills.

Neurological Research on Complex Cognitive Skills

Closed-class words, such as and and in, serve grammatical functions. Neville, Mills, and Lawson (1992) proposed that closed-class words are more related with left frontal cortical areas than are the open-class content words, such as nouns and adjectives. Nouns and verbs are the fundamental and universal primitives from which grammars are constructed.

Semantic knowledge provides individuals with the meaning of the messages they hear or read. It is suggested that semantic knowledge is diffusely represented by a distributed processing network (Small, Hart, Nguyen, & Gordon, 1995). The semantic system appears to be dissociated with regard to the distinction between living and nonliving stimuli (Caramazza, 1998). Research has shown that even though some partially overlapping brain areas are activated for living and nonliving stimuli, the nonliving stimuli do not activate the occipito-temporal areas as extensively as do the living stimuli. Thus, dissociated brain areas are involved in living and nonliving knowledge from either words or pictures (Perani et al., 1999).

The living/nonliving categorization task used in the present study sheds some light on semantic priming, in which a preceding prime word facilitates processing of subsequent target words that were semantic associates. These data are congruent with results obtained by Fischler and Raney (1991) showing that a decrease in the processing required for understanding the subsequent target word in that linguistic context as demonstrated by behavioural response latency and N400 amplitude to reading. Such a reduction in the processing demands is consistent with Raichle and his colleagues' (1994) brain imaging findings using positron emission tomography. They found that the blood flow to the brain region was less pronounced to the identical performances when processing becomes more automatic, proposing that the region was less activated with well-practiced skills.

The inferior area of the left frontal lobes and the middle or posterior area of the left temporal lobes, especially the superior area, are believed to be involved when attention is directed to semantic information. One or both of these areas have shown enhanced PET activity during semantic categorization (Wise et al., 1991) and during lexical decision-making (Frith, Friston, Liddle, & Frackowiak, 1991). Similarly, Posner and Raichle (1994) found that the semantic categorization task was related to an enhanced negativity over left frontal regions beginning around 300 ms after word onset. Herbster et al. (1997) also suggested that while the left inferior frontal gyrus may be involved in a phonological pathway for word reading, the left posterior areas may contribute to a more general semantic pathway. Such a suggestion is congruent with Rossion and his colleagues' (2000) findings showing that the left inferior prefrontal cortex is thought to be more involved in word processing, phonology, or verbal semantic retrieval than in general semantic processing.

Using neuroimaging techniques, the behavioural differences observed between the matching and nonmatching-to-sample tasks could enable one to assess explicitly whether these differences are due to differences at a neural level.

Future Research

Given the fact that the nonmatching task requires inhibition of responses to same category of stimuli, future research may attempt to explore whether there are differential neural responses associated with matching and nonmatching-to-sample tasks, in addition to activations common to both tasks. It would also be interesting to pursue Gupta's (1993) suggestion that automaticity is a function of the right hemisphere whereas non-automatic processing is executed by the left hemisphere. As mentioned previously, similar results have been obtained indicating that the left hemisphere is believed to be involved during semantic categorization and lexical decision-making. To differentiate between left- and right-hemisphere function, stimuli of a matching/nonmatching task could be presented to one hemisphere at a time using monocular vision. Better performance may be likely to occur when stimuli are presented to the left hemisphere.

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APPENDIX A

Living and nonliving stimuli utilized in this study

ADULT
AIRPORT
AUNT
AXE
BABY
BANK
BARN
BEAR
BED
BEE
BELT
BENCH
BIRD
BOARD
BOOK
BOY
BRICK
BROOM
BROTHER
BUTTERFLY
BUTTON
CAMEL
CAR
CASTLE
CAT
CEILING
CHAIR
CHILD
CLOSET
CLOTHES
COMPUTER
COW
CUP
DOCTOR
DOG
DOOR
DRESS
DUCK
EAGLE
ENTRANCE
EXIT
FARMER
FATHER
FISH
FLOOR
FLOWER
FLY
FORK
FOX
FROG
GIRAFFE
GIRL
GLASS
GOAT
GORILLA
HAMMER
HAT
HEN
HORSE
HOUSE
HUMAN
HUSBAND
KEY
KING
KITCHEN
KNIFE
KNOB
LADY
LAWYER
LETTER
LION
LOCK
MAIL
MAMMAL
MAN
MATTRESS
MEDAL
MONEY
MONKEY
MOON
MOTHER
MOUSE
NAIL
NURSE
PANTS
PAPER
PARROT
PENCIL
PERSON
PIG
PLANE
POLICEMAN
PRINTER
QUEEN
RABBIT
ROAD
ROBIN
ROCK
ROOF
ROOSTER
SEAT
SHEEP
SHIRT
SHOE
SHOP
SINGER
SINK
SISTER
SKIRT
SNAKE
SOCK
SON
SPOON
SQUIRREL
STAMP
STORE
STREET
STUDENT
SUIT
TABLE
TEACHER
THIEF
TIE
TIGER
TIRE
TOOL
TOY
TREE
TROUT
TURTLE
UNCLE
WHALE
WINDOW
WOLF
WOMAN
WORM

ABEILLE
ADULTE
AEROPORT
AIGLE
ARBRE
AVION
AVOCAT
BALAI
BALEINE
BANC
BANQUE
BEBE
BOUTIQUE
BOUTON
BRIQUE
CANARD
CEINTURE
CHAISE
CHAMEAU
CHANTEUR
CHAPEAU
CHAT
CHATEAU
CHAUSSETTE
CHEMISE
CHEVAL
CHEVRE
CHIEN
CLE
CLOU
COCHON
COQ
COSTUME
COUTEAU
CRAVATE
CRAYON
CUILLERE
CUISINE
DAME
DOCTEUR
ECUREUIL
ENFANT
ENTRÉE
ETUDIANT
EVIER
FEMME
FENETRE
FERMIER
FILLE
FILS
FLEUR
FOURCHETTE
FRERE
GARCON
GIRAFE
GORILLE
GRANGE
GRENOUILLE
HACHE
HOMME
HUMAIN
IMPRIMANTE
INFIRMIERE
JOUET
JUPE
LAPIN
LETTRE
LION
LIT
LIVRE
LOUP
LUNE
MAGASIN
MAISON
MAMMIFERE
MARI
MARTEAU
MATELAS
MEDAILLE
MERE
MONNAIE
MOUCHE
MOUTON
OISEAU
ONCLE
ORDINATEUR
OURS
OUTIL
PANTALON
PAPIER
PAPILLON
PERE
PERROQUET
PERSONNE
PLACARD
PLAFOND
PLANCHE
PLANCHER
PNEU
POIGNEE
POISSON
POLICIER
PORTE
POSTE
POULE
PROFESSEUR
REINE
RENARD
ROBE
ROCHER
ROI
ROUGE-GORGE
ROUTE
RUE
SERPENT
SERRURE
SIEGE
SINGE
SOEUR
SORTIE
SOULIER
SOURIS
TABLE
TANTE
TASSE
TIGRE
TIMBRE
TOIT
TORTUE
TRUITE
VACHE
VER
VERRE
VETEMENT
VOITURE
VOLEUR

APPENDIX B

Matching/nonmatching-to-sample stimuli utilized in this study

Neutral Category

Shape	Digit	Letter	Nonalphanumeric symbol
Δ	5	P	?
	6	T	!
◊	7	X	%
□	9	Y	&

Concrete Category

Fruit	Building	Body Part	Animal
apple	house	leg	dog
banana	school	arm	cow
peach	church	head	cat
pear	store	foot	tiger

Concrete Category

Fruit	Building	Body Part	Animal
pomme	maison	pied	chien
banane	école	bras	vache
pêche	église	tête	cheval
poire	magasin	jambe	tigre

Abstract Category

Mental Activity	Time Unit	Verbal Activity	Type
idea	hour	answer	kind
hope	year	story	sort
thought	day	word	group
wish	week	news	class

Abstract Category

Mental Activity	Time Unit	Verbal Activity	Type
idée	heure	réponse	genre
espoir	année	histoire	sorte
pensée	jour	mot	groupe
souhait	semaine	nouvelles	classe

Grammaticized Category

To Be	**Connective**	**Where**	**To Whom**
is	and	near	him
are	but	under	her
was	or	in	them
were	because	on	you

Grammaticized Category

To Be	Connective	Where	To Whom
suis	et	dehors	lui
sont	donc	sous	elle
sommes	mais	dans	eux
est	puisque	sur	nous

APPENDIX C

Consent Form to Participant in Research

This is to state that I agree to participate in a program of research being conducted by Noel Chung of the Department of Psychology of Concordia University, as part of her Master's thesis under the supervision of Dr. Norman Segalowitz.

A. PURPOSE

I have been informed that the purpose of the research is to investigate cognitive mechanisms that involved in acquiring a second language.

B. PROCEDURES

I will be required to classify words into categories and also to choose words that are either in the same or different categories as sample words by typing a key on a computer keyboard. The experiment is conducted in the research laboratory and participation takes approximately one hour and a half. Upon completion, I will either receive compensation of $14 or credit recognition in Professor De Almeida's Psychology course on Cognition. There is no harm, discomfort or deception involved in this experiment. All necessary safeguards are taken in order to assure the confidentiality and the well-being of the participant.

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 my identity will not be revealed.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

NAME (please print)

____

SIGNATURE

____

WITNESS SIGNATURE

____

DATE ____

APPENDIX D

Participant Questionnaire

Name: ____
Age: ________________________ Sex: M F
Field of Study: ____

1. Where were you born? (city, country) _____________________
2. What do you consider to be your first language? English French Other________
3. What do you consider to be your second language? English French Other________
4. What language do you consider your dominant language? English French Other________
5. At what age did you learn your second language? ______________________________
6. What language do you speak at home now? ___________________________________
7. What is the first language of your mother? _____________ and father? _______________
8. In what language did you attend school (Please circle the appropriate one):
   - Elementary school: English French Other____________________
   - High school: English French Other____________________
   - CEGEP: English French Other____________________
   - University: English French Other____________________
9. Do you have a known visual impairment that is NOT corrected by wearing glasses or contact lenses? Yes No
10. Do you have a known learning, attention, and/or reading disability (e.g., dyslexia, ADD)? Yes No
11. Please rate your level of ability for each of the three skills listed below by using the following rating scheme and circling the appropriate number in the boxes below:

1 = no ability at all **2** = very little **3** = moderate **4** = very good **5** = native-like ability

Language	**Speaking**	**Reading**	**Writing**
English	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
French	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

12. Please fill out column 1 first. Then rate the time spent each week using each language. Use the following rating scheme and circle the appropriate number in the boxes:

1 = never/almost never **3** = four to six times/week **5** = main language used
2 = one to three times/week **4** = more than six times but less than my main language

Language	**Speaking**	**Reading**	**Writing**	**Listening/Media**
First language:	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Second language:	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other:	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other:	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

APPENDIX E

Living/nonliving written instructions given to the participants

Each word will appear in the center of the computer screen. You will be required to indicate whether each word refers to an object that is nonliving or living.

Items in the nonliving category include furniture, toys, vehicles, etc.

Items in the living category include people, animals, plants, etc.

Nonliving	Living
The table	The fish
The hat	The flower

To respond nonliving press the left key on the keyboard with your left finger.

To respond living press the right key on the keyboard with your right finger.

The table	The flower

Nonliving	Living
left finger	right finger

Chaque mot sera présenté au centre de l'écran de l'ordinateur. Vous devez identifier si le mot fait référence à un objet qui est nonvivant ou vivant.

Les items dans la catégorie nonvivant peuvent être des meubles, des jouets, des véhicules, etc.

Les items dans la catégorie vivant peuvent être des gens, des animaux, des plantes, etc.

Nonvivant	Vivant
La table	Le poisson
Le chapeau	La fleur

Pour répondre nonvivant appuyez sur la touche de gauche sur le clavier avec votre index gauche.

Pour répondre vivant appuyez sur la touche de droite sur le clavier avec votre index droit.

La table	La fleur
Nonvivant	Vivant
Index gauche	Index droit

APPENDIX F

Matching/nonmatching written instructions given to the participants

In a moment, four words and a sample word will be presented to you on the computer screen. You have to choose a word belonging to a different category from the sample word.

Select a word by pressing on the key that corresponds to the position of the word on the screen.

E.g., Trial # 1: Suppose these words are presented on the screen:

---

seven	bed	blue	green
Position 1	Position 2	Position 3	Position 4

yellow
different category

You should either choose the word "seven" or the word "bed" on this trial (e.g., to respond "seven", press the **position 1 key** to indicate the left position on the screen).

seven		**bed**		blue		green
Position 1	OR	**Position 2**	BUT NOT	Position 3	AND NOT	Position 4

On trials that follow, you will again have to select a word belonging to a different category from the sample word, and so forth.

In a moment, four words and a sample word will be presented to you on the computer screen. You have to choose a word belonging to the same category as the sample word.

Select a word by pressing on the key that corresponds to the position of the word on the screen.

E.g., Trial # 1: Suppose these words are presented on the screen:

---

blue	green	seven	bed
Position 1	Position 2	Position 3	Position 4

yellow
same category

You should either choose the word "blue" or the word "green" on this trial (e.g., to respond "blue", press the **position 1 key** to indicate the left position on the screen).

blue		**green**		seven		bed
Position 1	OR	**Position 2**	BUT NOT	Position 3	AND NOT	Position 4

On trials that follow, you will again have to select a word belonging to the same category as the sample word, and so forth.

Dans un instant, quatre mots et un mot d'exemple vous seront présentés sur l'écran de l'ordinateur. Vous devrez sélectionner un mot appartenant à une catégorie différente du mot d'exemple.

Sélectionnez un mot en appuyant sur la touche correspondant à la position de ce mot sur l'écran.

Ex: Essai # 1: Supposez que ces mots sont présentés à l'écran:

---

sept	lit	bleu	vert
Position 1	Position 2	Position 3	Position 4

jaune
catégorie différente

Vous devrez choisir le mot "sept" ou le mot "lit", lors de cet essai (pour répondre "sept", appuyez sur la **touche de la position 1** afin d'indiquer la position de gauche à l'écran).

Sept		**lit**		bleu		vert
Position 1	OU	**Position 2**	<u>MAIS PAS</u>	Position 3	<u>ET PAS</u>	Position 4

Lors des essais subséquents, vous devrez sélectionner d'un mot appartenant à une catégorie différente du mot d'exemple, et ainsi de suite.

Dans un instant, quatre mots et un mot d'exemple vous seront présentés sur l'écran de l'ordinateur. Vous devrez sélectionner un mot appartenant à une même catégorie du mot d'exemple.

Sélectionnez un mot en appuyant sur la touche correspondant à la position de ce mot sur l'écran.

Ex: Essai # 1: Supposez que ces mots sont présentés à l'écran:

---

bleu	vert	sept	lit
Position 1	Position 2	Position 3	Position 4

jaune
même catégorie

Vous devrez choisir le mot "bleu" ou le mot "vert", lors de cet essai (pour répondre "bleu", appuyez sur la **touche de la position 1** afin d'indiquer la position de gauche à l'écran).

bleu		**vert**		sept		lit
Position 1	OU	**Position 2**	<u>MAIS PAS</u>	Position 3	<u>ET PAS</u>	Position 4

Lors des essais subséquents, vous devrez sélectionner d'un mot appartenant à une même catégorie du mot d'exemple, et ainsi de suite.

APPENDIX G

Study lists utilized in this study

Please study the following <u>four</u> groups of <u>symbols</u> and note which ones go together.

Category 1	**Category 2**	**Category 3**	**Category 4**
Δ	5	P	?
	6	T	!
◊	7	X	%
□	9	Y	&

Now take the pack of cards containing all 16 of these symbols. Please sort the cards into the four groups you have just seen without looking at the study list.

Please study the following <u>four</u> groups of <u>four</u> words each and note which words go together.

Category 1	**Category 2**	**Category 3**	**Category 4**
apple	house	leg	dog
banana	school	arm	cow
peach	church	head	cat
pear	store	foot	tiger

Now take the pack of cards containing all 16 of these words. Please sort the cards into the four groups you have just seen without looking at the study list.

Please study the following <u>four</u> groups of <u>four</u> words each and note which words go together.

Category 1	**Category 2**	**Category 3**	**Category 4**
is	and	near	him
are	but	under	her
was	or	in	them
were	because	on	you

Now take the pack of cards containing all 16 of these words. Please sort the cards into the four groups you have just seen without looking at the study list.

Please study the following <u>four</u> groups of <u>four</u> words each and note which words go together.

Category 1	**Category 2**	**Category 3**	**Category 4**
idea	hour	answer	kind
hope	year	story	sort
thought	day	word	group
wish	week	news	class

Now take the pack of cards containing all 16 of these words. Please sort the cards into the four groups you have just seen without looking at the study list.

S'il vous plaît, veuillez étudier les quatre groupements de quatre mots chacun et prendre note des mots qui vont ensemble.

Catégorie 1	**Catégorie 2**	**Catégorie 3**	**Catégorie 4**
pomme	maison	pied	chien
banane	école	bras	vache
pêche	église	tête	cheval
poire	magasin	jambe	tigre

Maintenant, prenez le paquet de cartes contenant tous ces 16 mots. S'il vous plaît, classez les cartes selon les quatre groupes que vous venez de voir sans regarder sur la feuille d'étude.

S'il vous plaît, veuillez étudier les quatre groupements de quatre mots chacun et prendre note des mots qui vont ensemble.

Catégorie 1	**Catégorie 2**	**Catégorie 3**	**Catégorie 4**
idée	heure	réponse	genre
espoir	année	histoire	sorte
pensée	jour	mot	groupe
souhait	semaine	nouvelles	classe

Maintenant, prenez le paquet de cartes contenant tous ces 16 mots. S'il vous plaît, classez les cartes selon les quatre groupes que vous venez de voir sans regarder sur la feuille d'étude.

S'il vous plaît, veuillez étudier les quatre groupements de quatre mots chacun et prendre note des mots qui vont ensemble.

Catégorie 1	**Catégorie 2**	**Catégorie 3**	**Catégorie 4**
suis	et	dehors	lui
sont	donc	sous	elle
sommes	mais	dans	eux
est	puisque	sur	nous

Maintenant, prenez le paquet de cartes contenant tous ces 16 mots. S'il vous plaît, classez les cartes selon les quatre groupes que vous venez de voir sans regarder sur la feuille d'étude.