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CHAPTER 7

The L2 semantic attentional blink

Implications for L2 learning

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Second language (L2) users are typically less proficient in their L2 than in their first language. One explanation may be that the L2 requires more attentional capacity. To test this, English speakers of L2 French performed a semantic attentional blink (AB) task, in both languages. A significant AB effect was obtained in each language; however, the effect was *smaller* in the L2, indicating that the attention burden associated with the AB task was paradoxically lower in the L2. Also, the magnitude of the AB effect correlated positively with a measure of L2 lexical access efficiency. Results are discussed in terms of attention-based and automatic processing in L2 lexical access and in terms of their implications for L2 learning and teaching.

Introduction

Typically, when people use their second language (L2), they must pay more attention to what they are doing than when they use their first language (L1). Speaking, listening or reading in an L2 usually requires more concentration and feels more effortful than in the L1, especially for people in the earlier phases of L2 development. For example, it is typically harder for a learner to understand L2 messages spoken in a noisy room or to speak the L2 while multi-tasking, compared to the L1. Although such observations about the role of effort and attention during L2 acquisition are anecdotally commonplace, it is nevertheless a challenge to quantify experimentally the impact on attention of using the L2. In the study reported here, we attempted to do this using a semantic attentional blink task.

This question – does processing L2 words require more attentional capacity than processing L1 words? – is interesting because of the place attention has come to occupy in the L2 acquisition literature. Schmidt (1995, 2001), for example, has focused on the role attention plays in learning, as articulated in his *noticing hypothesis* that "what learners notice in input is what becomes intake for learning"

(1995: 20). Tomlin and Villa (1994) provide a cognitive science grounding for thinking about attention issues in L2 learning. Talmy (2008) presents a cognitive linguistics framework for thinking about the acquisition of attentional competence relevant to L2 learning. Leow (2007) reviews the role attention plays in practice. Segalowitz (2010) discusses the varieties of attention that underlie L2 fluency. A basic theme in all this work is that the recruitment of attentional resources for using the L2 is usually more challenging than for using the L1, regardless of what the attention is to be used for. The study described here looks at attention recruitment through the lens of the attentional blink research paradigm.

Before describing our research, we need to consider why it is appropriate to include an attentional blink study in a volume about priming. The attentional blink (AB) is an effect whereby "[u]nder conditions of rapid serial visual presentation, subjects display a reduced ability to report the second of two targets … in a stream of distractors if it appears within 200–500 msec of [the first target]" (Dux & Marois 2009: 1683). For example, suppose viewers see a long stream of letters presented one at a time very rapidly in the centre of the screen. Embedded in this stream are two digits that viewers have to identify. If the two digits occur close together in time (i.e., with few intervening letters) viewers typically have difficulty reporting the second digit given they are able to report the first digit. Priming, on the other hand, has been defined as a "phenomenon in which prior exposure to language somehow influences subsequent language processing, which may occur in the form of recognition or production" (McDonough & Trofimovich 2009: 1), with some authors emphasizing the facilitatory effects of priming (e.g., "Priming is an improvement in performance", McNamara 2005: 3). Thus, for example, it is easier to identify a target word that is presented under difficult viewing conditions if there is prior presentation of a prime word that is semantically related to it. What brings studies of AB and priming phenomena together is their shared concern with the effect of prior processing on subsequent processing. Just as priming studies can reveal important facets of language processing by the positive effects that carefully manipulated prior processing can have on subsequent processing, so can AB studies reveal interesting aspects of language processing by the interference effects they demonstrate. In the case reported here, the AB effects speak to issues about the recruitment of attention resources and the (non)automatic nature of word processing in L2 users at different levels of proficiency.

In the experiment reported here we investigated the ability of L2 users to access the meaning of words presented visually in very rapid sequence, similar in some respects to hearing rapid-fire speech, but in the visual domain instead. The main research question we asked was whether doing this in the L2 places a special burden on attention resources. The research design allowed us to address this question by making two types of comparisons. The first was *within-subject* comparisons contrasting L2 (lower level skill) against L1 (higher level skill) performance in the same individuals. The second was *between-subject* comparisons contrasting L2 performance (after controlling for L1 performance) in L2 users with lower proficiency versus those with higher proficiency. In this way, it was possible to look at the impact that functioning in the L2 has on the recruitment of attention resources in a convergent manner from two different perspectives. Before proceeding to the research itself, we present a few words about how the recruitment of attention resources and how L2 proficiency were operationally defined.

Operationalizing the recruitment of attention resources

In the present study, the recruitment of attention resources during lexical access was investigated using rapid serial visual presentation (RSVP) to create AB effects (Broadbent & Broadbent 1987; Raymond, Shapiro & Arnell 1992; Shapiro, Arnell & Raymond 1997). Lexical access here refers to the mental process whereby a person retrieves information about the meaning of a stimulus word (see Altarriba & Knickerbocker; Barcroft, Sommers & Sunderman; Sunderman; Trofimovich & John; and Williams & Cheung, this volume, for examples of other research on lexical access). In the study reported here, this would mean understanding that a word just seen refers to an object belonging to a particular category (e.g., the word *apple* refers to a member of the fruit category). In the RSVP paradigm, the participant sees a series of rapidly presented stimuli (say, 30 items at the rate of 10 per second) in which are embedded two significant targets. The participant has to make a judgment about one or both of these targets and ignore the other stimuli. The typical outcome is that people find it difficult to process the second target stimulus if it occurs within approximately 200–500 milliseconds of the first, given that the first target had been processed. This interference effect is called the *attentional blink* and in the original accounts of the phenomenon it was generally assumed to be due to some kind of attentional bottleneck in the processing system. The bottleneck arises because ongoing processing of the first target stimulus prevents sufficient attention from being devoted to the second (theories differ in terms of the specific details about what precisely occurs during the bottleneck period; see Dux & Marois 2009 and Martens & Wyble 2010, for reviews). The most direct prediction one can make from an attentional bottleneck account in the present study is this. People whose proficiency is lower in the L2 than in the L1 are assumed to require greater attention resources to understand L2 stimuli, and hence process them more slowly compared to L1 words. This should affect the processing of stimuli in RSVP. If one assumes that

L2 words require more attention to be understood than L1 words, then there should be larger AB effects in the L2 than in the L1. This is because processing the first target stimulus in the L2 will consume relatively more attention resources than in the L1, thus temporarily interfering for a longer period of time with the recruitment of attention resources needed for processing a second target that arrives very soon after the first. This interference would be even greater in less proficient than in more proficient L2 users because of the former's increased reliance on attention-based processing.

There is an alternative view, however. Segalowitz (2010) has argued that what most significantly distinguishes more proficient from less proficient L2 users is the automaticity of processing, as opposed to the speed of processing. For example, Favreau and Segalowitz (1983) discovered that less proficient L2 users – people who read text more slowly in their L2 than in their L1 to achieve full comprehension – were not necessarily slower at processing single words. Favreau and Segalowitz used a primed lexical decision task to examine automaticity, which they operationally defined as ballistic or unstoppable processing of a word's meaning. They found no significant differences between higher and lower proficient L2 users in basic speed of response in a control condition but did find significant differences in the ballistic nature of responses in the experimental condition. Their results can be interpreted as follows. When a person encounters a stimulus word, some basic set of information about what that word means is elicited (e.g., that the word *apple* refers to something that is a fruit, has many fruit-like properties such as being edible, round, typically red, has such and such a taste, may be put into salads, and so on). When processing is automatic, *all* this basic information becomes available (this does not imply that everything a person knows about the word's meaning becomes available, only that some basic set of information does). This basic package is, relatively speaking, information-rich, and is the information used to make the decision required by the task. In contrast, with non-automatic processing not all this basic information is elicited, only parts of it – it is relatively information-poor. Nevertheless, there may be enough information to decide that the word *apple* refers to something from the fruit category, but the package of information about the word's meaning – for example, about the various fruit-like properties associated with the referent to *apple* – is less rich than in the case of automatic processing (see Williams & Cheung, this volume, for a closely related point about L1-L2 semantic differences arising from how the L2 vocabulary is acquired).

On this view, one might expect a different outcome in the RSVP task from the one described earlier. If L2 users with lower proficiency are less automatic in accessing word meaning, then when they encounter the first significant stimulus, the information elicited will be less rich, and categorization of the word as a target or nontarget can be accomplished without having to deal with as much information as in the case of automatic processing. In an AB task, this information-poor representation of the first stimulus should interfere less with processing the second significant stimulus, an outcome reflected in performance as a *weaker* AB effect. This is contrary to what would be predicted by an account based on the recruitment of attentional resources. In the main study presented below, the first significant stimulus is actually a distractor that should be ignored by the participant. It is a word from a different category but whose meaning is semantically close to the category of the intended target. If in the L1 condition accessing the meaning of the distractor word is automatic, the information elicited about it will be relatively rich, thereby increasing its resemblance to actual targets. In this case, to correctly reject it as a nontarget will require more processing than if the information about it had been less rich, and this extra processing will result in a larger AB effect. In the L2 condition, processing the distractor stimulus will be less automatic, and the information elicited correspondingly less rich. Consequently, performance in reporting the second significant stimulus in an L2 RSVP task could be (paradoxically) *better* than in the L1 task because of reduced competition or interference from the distractor (see Lacroix et al. 2005, for an AB result contrasting normal versus poor readers supporting this alternative view).

These issues of automatic and attention-based processing are relevant to understanding second language proficiency, especially with respect to fluency. Fluent speakers need to be able to process a good deal of language automatically, and they also need to have good attentional resource recruitment skills if their L2 performance is to be fluid, flexible and sustainable under a variety of conditions. Different learning environments, including those specifically designed to promote L2 acquisition, will – by the nature of the activities involved – target different aspects of the cognitive processing that underlie L2 performance. That is why it is important to be able to operationally distinguish between automatic and attention-based processing in the L2. The present study addresses one way how this may be accomplished.

Operationalizing L2 proficiency

For this study, a measure of L2 cognitive processing fluency was needed to distinguish participants on the basis of L2 proficiency. The measure chosen was one based on performance of the most fundamental ability required for any skilled language use – lexical access. Without efficient lexical access, communication cannot proceed in a normal, fluent manner. People typically perform lexical access less efficiently in the L2 than in the L1, even when they clearly know the words in question, as demonstrated in a wide variety of studies touching on lexical decision, picture naming, reading, word naming, and semantic classification (e.g., Meuter & Allport 1999; Segalowitz & Freed 2004; Segalowitz & Frenkiel-Fishman 2005; Segalowitz & Segalowitz 1993; for reviews, see Costa 2005; Dijkstra 2005; Kroll & Sunderman 2003; La Heij 2005). This makes intuitive sense. People are less proficient in the L2 typically because they have had less exposure to and fewer opportunities to make use of the language. Without frequent and consistent practice (Schneider & Shiffrin 1977), the cognitive components underlying lexical access cannot develop in terms of speed and automaticity (Segalowitz 1997, 2010). Generally speaking, therefore, lexical access in a weak L2 can be expected to rely more on controlled or attention-based processes than in the L1. With stronger L2 mastery, the efficiency of lexical access in the L2 should approach that of the L1.

The method selected for assessing efficiency of L2 lexical access was the semantic classification task described in Segalowitz and Frenkiel-Fishman (2005). This is a speeded 2-alternative forced-choice animacy judgment task in which participants press a reaction time panel to indicate whether a stimulus word shown on a computer monitor refers to a living (e.g., cow) or non-living (e.g., cup) object. The task was performed in separate L1 and L2 blocks, yielding for each participant a mean reaction time (RT) and a coefficient of variation (CV) of the RT (the standard deviation of the participant's RT divided by that participant's mean RT). The RT provided a measure of speed of lexical access. The CV provided a measure of the variability in speed of lexical access, adjusted for RT (here, the CV can be thought of as the standard deviation of RT per millisecond of RT). A lower CV indicates less "noisy" processing, reflecting lexical access based on greater reliance on fast, stable processing components and less reliance on slower, less stable processing components. The CV is interpreted here as a reflection of an underlying *cognitive fluency*, to be distinguished from speed of processing (Segalowitz 2010). Finally, participants' RTs and CVs in the L1 were used as baseline measures to control for individual differences in general task performance and for task demands not directly related to L2 lexical access that could influence RT and CV levels in the L2 (such as individual differences in motor skills, in attending to the demands of the task, general lexical access ability independent of L2 skill, among others).

In sum, we used a priming task – the attentional blink paradigm – to investigate whether lexical access in a weaker L2 requires greater recruitment of attention resources than in the stronger L1. Such a difference would be reflected in greater AB effects in the L2 than in the L1 in a RSVP task, and in greater L2 AB effects for participants who were less proficient in the L2 versus those who were more proficient.

The main study

The RSVP task used in this study was an adaptation of the semantic AB task used by Barnard, Scott, Taylor, May, and Knightley (2004). Our participants were instructed to name a single target stimulus word embedded in a string of 30 rapidly presented stimuli. The target word was always from one particular category (e.g., the name of a fruit: *apple*) and the other words were all names of common household objects (e.g., *carpet*). In the experimental condition, the target was preceded by a non-target semantic distractor that named a semantically related object from a different category (e.g., the name of a vegetable: *carrot*). For half the participants, the targets were fruit names and the semantic distractors were vegetable names and for half the participants the reverse. Participants were not explicitly made aware of the presence of semantic distractors. In a separate control condition, only a single target (and no semantic distractor) appeared on each trial. Targets were located at one of five different positions within the string of 30 stimulus words, making the location relatively unpredictable for the participant. Each target position was associated with six different semantic distractor positions preceding it, making it possible to assess the impact of the attention-grabbing distractor on the target as a function of distractor-target time interval (or lag).

The study by Barnard et al. (2004) used only L1 English and different word categories from those used here. They found that the presence of a semantic distractor lowered the probability of correctly naming the target word. Indeed, when the distractor occurred within 550 milliseconds of the target, the probability of target naming was lower compared to naming targets in the same stimulus location when there was no semantic distractor. Barnard et al. proposed a "glance-and-look" approach to explain AB effects whereby the viewer first analyzes incoming stimuli for generic relationship to the target and, given that a generic relationship is found, then analyzes the stimulus more deeply for potential candidacy as a target. This creates a processing bottleneck that interferes with subsequent processing of a second target stimulus presented close by in time. This analysis led to their conclusion that "semantic representations can play a substantial role in the allocation of visual attention over time" (Barnard et al. 2004: 186) but they did not directly address how this allocation might differ as a function of language proficiency. To the best of our knowledge, there have been very few studies of AB effects where the stimuli to be identified are defined solely in terms of their semantic characteristics as in Barnard et al. Some studies (e.g., Maki, Frigen & Paulson 1997; Potter et al. 2005) have used words and their associates as targets, but targets are typically distinguished from nontargets by their physical characteristics (e.g., in Maki et al., participants were instructed to name targets that appeared in a colored font, such as *airplane* written in red, and to ignore words in a black font). None, as far as we can tell, have compared AB effects in the L1 to a weaker L2. The Barnard et al. study best demonstrates the possibility of studying the role of attention in lexical access using the AB paradigm.

Method

Participants

Participants were 32 L2 users with English as L1 and French as L2 (22 females, 10 males; median age = 22.5 years, range = 19–30). All were volunteers studying at a major English speaking university in Montréal; none were formally studying French at the time of the experiment but, being in a bilingual city, they used the L2 in everyday activities to a greater or lesser extent. To be accepted in the study, participants had to self-report on five-point Likert-type scales to be English dominant with regards to their ability and usage of English and French. Means for speaking, reading, listening and writing abilities in French were 3.3, 3.6, 3.8 and 2.9 respectively, where 1 = "no ability at all" and 5 = "native-like." Corresponding means for English were 4.9, 4.8, 4.8 and 4.8. Mean self-reported usage of French for each of the same four skills were, respectively, 3.0, 2.4, 3.0 and 1.8, where 1 = "almost never used" and 5 = "main language used." The corresponding means for English were 4.9, 5.0, 5.0 and 5.0.

Materials

RSVP stimulus lists. Word lists consisting of 10 fruit names, 10 vegetable names and 30 household object names were constructed in English and French (see Appendix A). Words were matched in each language for frequency of occurrence, based on Kucera and Francis (1967) in English (M = 21.7 per million) and Baudot (1992) in French (M = 27.8 per million). Words that were highly similar visually in English and French (e.g., *tomato/tomate*) were not used.

These words were combined to create 30 experimental-trial word lists of 30 words each. In each list, 28 of the items were drawn randomly without replacement from the 30-word household object list. A target word was chosen from the fruit (or vegetable list, depending on counterbalancing) and the semantic distractor was drawn from the vegetable (or fruit) list. Each of the 10 semantic distractors and the 10 targets thus appeared three times each across the 30 trials. The semantic distractors were located in positions 5, 7, 9, 11 and 13, with six different distractors in each position. Each of the six semantic distractors at a given position was followed by a different target word, located 1, 2, 3, 4, 5 or 8 lag positions following it. The control-trial word list was constructed in exactly the same way except that each semantic distractor was replaced by an unused household object name, thereby creating a control condition list that matched the experimental condition list structurally in every way with the exception of absence of a semantic distractor.

Twenty practice-trials were created in a manner similar to the experimental trials. The target stimuli were five additional fruit (or vegetable) names (see Appendix A), each used four times. For the practice trials, non-word distractors were used instead of semantic distractors, each composed of seven repetitions of one of ten symbols @, #, $, %, ^, &, *, (,), or +. On any given practice trial, the target was located in a position corresponding to lag 2, 3, 4, 5, or 8 target positions in the experimental condition. Practice trials 1–10 each consisted of 29 household object names plus one target stimulus. Practice trials 11–20 each consisted of 28 household object names, one target, plus one nonword distractor (e.g., #######) located in a position appropriate for the target lag of 2, 3, 4, 5, or 8. The RSVP task was presented on a PC using E-Prime (Schneider, Eschman & Zuccolotto 2002a, b).

Animacy judgment stimulus lists. Words for the animacy judgment task are shown in Appendix B. Each word appeared together with either a definite or indefinite article (*the* or *a* in English; *le, la, l'* or *un, une* in French). The articles were included to ensure that English words were unambiguously understood as nouns and not verbs and to reinforce the English or French character of the stimuli. The words were organized into a fixed quasi-random order such that there were no strong semantic links between words on successive trials. Lists were also constructed so that no participant received words in one language that were translation equivalents of words seen in the other language. The use of definite and indefinite articles was counterbalanced across animate and inanimate words. The sequencing of animate and inanimate trials was random with the restriction that the four possible sequences (an animate or inanimate trial followed by either an animate or inanimate trial) were counterbalanced across the block to prevent response priming or interference biases. The animacy judgment task was presented using a Macintosh iBook programmed in HyperCard 2.3, using an XCMD subroutine to collect the reaction times synchronized with frame onset.

Procedure

Participants performed the following tasks in this order: (a) the language background and abilities/usage questionnaire; (b) the animacy judgment task in one language and then in the other; (c) the practice, experimental and control RSVP tasks, doing all in one language and then all in the other language; (d) a word knowledge checklist to ensure that they understood the meanings of all the French words used. The order of the language blocks (English then French, or vice versa) was held constant for a given participant and counterbalanced across participants. Similarly, the order of the RSVP tasks (experimental then control, or vice versa) was held constant for a given participant and counterbalanced across participants.

Animacy judgment task. This was a 2-alternative forced choice reaction time task in which concrete nouns appeared singly on the screen to be judged as referring to animate or inanimate objects. There were eight warm-up trials and 64 test trials in each language. Stimuli were shown for a maximum of 3000 milliseconds or until the participant responded. The next stimulus appeared immediately after the deadline elapsed or the participant responded. On error trials, the computer generated an audible feedback signal. Prior to doing the main animacy judgment task, participants performed a 40-trial practice letter-digit judgment task.

RSVP task. The RSVP task included a practice condition, control condition and an experimental condition. In each of these, the participant was instructed to carefully watch the rapid stream of words and to name aloud the fruit name (or vegetable name, depending on which counterbalancing group the participant was in) if one was detected. The RSVP stimuli were delivered at the rate of 110 milliseconds each. For half the participants, the target was from the fruit category and the semantic distractor was from the vegetable category and vice versa for the other half. The research assistant keyed in the participant's response whether it was correct or incorrect and then initiated the next trial. The participant was not alerted to the fact that a semantic distractor preceded the targets in the experimental condition.

Results

For all tests reported below, $N = 32$ and tests of significance are two-tailed. The alpha level is .05 unless otherwise specified. The word knowledge checklist revealed that the mean number of the 20 RSVP target and distractor words not known was less than one word (0.45) per participant. There were no outlier words that were strikingly less known than the others and so no adjustments were made for word knowledge. Figure 1 shows the means and standard errors for proportion of correct identification of the target word in L1 and L2, at each lag, in the experimental and control conditions.

L1-L2 differences in AB effects

To investigate the main question about whether there would be a language difference in the magnitude of the AB effect, the data were submitted to analysis of

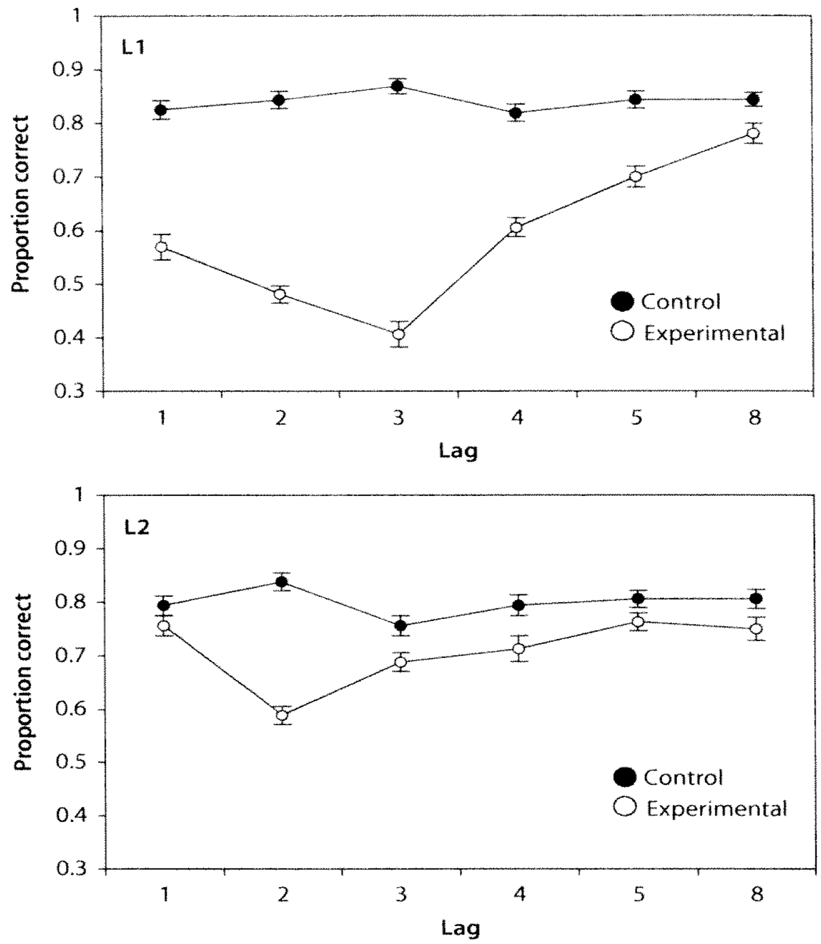

Figure 1. Mean proportion and standard errors from the main study for correct naming of targets in L1 (upper panel) and L2 (lower panel) with without semantic distractors (control condition) and semantic distractors (experimental condition) as a function of lag (each lag unit = 110 ms)

variance (ANOVA) as follows. For each participant, an AB (attentional blink) score was computed in each language to reflect the interference effect of the semantic distractor at each lag. This number was the difference between the proportion of targets correctly identified in the control condition and the proportion correctly identified in the experimental condition in the positions corresponding to a given lag. The AB scores for lags 1 through 5 were subjected to a 2 × 5 within-subjects ANOVA with the factors Language (L1, L2) and Lag (1, 2, 3, 4, 5) (lag 8, representing a stimulus onset asynchrony of 880 milliseconds, was excluded as being outside the range where an AB effect would be expected to be found). The results revealed a significant language effect, $F(1, 31) = 40.68$, $p < .001$, η_p^2 (effect size) = .57, indicating that the mean AB effect in the L2 was significantly smaller (9.6% more accurate in the control condition than in the experimental condition) than in the L1 condition (28.8% more accurate in the control condition). The analysis also revealed a significant lag effect, $F(1, 31) = 9.57$, $p < .005$, $\eta_p^2 = .236$, indicating that the AB effect was different at different lags. The language by lag interaction effect was not significant ($F < 1$).

To assess the duration of the AB effect in each language, accuracy data for each lag in each language in each condition from the RSVP task were submitted to a three-way within-subjects ANOVA with the factors being Condition (Experimental, Control), Language (L1, L2) and Lag (1, 2, 3, 4, 5, 8). This analysis addressed a somewhat different question about lag by language effects compared to the ANOVA reported earlier, by including condition as a factor and data from lag 8. This analysis yielded a significant three-way interaction effect, $F(1, 31) = 5.39$, $p = .027$, $\eta_p^2 = .148$. Post hoc t-tests using a Bonferroni correction revealed that there was a longer lasting AB effect in the L1 (550 milliseconds; spanning 5 lags) than in the L2 (220 milliseconds; spanning 2 lags).

In summary, in both languages, when the target stimulus occurred soon after the distractor stimulus (i.e., with zero to four intervening words) the participants were less able to name the target than when there was no distractor or when the distractor occurred much later. This was the AB effect. Importantly, the L1 AB effect was significantly stronger at each of the short distractor-target distances than in the L2, and it occurred over a longer time span than in the L2.

The relationship between L2 AB effects and L2 proficiency

Next, analyses were conducted to examine the association between L2 lexical access efficiency and the L2 AB effect. For this we needed an L2-specific measure of performance, that is, a measure that does not reflect general performance considerations having nothing to do directly with ability in the L2 (a person's intelligence, general ability to process word meaning, ability to concentrate on the task at hand, agility in pressing the reaction time panels, etc.). That is, we needed a control measure that would help us to isolate the L2-related aspects of task performance from all the other aspects of task performance that are normally also at play. A good control measure for this is performance in the L1. Thus, for this analysis, mean RT and CV of performance in the animacy judgment task were computed for the L2 (RT = 940 milliseconds [SD = 178] and CV = .377 [.124], respectively) and for the L1 (827 milliseconds [123] and .356 [.118], respectively). Data from trials on which the participant made an incorrect response were excluded, as were data from trials immediately following an incorrect response (the overall error rates were low: 4.1% in L1 and 8.3% in L2). The L2 RTs were then regressed against the L1 RTs and the residuals saved, to obtain an L2 residualized score for each participant. These residualized scores reflected RTs in the L2 after adjusting for general factors (motor skill, attention, motivation, etc.) that could be expected to affect RTs generally, including in the L1. Similarly, a residualized CV score was obtained for each participant. These residualized RT and CV scores correlated significantly with each other ($r = .625$, $p < .001$), indicating that faster L2 performance reflected more efficient L2 lexical access independent of speed, after taking L1 performance into account. This correlation indicates that about 61% ($1 - r^2$) of the variance of the L2-specific (residualized) RT was *not* related to the L2-specific CV, reinforcing the idea that RT and CV address different aspects of the cognitive fluency underlying lexical access. These residualized RT and CV scores represent measures of *speed* and *efficiency* aspects of L2-specific cognitive fluency, respectively (Segalowitz 2010).

To address the question of whether the L2 AB effect reflected individual differences in participants' level of cognitive fluency in the L2, the data were submitted to multiple regression analysis. The dependent variable was the L2 AB effect (the mean difference, for each participant, between the proportion of correct target identification in the control condition versus the experimental condition, summed over lags 1 through 5). In the first step of the analysis, the participants' L1 AB scores (the analogous scores based on data from the L1 condition) were entered as a control measure for general individual differences in RSVP interference effects (see Martens & Johnson 2009, on individual differences in AB effects). In the next steps, the L2 residualized CV and RT measures were entered sequentially as cognitive fluency predictors of the L2 AB effect. Regardless of the order in which these were entered, the L2-specific CV measure accounted for a significant amount of the variance of the L2 AB effect (23.3%, $p < .01$) whereas the L2-specific RT measure did not (< 1%, not significant). The direction of this relationship was the following: a larger L2 AB effect was associated with a lower L2-specific CV (which indicated a more stable, more automatic lexical access ability).

In summary, performance scores in the L2 were statistically adjusted to take into account performance in the L1, thus eliminating associations between L2 performance and general features of individual differences not specifically related to L2 use. This provided scores that could be considered more L2-specific measures of performance than would be the original L2 scores used alone. The analyses showed that the L2-specific processing efficiency measure was more strongly associated with the L2-specific AB effect than was the L2-specific speed measure.

Discussion

The questions motivating this experiment were the following. Would the semantic AB effect vary as a function of language (L2 vs. L1) in within-subject comparisons? Would the direction of these differences reflect greater demands on *attention* resources in the L2 than in the L1? Finally, would the magnitude of the AB effect vary as a function of proficiency level in the L2, after controlling for performance in the L1, in between-subject comparisons?

Regarding the first question, Figure 1 shows that in both L1 and L2 there was a significant within-subject semantic AB effect, thus replicating in broad terms the result reported by Barnard et al. (2004) and confirming that the semantic AB design worked in this experiment. The figure shows that the AB effect in the L1 extended over a range of 5 lags (550 ms) and was quite large (percent correct target identifications were, on average, around 59% in the presence of a semantic distractor and 84% in the absence of a semantic distractor, for an AB effect of about 25%). These results are comparable to those obtained by Barnard et al. (AB effects in the 20% range, extending over 550 ms). In the present experiment, there was a clear effect in the L2 as well, extending to lag 2 only (220 ms), with a mean difference in percent correct target identifications of 9% between experimental and control conditions.

Regarding the second question, statistical comparison of the L2 versus L1 AB effects showed clearly that the L2 effect was significantly *smaller,* indicating that there was better target identification in the weaker language than in the stronger language. This result cannot be explained in terms of *greater* reliance on the recruitment of attention resources for processing the distractor stimulus in the weaker language; if anything, it suggests the opposite.

Finally, there is the third question about whether the L2 AB effect would vary as a function of L2 proficiency. The results of the regression analyses revealed this to be true and, in doing so, pointed to an explanation for why there was a paradoxically smaller AB effect in the weaker L2. The regression analyses revealed that the magnitude of the semantic AB effect in the L2 was significantly associated with performance on the test of lexical access in the L2 (after controlling for L1 performance). Moreover, the larger AB effects (indicating greater interference by the distractor stimulus) were associated with lower L2-specific CV measures and not with lower L2-specific RT measures. The association with the CV measure was quite strong (22% shared variance) whereas the association with the RT measure was nearly absent (< 1% shared variance). These results suggest that the important factor underlying the AB effect was the stability (efficiency) of the processing, and not the speed of lexical access as such. Insofar as the AB effect reflects unintended interference by the distractor on processing of the target, the results support the idea proposed in Segalowitz and Segalowitz (1993) that the CV measure reflects the automaticity of the underlying processing.

In trying to fit the answers to these three questions together, we were led to these main conclusions. First, performance in the weaker L2 did not necessarily consume more attentional resources compared to performance in the stronger L1. Second, the interference effects most likely reflected the information-rich way the distractor words were processed, resulting in them appearing to be more similar to the target set than if they had not been processed in such an information-rich way. This greater similarity to the target set made them more distracting, and hence the greater AB effects. This information-rich processing was a consequence of the words being processed automatically. Thus, it was the richness of the information available that was responsible for the blink effect, not the difficulty in recruiting attentional resources.

A note of caution in interpreting the present results is in order. It might be suggested that perhaps the smaller AB effect in the L2 was due to more frequent failure to process the semantic distractor in the weaker L2 than in the stronger L1. If this had occurred, it would have resulted in fewer trials on which there would be an AB effect. The results from the control condition, however, suggest that this was not the case. As can be seen from Figure 1, the target was correctly identified about 80% of the time or more in each language in the absence of a semantic distractor, suggesting that in the experimental condition the distractor stimulus must have been identified in at least 80% of the time in each language. Nevertheless, apart from the existence of the AB effects, it is true that the present experiment did not provide direct evidence that the distractor stimulus had been fully processed on those trials when the target itself was correctly identified.

Follow-up study

To address this potential alternative interpretation of the results, we conducted a follow-up experiment using the same L1 and L2 stimuli, with a slightly modified task to ensure that AB patterns would truly reflect interference effects arising from the processing of the first stimulus. This follow-up experiment thus served two purposes. It aimed to clarify the result of the first experiment by relating the AB effect more explicitly to processing of the interfering stimulus, and it aimed to replicate the main result that the semantic AB effect is smaller in the L2 than in the L1. This follow-up study compared the magnitude of the L1 versus the L2 AB effect in a more traditional blink task where the viewer has to respond to both a first and second target (Raymond et al. 1992). We reasoned that if L1-L2 AB effect differences were found using only data from trials where the first target had been successfully processed, then this would eliminate concern that the result of the main study was due simply to failure to process the semantic distractor more often in the L2 than in the L1.

The experiment used exactly the same stimulus words as in the main study but with a modified procedure. A new group of 29 participants with similar language and demographic characteristics to the previous group took part. In the new AB task, participants were told to look for two targets in a 30-word RSVP stream. They had to name the first target and to report whether or not a second target also occurred afterward without naming it. On every trial there was a first target and on half the trials, distributed randomly, there was also a second target. For half the participants, the first target was defined as a word from the category "fruit" and the second target as a word from the category "vegetable." For the other half, the assignments were reversed. The first target stimuli were distributed within the RSVP stream to exactly the same positions as the semantic distractors in the main study, and the second target stimuli to the same positions as the targets in the main study, thus creating 6 lag conditions as before. The expectation was that in both languages there would be an interference or AB effect, in which participants would less often correctly report the presence of a second target, given successful naming of the first target, if the second target occurred within lags 1 to 5 compared to lag 8. Moreover, it was also predicted that the AB effect in the L2 would be smaller than in the L1, based on the findings and conclusion from the main study. These were exactly the results that were obtained.

Figure 2 shows the mean proportion (plotted as a function of lag) of accurate reporting of the presence of a second target, given that the first target had been correctly named. At lag 8, where one would not expect the first target to interfere with processing of second target because of the very long (880 ms) time lag, there was no difference between L1 and L2 in accuracy of second target responses. However, at lags 1–5 there was significantly more accurate reporting of the second target in the L2 than in the L1, indicating greater AB effects in the L1. These results clearly indicate that when the participants had correctly identified the first target, they were better overall in the L2 than in the L1 at detecting the presence of a second target when it occurred within 550 ms of the first target. These results support the conclusions drawn from the main study, namely that in the L2 the AB effect is smaller than in the L1, and these results indicate that this effect is not simply due to more frequent failure to process the first stimulus.

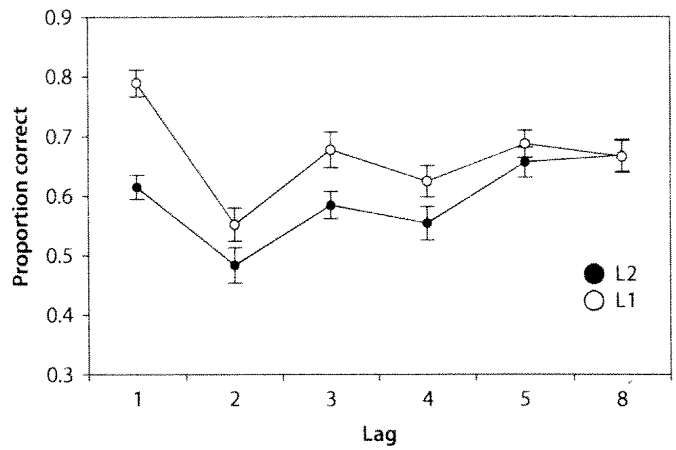

Figure 2. Mean proportion and standard errors from the follow-up study for correct detection of T2, given that T1 was correctly named, in the L1 (English) and L2 (French) as a function of T1-T2 lag (each lag unit = 110 ms)

General discussion

To summarize, in this study bilinguals with weaker mastery of the L2 compared to the L1 performed *better* in the L2 in identifying target words occurring shortly after the presentation of a semantic distractor. Moreover, performance *accuracy* on this task was associated with *RT stability* in word recognition (greater accuracy, lower CV) and not with RT itself, as measured in a separate semantic classification task. That is, the more stable and hence efficient the processing, the more interference there was in identifying the target stimulus. These results are not consistent with the idea that functioning in a non-dominant L2 with below optimal proficiency places greater demands on the recruitment of attention resources. Instead, the results are consistent with the hypothesis that what matters is how efficient or automatic lexical access is. Together, these results suggest that better processing of the words, not reduced attention, brought about the observed interference. We suggest that the most likely way that better processing could produce more interference is by bringing into play richer meaning representations.

The present results thus highlight the distinction between two separable aspects of L2 processing abilities – the ability to process meaning in a highly efficient and automatic way, and the ability to recruit necessary attentional resources for processing meaning. This distinction has implications for L2 acquisition and instruction, to which we now turn.

Implications for L2 instruction and learning

If learners are to attain high levels of L2 proficiency and fluency they must be exposed to the target language in appropriate ways and at an appropriate level of intensity. There are, however, many different possible ways to design exposure activities that provide this intensity, and some of these may impact more on one or the other of the two aspects of L2 processing identified in this research – attention-based versus automatic processing. By way of examples, consider the following. One way in which exposure activities can vary is in the degree to which they might qualify as being open-ended versus constrained. An open-ended exposure activity would be one that can evolve in a number of unpredictable directions depending on how events unfold (e.g., a communicative activity involving improvisation), whereas a constrained activity would be one that is tightly controlled or preset (e.g., scripted role plays). The more open-ended an activity is, the more learners will have to deal with surprise turns of events, placing on them demands of an *attentional* nature. Consequently, the cognitive impact of open-ended activities, as opposed to constrained activities, would be *to promote skills related to attention-based processing* (managing the recruitment of attentional resources while using the L2).

In contrast, a different way exposure activities can vary is the degree to which they involve repetition of what is to be learned. A repetition-rich activity would be one that involves highly frequent encounters with target information (e.g., a communicative activity requiring learners to obtain similar information from many different sources in order to achieve some goal), whereas a repetition-poor activity would be one that provides low frequency encounters with target information (e.g., activities where there is no inherent reason to seek or use target elements more than once or twice). The more an activity has been designed to provide repetition, the more the learner will have to re-activate particular processing mechanisms, a condition favorable for the development of stable and efficient (automatic) processing. Consequently, the cognitive impact of repetition-rich activities, as opposed to repetition-poor activities, would be *to promote automatic processing.*

To some, the features of learning activities that promote attention-based processing (open-ended) and those that promote automaticity (repetition-rich) may not seem to be very compatible with one another. However, it is both possible and desirable to design learning activities that are repetition-rich *and* open-ended, and that therefore promote both automaticity and attention-based processing (Gatbonton & Segalowitz 2005). The point to note here is that one needs to make a clear distinction between these two aspects of processing when thinking about the design of L2 learning activities, so as to ensure that the activity is able to target the intended aspect of cognitive processing.

The results of the present study relate to the above discussion as follows. Our AB study revealed that, with respect to L2 lexical access for decontextualized concrete nouns, L2 proficiency was associated primarily with *automaticity* of lexical access, not with attentional resource recruitment. This finding underscores the need to ensure that learning activities enhance exposure frequency of what is to be learned (see Ellis 2002, for more on frequency in L2 learning). This finding is interesting when seen in the context of results reported by Taube-Schiff and Segalowitz (2005). They found that, with respect to L2 function words, but not concrete L2 nouns, *attention-based* processing was more closely associated with proficiency (see also Segalowitz & Frenkiel-Fishman 2005). It may be, therefore, that learning activities need to be selected for their cognitive appropriateness (e.g., do they focus on automaticity or attention-based processing?) as a function of the particular aspect of the L2 targeted for instruction.

Another interesting possibility to consider was suggested to us by the editors of this volume. Perhaps there is a pedagogical advantage for learners who have not yet developed automatic L2 lexical access skills, as revealed in a shallow AB effect. As the study reported here concluded, there may be reduced lexical competition between stimulus words when automaticity is low. Perhaps this reduced competition makes it easier to draw learners' attention to specific form or meaning properties of the language they are exposed to at a given time in contrast to when processing is automatic and there is greater lexical competition. This pedagogical advantage might, of course, only surface in early phases of learning when automaticity is low. The AB research design provides a potentially useful tool for investigating this possibility.

In conclusion, the pedagogical relevance of the present study lies in the way it highlights the distinction between automatic and attention-based processing, a distinction that carries with it important implications for the design of learning activities. More generally, the study also demonstrates that the AB research design provides a promising way to investigate some of the cognitive underpinnings of L2 learning and to assess the cognitive impact of different types of learning and instructional environments.

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Appendix A

English and French words used in the RSVP task in Experiments 1 & 2

List type	Words
English-Fruit	apple, blueberry, cherry, cranberry, lemon, peach, pear, pineapple, raspberry, strawberry
English-Vegetables	asparagus, bean, cabbage, corn, cucumber, lettuce, mushroom, onion, pea, spinach
English-Fillers	armchair, basket, book, box, candle, chandelier, couch, counter, curtain, cushion, door, drawer, fireplace, glass, key, knife, ladder, light, mattress, mirror, napkin, painting, pillow, plate, rug, shelf, sink, toilet, washbasin, window
English-Fruit (practice)	orange, melon, banana, kiwi, apricot
English-Vegetables (practice)	tomato, broccoli, carrot, potato, celery
French-Fruit	*ananas* [pineapple], *bleuet* [blueberry], *cerise* [cherry], *citron* [lemon], *fraise* [strawberry], *framboise* [raspberry], *pêche* [peach], *poire* [pear], *pomme* [apple]
French-Vegetables	*asperge* [asparagus], *champignon* [mushroom], *concombre* [cucumber], *épinards* [spinach], *haricot* [beans], *laitue* [lettuce], *maïs* [corn], *oignon* [onion], *pois* [pea]
French-Fillers	*assiette* [plate], *boîte* [box], *bougie* [candle], *clef* [key], *comptoir* [counter], *coussin* [cushion], *couteau* [knife], *divan* [couch], *échelle* [ladder], *étagère* [shelf], *évier* [basic], *fauteuil* [armchair], *fenêtre* [window], *foyer* [fireplace], *lampe* [lampe], *lavabo* [sink], *livre* [book], *lumière* [light], *matelas* [mattress], *miroir* [miroir], *oreiller* [pillow], *panier* [basket], *porte* [door], *rideau* [curtain], *serviette* [towel], *tableau* [picture], *tapis* [carpet], *tiroir* [drawer], *toilette* [toilet], *verre* [glass]
French-Fruit (practice)	*orange* [orange], *melon* [melon], *banane* [banana], *kiwi* [kiwi], *abricot* [apricot]
French-Vegetables (practice)	*tomate* [tomato], *brocoli* [broccoli], *carotte* [carrot], *patate* [potato], *céleri* [celery]

Appendix B

English and French words used in the Animacy Judgment task in Experiment 1

List type	Words
English warm-up	camel, ceiling, lock, monkey, musician, nail, queen, store
English test	aunt, baby, bag, bed, bee, bench, boat, boy, car, chair, church, closet, cotton, cow, cup, daughter, door, eagle, exit, fence, fish, floor, flower, football, fork, fox, frog, gentleman, goat, guest, hammer, hat, horse, key, knife, knight, lady, lobster, manager, mosquito, parrot, person, pig, plastic, road, rope, rug, school, sheep, sister, skirt, soap, sock, son, spider, spouse, squirrel, tool, tourist, trout, violin, watch, window, woman
French warm-up	*acteur, bol, cahier, crabe, débutant, gâteau, mouche, sable*
French test	*aéroport, âne, assiette, auberge, avion, banque, boisson, bouilloire, bouton, canard, canot, ceinture, chandail, chat, chemise, chien, chocolat, colline, copain, coq, cravate, cuillère, cuisine, cygne, enfant, entrée, étudiant, fourmi, frère, grand-père, homme, horloge, infirmière, insecte, jouet, lait, lapin, loup, manteau, mère, métro, mouchoir, neveu, oiseau, oncle, ours, papillon, père, pneu, poche, poêle, porcelaine, poule, professeur, roi, rouge-gorge, ruban, saumon, serviette, tigre, timbre, tortue, ver, verre*