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Bilingual lexical selection as a dynamic process: Evidence from Arabic-French bilinguals

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Bilingual lexical selection as a dynamic process: Evidence from Arabic-French bilinguals

Abstract

The nature of the lexical selection process in bilingual spoken word production is one of the pending questions of research on bilingualism. According to one view this competitive process is language-specific, while another holds that it is language-nonspecific (i.e., lexical competition is cross-linguistic). In recent years, research on bilingual language production has seen the rise of a third view which postulates that lexical selection is in fact dynamic and may function as language-specific or non-specific depending on a number of factors. The aim of the present study was to investigate the lexical selection process among moderately proficient bilinguals whose two languages are typologically distant: Tunisian Arabic and French. The picture-word interference task was used in two experiments where moderately proficient Tunisian Arabic (L1)-French (L2) bilinguals were asked to name pictures in their L2 while ignoring auditory distractors (semantic, phono-translation, phonological, or unrelated) in their L2 (Experiment 1) or their L1 (Experiment 2). Thus, the language context was entirely monolingual in Experiment 1 and bilingual in Experiment 2. In Experiment 1, only a phonological facilitation effect was observed. In Experiment 2, interference was found in the phono-translation, semantic, and phonological conditions. Taken together, these results indicate that cross-language competition occurs among moderately proficient Tunisian Arabic-French bilinguals only in a bilingual context (Experiment 2) as indexed by the phono-translation interference effect observed. Our findings are in line with the recent hypothesis that lexical selection is a dynamic process modulated by factors like language similarity, language proficiency, and the experimental language context.

Keywords: bilingualism; lexical selection; language control; Arabic; French.

Research on bilingual word production has consistently shown that during lexical access the target concept spreads activation to representations from both languages (e.g., Colomé & Miozzo, 2010; Colomé, 2001; Hermans, Ormel, van Besselaar, & van Hell, 2011), regardless of the task or the language context (monolingual or bilingual) the bilingual is placed in. That is to say that even in a task or context where only one language is explicitly used (for example, in a monolingual communicational context or in a task where all stimuli are in one language), both languages are activated (e.g., Marian & Spivey, 2003). The presence of such cross-language activation complicates matters for bilingual access and begs the question of how bilinguals are able to select the lexical alternative of the intended language of communication (a process known as lexical selection). Lexical selection typically involves competition between related lemmas (Levelt, Roelofs, & Meyer, 1999). There is lack of consensus among researchers on whether this competitive process is cross-linguistic. More to the point is lexical competition during bilingual spoken word production restricted to the target language lexicon or does it involve lemmas from both languages? This is what has been known as the bilingual "hard problem" (Finkbeiner, Gollan, & Caramazza, 2006) and is the subject of an ongoing debate in the field of bilingual language processing. Two main views dominate the debate: the language-specific versus the language-nonspecific view. According to the first, even though lemmas and lexemes from both languages are activated, only the target language representations enter into competition (Costa & Caramazza, 1999). The second view conceives lexical access as a wholly cross-linguistic process, from activation to selection (Green, 1998; Hermans, Bongaerts, De Bot, & Schreuder, 1998).

Thus far, experimental studies investigating the nature of bilingual lexical selection have yielded conflicting and inconclusive evidence. For instance, Hermans et al. (1998), in their seminal picture-word interference study, hypothesized that both target and non-target language lemmas are activated and compete for selection during bilingual lexical access. In two experiments, Dutch-English highly-proficient bilinguals named pictures in their L2 (English) while ignoring auditory distractor words in L2 (Experiment 1) or L1 (Dutch) (Experiment 2). Distractors were semantically or phonologically related to the picture name in English. Additionally, for the purposes of their study, Hermans et al. (1998) developed a new type of distractors that were phonologically related to the name of the picture in the non-target language. For example, they would present the picture of a mountain with the distractor *bench* which is related to the name of the picture in Dutch (*berg*). The authors hypothesized that this distractor would not only activate the lemma and lexeme of *bench* but also that of *berg* which is, potentially, a competitor to *mountain*. Therefore, the authors assumed that this distractor (called phono-Dutch in their study and dubbed as phono-translation in subsequent studies) will result in an interference effect indicating that *mountain* and *berg* do indeed compete with each other. Finally, an unrelated distractor condition was also presented. In addition, the delay between the picture and the distractor presentation (stimulus onset asynchrony or SOA) varied with four SOAs of -300 ms, -150 ms, that is, before the presentation of the picture, 0 ms (i.e., the distractor and the picture were presented simultaneously), and +150 ms after picture onset. This aimed to determine the probable locus of cross-linguistic interaction.

In this regard, the processing stage at which the distractor interacts with the target picture name will differ depending on the SOA at which it is presented. For example, when the semantic condition is presented before or at the same time as the picture, the distractor lemma should interfere with the picture's lemma selection process (Indefrey & Levelt, 2004). Following the same logic, the semantic distractor should not yield any effects when it is presented at a later SOA (e.g., 150 ms after picture onset) because the target lemma will have already been selected and the picture name will be at the lexeme retrieval stage (Hall, 2011). In the phonological condition, when the distractor is presented 150 ms after picture onset, naming latencies are faster than in the unrelated condition (i.e., the phonological distractor facilitates naming) (Indefrey & Levelt, 2004; Roelofs, 1997). Surprisingly, this effect is also observed at early SOAs (Hermans et al., 1998). Thus, the phonological distractor seems to facilitate both the lemma and lexeme retrieval stages. Finally, interference effects caused by the phono-translation distractors have been observed at SOAs -150 and 0 ms (Costa, Colomé, Gomez, & Sebastin-Galls, 2003, Experiment 1; Hermans et al., 1998; Hoshino & Thierry, 2011), as well as SOA +150 ms (Costa et al., 2003).

Thus, the phono-translation effect seems to have two possible loci: semantic and phonological. Seeing that the semantic interference effect has its locus at the lemma retrieval stage of lexical access (Indefrey & Levelt, 2004; Roelofs, 1992), if the phono-translation effect is observed at the same SOAs at which semantic interference is observed (i.e., early SOAs), then one may assume that the interference takes place at the lemma selection process. However, if the effect is also observed at later SOAs (at which phonological facilitation appears) then the phono-translation interference is assumed to extend to the lexeme retrieval stage (Hermans et al., 1998). Consequently, this phono-translation effect became the most important index of cross-language lexical competition in the picture-word interference task.

Hermans et al. (1998) found a weak phono-translation effect in Experiment 1(purely monolingual task, since pictures were named in L2 and distractors were presented in L2 as well), reaching significance only in the by-participant analysis in SOA 0 ms. In Experiment 2 (which was similar in all aspects to Experiment 1, except that distractors were presented in L1, thus creating a bilingual experimental setting), however, the effect was more robust. The authors concluded that lemmas (and subsequently, the lexemes) from both languages are activated and enter into competition during bilingual lexical access. To account for this difference in the phono-translation effects observed in Experiments 1 and 2, Hermans et al. (1998) proposed two possible explanations. First they argued that the unreliable phono-translation effect obtained in Experiment 1 could possibly be due to the small overlap between the first phonemes of the English phono-translation distractor and the initial phonemes of the Dutch picture name. Second, they suggested that the robust phono-translation effect observed in Experiment 2 could be due to the strong activation received by the non-target language from the L1 distractor. The authors draw support for this idea from Grosjean's (2001) language mode hypothesis according to which, in bilinguals, the target language is much more activated than the non-target language in a monolingual mode (i.e., when only one language is used), whereas both languages are highly activated in a bilingual mode (i.e., a setting where both languages are present). However, in their first experiment where the setting was monolingual the phono-translation interference effect was present only in the by-items analysis. Unfortunately, since the effect found in Hermans et al. (1998) was not robust, no strong conclusions could be drawn with regards to the nature of the bilingual lexical selection process.

Two other studies replicated the phono-translation effect (Costa et al., 2003; Hoshino & Thierry, 2011) found in Hermans et al's (1998) first experiment. In an experiment identical to Hermans et al.'s (1998) Experiment 2, Costa et al. (2003) got highly proficient Spanish-Catalan bilinguals to name pictures in Catalan (their L2) while ignoring auditory distractors in Spanish (their L1). The authors replicated Hermans et al's (1998) results, as they found a phono-translation effect, although it was significant only in the by-participants analysis. However, the fact that the number of related trials in their first experiment was too great may have caused the participants to consciously think about the relationship of distractors to the picture. Costa et al. (2003) therefore conducted a second experiment where they introduced a number of filler trials (unrelated distractors). In this second experiment, only 37 % of the distractors were related to the picture (compared to 75% in the first experiment). Again, slower naming latencies in the phono-translation condition were found in the by participants and by items analyses (but only at SOA +150 ms), although this interference effect had a reduced magnitude in comparison to the one observed in their Experiment 1.

Hoshino and Thierry (2011) conducted a similar experiment with highly proficient Spanish-English bilinguals but with only one SOA at 0 ms and found a significant phono-translation interference effect. However, in the phonological condition they found interference instead of the expected facilitation effect found in both bilingual and monolingual picture-word interference tasks which included this condition (e.g., Costa et al., 2003; Hermans et al., 1998; Meyer & Schriefers, 1991). In this study, the picture names were also used as distractors in order to limit variation in lexical and physical characteristics of items. In order to verify whether this repetition of the target words as distractors induced the unusual interference effect found in the phonological condition, the authors conducted a control experiment with monolinguals using the same materials as in their main experiment. The results revealed a significant phonological interference effect, thus confirming that it was caused by the stimulus repetition.

It is also possible that the observed interference effect in these reported studies was due to the typological proximity of both language subsystems (e.g., English and Dutch in Hermans et al., 1998). To the best of our knowledge, only one study has addressed the issue of language-specific or -nonspecific selection with the picture-word interference task in highly proficient bilinguals whose languages were typologically distant, that is, Persian and French (Deravi, 2009). In their study, the phono-translation condition yielded conflicting results with facilitation instead of interference at SOA -150 ms, and an interference effect at SOA +150 ms. It is difficult to determine whether these results are due to the fact that the two languages were topologically different or to the lack of control of a number of psycholinguistic variables, including word frequency, in this study.

As can be seen, the literature on bilingual language processing, especially with regards to cross-language interactions, is rife with conflicting and inconsistent patterns of results. Taken together, these results seem to point to the idea that bilingual processing mechanisms are highly flexible and adaptable. In recent years, such a hypothesis has begun to take shape as an alternative solution to the bilingual "hard problem" and has been advocated by a number of recent theoretical accounts of bilingual language control and processing (e.g., Abutalebi & Green, 2007; Grosjean, 2013; Kroll, Bobb, & Wodniecka, 2006). According to this view, bilingual lexical selection is a dynamic process which is by default language non-specific but can also operate in a language-specific way under certain conditions. The way processing takes place during bilingual language production is possibly modulated by the interplay of a number of factors specific to bilingualism (for example, language proficiency) (Costa, Santesteban, & Ivanova, 2006; Kroll, Bobb, Misra, & Guo, 2009; Kroll et al., 2006). Such a hypothesis of a dynamic selection process is a theoretical claim worthy of further investigation, as it would reconcile the conflicting findings currently present in the literature. Thus, the focus of the present study will be on the interplay of three factors of importance: language similarity (or dissimilarity in the present case), L2 language proficiency, and language context of the experiments.

The role of language similarity. To the best of our knowledge the role of language similarity/dissimilarity in cross-language interactions during lexical access has been investigated by very few studies and only with highly-proficient bilinguals. Using a Stroop task, van Heuven, Conklin, Coderre, Guo, & Dijkstra, (2011) investigated the effect of language similarity on cross-language Stroop interference. They found that trilinguals whose languages widely differed at the level of script (Uyghur, Chinese and English) showed a smaller Stroop interference effect than same-script trilinguals (German-English-Dutch). Language similarity at the lexical, grammatical, and phonological levels also seems to play a significant role in modulating the degree of recruitment of the cognitive control mechanisms during bilingual language processing (Rodriguez-Fornells, De Diego Balaguer, & Münte, 2006).

L2 language proficiency. Language proficiency is one of the main factors modulating the activity of the non-target language and of the network responsible for language control (Green, 2011; Kroll et al., 2009, 2006). It has been mostly investigated in studies on bilingual language control. For example, in a series of language-switching experiments, Costa and colleagues (Costa et al., 2006; Costa & Santesteban, 2004) found that the control mechanisms recruited by low-proficient bilinguals are different from those of highly proficient bilinguals. In line with these findings, Abutalebi and Green's (2007) convergence hypothesis predicts that recruitment of control mechanisms decreases with an increase in L2 proficiency level, as L2 processing shifts from controlled to automatic. This hypothesis of bilingual representation and processing also assumes that cross-language competition is greater among low-proficient bilinguals than among highly proficient ones.

Language context. In everyday communication as well as in experimental settings, bilinguals find themselves in contexts where they are required to use only one of their languages (single-language or monolingual context) or in contexts where both of their languages are involved (dual-language or bilingual context). This is what has been referred to by Grosjean (2001) as the language mode. When in the monolingual mode (i.e., when the input and/or output is only in one language), both languages are activated but the non-target language's level of activation is much lower than the target language. In the bilingual mode (i.e., when both languages are present in the communication context or task), both languages are activated to a similar degree. Thus, the language mode or context influences the relative degree of activation of the two languages. There is increasing theoretical consideration and support for the effect of the language context on language processing and control mechanisms (e.g., Abutalebi & Green, 2007; Green, 2011; Green & Abutalebi, 2013; Kroll et al., 2009, 2006; Rodriguez-Fornells et al., 2006; Rodriguez-Fornells, Krämer, Lorenzo-Seva, Festman, & Münte, 2012; Wu & Thierry, 2010). Evidence for the effect of context comes from a few neuroimaging studies (e.g., Abutalebi et al., 2008; Wu & Thierry, 2013). Extensive activation of the neural network underlying language control (consisting mainly of the left prefrontal cortex, the left caudate, and left anterior cingulate cortices) was found in contexts during which both languages are involved in processing as compared to contexts where only one language is being processed. In the latter, it seems that control is mainly mediated by frontal areas (Green, 2011). Thus it would seem that bilinguals recruit different language processing and control mechanisms depending on language context.

In the present study, we aimed to investigate the lexical selection process among bilinguals whose languages are typologically distant: Tunisian Arabic and French, using the picture-word interference task in two experiments. As in Hermans et al. (1998), in Experiment 1, the language setting was entirely monolingual (L2), whereas in Experiment 2 it was bilingual. This allowed us to investigate whether language experimental setting influenced how processing operates among bilinguals. We predicted that if bilingual lexical selection is always a language non-specific process, we should observe the phono-translation effect in both Experiments 1 and 2. We also predicted that in both experiments we should observe a semantic interference and a phonological facilitation effects as in previous picture-word interference studies (Costa et al., 2003; Hermans et al., 1998).

Experiment 1: Bilingual word production in a monolingual setting

In this experiment, Tunisian Arabic-French bilinguals named pictures in their L2 (French) while ignoring an L2 auditory distractor. The aim of this experiment was to investigate cross-language activation and competition in a purely monolingual experimental setting where the non-target language (Tunisian Arabic) was absent.

If cross-language competition always takes place in a purely monolingual setting (as in Hoshino & Thierry, 2011), a phono-translation interference effect (i.e., slower naming latencies in the phono-translation condition relative to the unrelated condition) is predicted. The phono-translation distractor will activate the picture name in the non-target language, thus causing it to interfere with the selection of the picture name in the target language. Additionally, semantic interference (i.e., slower naming latencies in the semantic condition relative to the unrelated condition) as well as a phonological facilitation effects (i.e., faster naming latencies in the phonological condition relative to the unrelated one) are also predicted.

Regarding the interaction between the SOA and distractor type, inconsistent results have been reported for the picture-word interference task. Only Hermans et al. (1998) and Costa et al. (2003) investigated this interaction, since they both used three SOAs in their studies (-150, 0, and +150 ms), while Hoshino and Thierry (2011) used only one (SOA 0 ms). The SOA by distractor type interaction has only been reliably found in Hermans et al's (1998) Experiment 1. In their Experiment 2, this interaction was found in the by-participants but not in the by-items analysis. In Costa et al. (2003), it was not found in Experiment 1 and reached significance only in the by-items analysis in Experiment 2. Thus, in studies that used the phono-translation distractor in a picture-word interference task, the SOA by distractor type interaction has not been found consistently. We do not expect a consistent SOA by distractor type interaction in our study.

Method

Participants.

Twenty-four Tunisian Arabic-French bilingual university students in Quebec, Canada, participated in Experiment 1 (age: M = 27.3 years old, SD = 3.6, range = 22-36 years old; education: M = 19.7 years of education, SD = 2). Participants received a monetary compensation for their participation (20 $) and signed two consent forms (in French). The first form, signed before the experiment began, made only partial divulgation of the aims of the experiment, as it informed participants that the research was on language processes. The second form, signed at the end of the experiment, informed the participants of the real aims of the research (i.e., to investigate bilingual language processing). All were native speakers of Tunisian Arabic and learned French as a second language at primary school (*M* = 7.1 years old, *SD* = 1.3). Participants' proficiency was assessed by means of self-ratings on a 7-point Likert scale as part of a language history questionnaire (Grosjean, *personal communication*) and, following Primativo et al. (2013), a lexical decision task used as a vocabulary test. Table 1 shows the characteristics of the Tunisian Arabic-French bilinguals in Experiment 1.

-Table 1 about here-

The lexical decision task used in this study consisted of 120 low-frequency words and 120 non-words. Participants were asked to decide whether a given stimulus was a real word in French or not by pressing the button corresponding to their response on the keyboard. In order to make the assessment of L2 proficiency with this measure time-efficient, we focused on low frequency words only, in order to reliably determine whether our participants were highly proficient or not. Low-frequency words have been shown to be more efficient to determine large vocabulary size values in children (see, for instance, Vermeer, 2001).

The task was run on the DMDX software (Forster & Forster, 2003) as follows: a fixation point appeared for 400 ms after which the stimulus appeared at the center of the screen for 1500 ms or until participants responded. A proficiency score was computed for each participant from their performance on the lexical decision test using Meara's (1992) ΔM formula:

$$\frac{h-f}{1-f} - \frac{f}{h} = \Delta M,$$

where h = proportion of correctly recognized words (hit rate), and f = proportion of incorrectly accepted non-words (false alarm rate). The ΔM score is a measure reflecting L2 vocabulary size based on performance in lexical decision tasks. This score ranges from -1 to 1 and represents the proportion of words within the given frequency range that is known by the participant (Lemhöfer & Broersma, 2012).

The results indicate that our Tunisian Arabic-French bilinguals were moderately proficient ($M = 0.28$ ΔM, $SD = 0.24$). Highly-proficient bilinguals have a large vocabulary size, often almost equivalent to that of their L1. By contrast, moderately proficient bilinguals have a smaller vocabulary, that is, know much fewer words especially in the low-frequency range (Primativo et al., 2013), as indicated by our participants' scores in the lexical decision task. Our participants are therefore at an intermediary level of L2 proficiency, namely they are more proficient than speakers who just began learning French and whose vocabulary knowledge is very limited in that language but not as proficient as L2 speakers who have an extensive and near-native mastery of the language. The self-ratings, however, indicated a higher level of L2 proficiency (see Table 1).

It has been demonstrated that lexical decision is a more reliable measure of L2 vocabulary size than self-ratings, especially in experimental contexts (Lemhöfer & Broersma, 2012). In several studies investigating bilingual word processing, researchers relied on this measure to assess their bilingual's sample lexical proficiency in L2 (e.g., Christoffels, Firk, & Schiller, 2007; Hermans et al., 1998; Primativo et al., 2013). Similarly, we chose to take the lexical decision score as a measure of participants' proficiency. This is especially relevant seeing that the lexical decision task was meant to assess vocabulary size and that the present study focuses on bilinguals' mental lexicon.

Materials.

The target stimuli were 22 line-drawings of common objects for the main experiment and eight pictures for the training session. All pictures were selected from Alario and Ferrand's (1999) French normative database. They were matched for familiarity and name agreement. Values for these variables were taken from Alario and Ferrand's normative database (1999).

Four French words were selected for each picture to serve as distractors in the following conditions: (1) phono-translation (the distractor is phonologically related to the picture name in the non-target language), for example, *chapeau* /ʃapo/ (*hat*) (target picture: a candle, *bougie* in French; Tunisian Arabic name: /ʃamʕɑ/); (2) semantic (the distractor and target picture are semantically related), for example, *ampoule* (*bulb*) for the target picture of a candle; (3) phonological (the distractor holds a phonological relationship with the picture name in the target language), for example, *bouée* (*buoy*) for the target picture *bougie*; and (4) unrelated (the distractor holds no relation to the picture name), for example, *feuille* (*leaf*).

The semantic distractor was not phonologically related to the picture name in either language (for example, semantically related pairs such as *chien-chat* [*dog-cat*] were not included since they are also phonologically related in French). Finally, phonological and phono-translation distractors were not semantically related to the target picture. All distractors were non-cognates and were matched for subjective frequency, imageability, and word length in number of phonemes. Values for these psycholinguistic variables were taken from the lexical database for French, *Lexique 3.0* (New, Pallier, Brysbaert, & Ferrand, 2004) and Ferrand et al.'s (2008) estimates. All distractors were spoken by a native French speaker. A list of picture names in French, their translation in English as well as the distractors used in each condition are presented in the Appendix. Table 2 presents the characteristics of the distractors and the pictures.

-Table 2 about here-

Procedure.

The distractor was presented 150 ms before picture onset, at the same time as the picture (0 ms), and 150 ms after picture onset. Stimulus presentation was blocked by SOA condition, i.e., in each block there was only one SOA condition. Each of the three SOA conditions was further divided into four blocks of 22 trials each. All 22 pictures were presented once within a given block. Thus, in each SOA condition, each picture was seen four times, each with a different distractor.

The order of presentation of the three SOA conditions was counterbalanced across participants. There were, then, six possible SOA combinations and an equal number of participants were presented with each one of these combinations. Block order presentation within a given SOA condition, as well as the order of the trials within the blocks, was randomized across participants.

Participants were tested individually in a sound-proof room. Grosjean's (2013) guidelines for experimenting with bilinguals and controlling the language mode were followed. Before the experiment began, participants were explicitly asked to communicate with the experimenter only in French (the target language) and not to use their native language. Additionally, all experimental instructions were given in French to ensure that the non-target language (Tunisian Arabic) was completely absent from the experiment, as in Hoshino and Thierry (2011). Participants were seated in front of a computer monitor. Similar to Hermans et al. (1998), a familiarization phase preceded the experimental session. Each participant was presented with a booklet of 30 pictures (including the 22 pictures involved in the experiment). The name of each picture was printed in French underneath it and participants were asked to use only these words to name the pictures. After participants saw all drawings, they were presented with another booklet with the same line-drawings, this time without the printed word, and were instructed to name these pictures. Next, a practice block of 8 trials was administered. The experimental blocks followed and participants were allowed to take regular breaks between blocks.

The DMDX software (Forster & Forster, 2003) was used to present the stimuli and record the response onset by means of a headset with a microphone. The naming latencies were measured from picture onset until response onset. Each trial started with a blank screen that lasted for 1000 ms and was followed by a fixation point (*) that appeared on the centre of the screen and remained for 500 ms. After the fixation point, a blank screen appeared for 500 ms after which the picture appeared on the centre of the screen and remained there for a maximum of 2000 ms. The distractor was spoken through the headphones either 150 ms before the picture appeared on the screen (i.e., 350 ms after the fixation point), at the same time, or 150 ms after picture onset. All RTs were extracted from recorded responses and corrected when necessary using the CheckVocal programme (Protopapas, 2007).

Once the experimental session was finished, participants were allowed to take a break and were then asked to do the lexical decision task and fill in the language history questionnaire.

Data analysis.

The linear mixed effects modeling approach, a type of analysis that controls for the crossed random effects of participants and items (Baayen, Davidson, & Bates, 2008), with distractor type (semantic, phonological, phono-translation, and unrelated) and SOA (-150, 0, and 150 ms) as within subjects factors was used for data analysis. Reaction times (RTs) were introduced in the model as dependent variables. Error rates (Experiment 1 mean percentage: 3.58%; Experiment 2 mean percentage: 4.04%) were not high enough to allow for analysis in either experiment. Comparisons of each of the phono-translation, semantic, and phonological distractor conditions with the unrelated one were also carried out to establish any effects of the phono-translation, semantic, and phonological distractors.

We conducted our data analyses in SPSS22 and in the R language and environment (R Core Team, 2014) using the lme4 (Bates et al., 2015) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2015) packages. We did this to indicate the comparability of mixed-effects model results in SPSS (an application familiar to many experimental psychologists) and in R (an application familiar to many users of linear mixed-effects models). We report the results of the analysis done in SPSS first. We then report the results of the same analysis, done in R, for comparison. R code used in analysis will be available from the authors on request.

Results

Mispronunciation errors were removed from the analysis of RTs along with responses that were 3 standard deviations above or below each participant's overall mean. This resulted in the exclusion of 5.57% of the total data.

-Figure 1 about here-

Tables 3 and 4 show the mixed model analysis estimates and tests of fixed effects by RTs. Distractor type significantly affected RTs ($ps < .05$). Figure 1 illustrates the comparisons between the unrelated condition and the three other distractor types.

-Table 3 about here-

The phonological distractor (M = 749.14 ms, SD = 195.49) was significantly faster than the unrelated condition (M = 765.08 ms, SD = 194.46). No significant differences were found between the unrelated and the phono-translation or semantic conditions. Also, SOA affected RTs. SOA 0 ms (M = 786.32 ms, SD = 197.60) was significantly slower than the other two SOA conditions (SOA -150 ms: M = 741.28, SD = 177.35; SOA +150 ms: M = 748.35, SD = 205.67). The interaction distractor x SOA did not reach significance.

-Table 4 about here-

The same results were apparent in a mixed-effects models analysis of the data using the lme4 package (Bates et al., 2015) in R (R Core Team, 2014). We estimated the effects of SOA and distractor type on RTs in two models. In the first, we specified fixed effects due to SOA and distractor type. In the second, we specified main effects due to SOA and distractor type as well as the interaction between SOA and distractor effects. A likelihood ratio test (LRT) comparison between the models (see Barr, Levy, Scheepers, & Tily 2013; Pinheiro & Bates, 2000) showed that the addition of the interaction did not significantly improve model fit to data ($\chi^2 = 3.9$, 6 df, $p = 0.69$), indicating that a model with just main effects provided the best account of variation in RTs. Consistent with this, in the model including main and interaction effects, no term corresponding to the interaction between SOA and distractor effects was found to be significant (all *p*s > .05). Consequently, we report in Table 5 the estimated effects of SOA and distractor type.

-Table 5 about here-

Note that we ran mixed-effects analyses specifying the unrelated distractor condition as the baseline condition or reference level for the distractor type variable. Thus, the tabled results show the estimated effect on RTs of naming pictures with related distractors compared to naming pictures with unrelated distractors. We specified the simultaneous SOA condition as the baseline condition or reference level for the SOA factor so that the results show the estimated effect of naming pictures at -150ms or +150ms compared to 0ms SOA. We calculated p-values using the lmerTest package (Kuznetsova et al., 2015).

In both analyses, using SPSS and R, model results indicated a significant effect of SOA (RTs were faster at -150 or +150ms than at 0ms SOA) and distractor type (RTs were faster in the phonological than unrelated distracter conditions) but no interaction between SOA and distractor effects. Table 6 presents the means, standard errors and percentage of errors for each SOA and distractor condition.

-Table 6 about here-

Also, to control for the possible effects of individual differences in L2 proficiency we ran additional analyses in SPSS where all participants' proficiency level (i.e., their ΔM scores) was added as a co-variable. L2 proficiency had no significant effect on RTs. Also, the main pattern of results remained unchanged with significant main effects of SOA and distractor type, no significant interaction between the two, a significant phonological effect but no significant phono-translation effect. Interestingly, the semantic effect remained non-significant but was closer to significance when L2 proficiency was added ($p = .063$). Distractor type did not significantly interact with L2 proficiency.

Additionally, SOA significantly interacted with L2 proficiency [$F(32, 5700.19) = 13.87$, $p < .001$]. Figure 2.a illustrates the SOA x L2 proficiency interaction. As a general trend, RTs were faster as L2 proficiency increased. L2 proficiency differently affected the slope of SOA -150 ms that was steeper as compared to the other two SOAs.

-Figure 2 about here-

Discussion

The results of Experiment 1 show that only the phonological distractor affected naming with faster naming latencies in the phonological condition than in the unrelated one. This replicates findings from previous studies with both bilinguals and monolinguals (e.g., Costa et al., 2003; Hermans et al., 1998; Schriefers, Meyer, & Levelt, 1990) where the phonological distractor facilitated naming.

The phono-translation and semantic distractors did not affect naming latencies. The absence of a phono-translation interference effect seems to indicate that the lexical selection process proceeded in a language-specific way in this experiment where the language experimental context was entirely monolingual. The semantic distractor also failed to interfere with the target picture. This might be related to the depth of processing of distractors in this experiment as a function of participants' moderate L2 proficiency level. Indeed, the presence of the phonological facilitation effect and the absence of the semantic interference effect seem to suggest that because of the moderate proficiency level of participants, processing of L2 distractors remained shallow and did not go beyond the phonological level.

When taking a closer look at the possible effects individual differences in L2 proficiency might have had on the results of this Experiment, we found that only SOA (but not the main effect of distractor type) was modulated by participants' L2 proficiency level. In general, participants were faster as their L2 proficiency level increased. Also, L2 proficiency level differentially affected the effects of the three SOAs with larger effects of L2 proficiency level for the SOA -150 ms. However, since L2 proficiency level per se did not affect latencies, nor had it interacted with the main effect of distractor type, we believe that even though depth of processing seems to have varied as a function of participants' individual differences in L2 proficiency, the amount of L2 activation did not.

Further support for this differential depth in the processing for moderately proficient bilinguals comes from the change in the semantic distractor effect when L2 proficiency was taken into account. Indeed, we found that the semantic effect now approached significance. This interesting change supports the idea that the moderate L2 proficiency level resulted in processing to remain shallow.

More importantly, the phono-translation effect remained absent when L2 proficiency was taken into consideration. This indicates that the absence of this effect cannot be attributed to the shallow processing of the distractors as a function of L2 level of proficiency in Experiment 1 but, more likely, to the monolingual language context that prevented competition from L2 phono-translation distractors. Further evidence for this explanation should come from Experiment 2, in which the semantic distractor is presented in participants' L1, their dominant language. If this explanation holds, deep processing of the semantic distractor presented in L1 should take place and we should observe a semantic interference effect in Experiment 2.

Experiment 2: Bilingual word production in a bilingual setting

In Experiment 1 we investigated whether there is cross-language competition during bilingual lexical selection in an entirely monolingual experimental setting. Results showed no interference effects, seemingly indicating that lexical selection among moderately proficient Tunisian Arabic-French bilinguals is language-specific in a monolingual context. To test whether the lexical selection process functioned similarly in a bilingual experimental setting, we conducted a second experiment where both languages (Tunisian Arabic and French) were present in the task. Tunisian Arabic-French bilinguals named pictures in their L2 (French) while ignoring an auditory distractor in their L1 (Tunisian Arabic).

If bilingual lexical selection is a dynamic process influenced by language setting as some theories suggest (e.g., Gorsjean, 2013; Hermans et al., 2011; Kroll et al., 2006), then we expect to observe cross-language competition in this experiment. If there is cross-language competition in a bilingual experimental setting, then an interference effect of the phono-translation condition (as compared to the unrelated one) should be observed. Additionally, if cross-language activation extends to the lexeme level, then the phonological facilitation effect reflected in faster naming latencies in the phonological condition should be observed. Finally, lexical competition at the lemma level should result in a semantic interference effect with slower naming latencies in the semantic condition.

Method

Participants.

Twenty-four Tunisian Arabic-French bilingual university students participated in this experiment (age: *M* = 27.2 years old, *SD* = 4.1 years old, range = 21-37 years old; education: *M* = 18.4 years of education, *SD* = 1.7 years). Participants received a monetary compensation for their participation (20 $). All were native speakers of Tunisian Arabic and learned French as a second language at primary school (*M* = 7.2 years old, *SD* = 1.1 years old). Participants' proficiency was assessed in the same way as in Experiment 1. Table 1 shows the characteristics of the participants. The lexical decision score indicated a moderate level of L2 proficiency for this group of Tunisian Arabic-French bilinguals as well (*M* = 0.29 *ΔM*, *SD* = 0.16). As in Experiment 1, the self-ratings indicated a higher level of proficiency (see Table1).

Materials.

The same 30 pictures used in Experiment1 (22 for the main experiment and 8 for the practice session) were used in Experiment 2. Tunisian Arabic phono-translation (e.g., /ʃabka/ [*net*] for the picture of a candle [*bougie* in French, /ʃamʕɑ/ in Tunisian Arabic]), semantic (e.g., /ʔambu:ba/ [*bulb*]), phonological (e.g., /bulu:na/ [*screw*]), and unrelated (e.g., /warqa/ [*leaf*]) distractors were constructed for this experiment (the full list of stimuli is in the Appendix). The semantic distractors were merely Tunisian Arabic translations of the French semantic distractors used in Experiment 1. All distractors were matched for subjective frequency, familiarity, and word length in number of phonemes in Tunisian Arabic. Values for these variables were taken from a Tunisian Arabic normative database (Boukadi, Zouaidi, & Wilson, 2015). All distractors were recorded by a native Tunisian Arabic speaker who was born and grew up in Tunis, Tunisia. Table 7 presents the characteristics of distractors and pictures used in Experiment 2.

Procedure and data analysis.

Design, general procedure and data analysis were the same as in Experiment 1.

-Table 7 about here-

Results

Mispronunciation errors were removed from the analysis of RTs along with responses that were 3 standard deviations above or below each participant's overall mean. This resulted in the exclusion of 5.90% of the total data.

-Figure 3 about here-

Tables 8 and 9 show the mixed model analysis estimates and tests of fixed effects. Distractor type affected RTs ($p < .05$). As can be seen in Figure 3, comparisons between the distractor conditions showed that RTs were significantly longer in the phono-translation (*M* = 964.72, *SD* = 285.94) than in the unrelated condition (*M* = 918.16, *SD* = 267.17), RTs in the semantic condition were significantly longer (*M* = 934.23, *SD* = 271.80) than in the unrelated condition and RTs in the phonological condition (*M* = 938.10, *SD* = 284.52) were also longer than in the unrelated condition.

-Table 8 about here-

SOA also affected performance. SOA -150 ms was significantly faster (*M* = 895.06, *SD* = 248.78) than the other two and SOA 0 ms was significantly faster (*M* = 952.74, *SD* = 290.17) than SOA +150 ms (*M* = 969.30, *SD* = 287.89). The interaction distractor type x SOA did not reach significance.

-Table 9 about here-

The same results were apparent in a mixed-effects model analysis of the data using the lme4 package (Bates et al., 2015) in R (R Core Team, 2014). As in Experiment 1, a likelihood ratio test (LRT) comparison between the models showed that the addition of the interaction did not significantly improve model fit to data ($\chi^2 = 7.7$, 6 df, $p = 0.26$), indicating that a model with just main effects provided the best account of variation in RTs. Consistent with this, in the model including main and interaction effects, no term corresponding to the interaction between SOA and distractor effects was found to be significant (all *p*s > .05). Consequently, we report in Table 10 the estimated effects of SOA and distractor type.

-Table 10 about here-

As in Experiment 1, results show the estimated effect on RTs of naming pictures with related distractors compared to naming pictures with unrelated distractors, and the estimated effect of naming pictures at -150ms or +150ms compared to 0ms SOA. Again, in both analyses, using SPSS and R, model results indicated a significant effect of SOA (RTs were faster at -150 or +150ms than at 0ms SOA) and distractor type (RTs were slower in the phonological, phono-translation and semantic than unrelated distracter conditions) but no interaction between SOA and distractor effects. Table 6 presents the means, standard errors and percentage of errors for each SOA and distractor conditions.

As in Experiment 1, we ran additional analyses with participants' L2 proficiency (measured in *ΔM* scores) as co-variable. Proficiency had no main effect on RTs and the main pattern of results was unchanged with significant main effects of SOA and distractor type, no interaction between these two factors, and significant interference phono-translation, semantic, and phonological effects. Once again SOA significantly interacted with proficiency [F (38, 5471.22) = 17.48, $p < .001$]. Figure 2b plots the SOA x proficiency interaction and shows that as the level of proficiency in L2 increases, latencies are faster. Also, L2 proficiency differently affected the SOA 0 ms, with its slope steeper than that of the other two SOAs. Level of proficiency in L2 did not interact with distractor type.

We also ran a joint analysis of Experiments 1 and 2 with experiment as a between-subject factor in order to investigate whether there was a between-experiment interaction. The main effect of experiment was significant [F (1, 11602.65) = 1787.28, $p < .001$] with faster RTs (*M* = 758.49, *SD* = 194.82) in Experiment 1 than in Experiment 2 (*M* = 938.78, *SD* = 277.92; difference: 180.29 ms). Additionally, experiment significantly interacted with SOA [F

(2, 11595.18) = 26.51, $p < .001$]. As reported in Experiment 1, SOA 0 was slower than SOAs -150 ms and +150 ms, whereas in Experiment 2, SOA +150 ms was slower than the other two and SOA 0 ms was slower than SOA -150 ms. More importantly, the interaction experiment x distractor type was significant [F (3, 11595.72) = 6.82, $p < .001$], as the phono-translation and semantic effects were absent in Experiment 1 but significant in Experiment 2 and the phonological effect was facilitatory in Experiment 1 but inhibitory in Experiment 2.

A post-hoc analysis comparing the phono-translation effects (phono-translation minus unrelated distractors) in Experiment 1 and Experiment 2 was carried out. We found a significant difference [t (46) = -5.67, $p > .001$] with a larger phono-translation effect in Experiment 2 (M = 45.71, SD = 33.93) than in Experiment 1 (M = -.79, SD = 21.47).

Discussion

The results show that the phono-translation, semantic, and phonological L1 distractors all interfered with the picture names in L2. The finding of interference in the phono-translation condition is of particular interest as it indicates that the non-target language lemma of the picture name was activated and competed for selection with the French target lemma. This finding replicates that of Hermans et al. (1998) who also found a significant phono-translation interference effect in a bilingual experimental context (i.e., a context where both languages were present). Thus, it appears that the lexical selection process operated in a language-nonspecific way in this Experiment. Additionally, the semantic interference effect shows that the target French lemma spreads activation to related lemmas not only in French but also in Tunisian Arabic.

Interestingly, interference instead of the expected facilitation effect was observed in the phonological condition. In most studies using the picture-word interference task, the phonological distractor has yielded a facilitation effect (Costa et al., 2003, Costa & Caramazza, 1999; Hermans et al., 1998). Only one study by Hoshino and Thierry (2011) has found an interference effect in the phonological condition, which they attributed to the repetition of the picture names as distractors in their experiment. In the present study, however, there is no such repetition. The interference effect observed in the phonological condition in the present study seems to indicate that cross-language interference took place at the level of word form retrieval. One possible explanation for this effect could come from the phonological dissimilarity between Tunisian Arabic and French. Phonological dissimilarity between L1 and L2 has been shown to play an important role in the processing of L2 (Rodriguez-Fornells et al., 2006). Indeed, Tunisian Arabic and French phonological systems differ in several aspects. For instance, the vocalic system in Tunisian Arabic is much more limited than the French one. While Arabic counts only six vowels (short and long /a/, /i/, /u/), the French language counts seventeen vowels (/i/, /e/, /ɛ/, /ɛ:/, /ə/, /œ/, /ø/, /y/, /u/, /o/, /ɔ/, /a/, /ɑ/, /ɑ̃/, /ɔ̃/, /œ̃/, /ɛ̃/). Tunisian Arabic is also characterized by pharyngealized consonants (e.g., /tˤ/) which do not exist in French. According to the BIMOLA model (Grosjean, 2008), the only model of bilingual speech comprehension with a relatively well-specified phonological level, phonemes from both languages are tagged as belonging to either language (for example, English /t/ and French /t/) and organized in what they call a "metric space" that determines the distance between the phonemes both within and between languages. It is possible that in our Experiment 2, the phonemes of L1 and L2 were perceived as relatively close between both languages but different enough to create competition that resulted in the interference effect. In other words, because of the highly distinct phonemic contexts (e.g., the presence of the pharyngealized /tˤ/ in the phonological distractor /batˤriq/ for the target *balançoire*, *swing* in English), the overlapping French and Tunisian Arabic phonemes might have been perceived as close but different enough to lead the lexemes of the French target word and its Tunisian Arabic phonological distractor to compete, making the retrieval of the French target lexemes more difficult. Thus, the activation of Tunisian Arabic phonological competitors resulted in interference. Moreover, this interference might have been heightened in late moderately proficient bilinguals, as the participants in our study. Studies in more proficient, early Tunisian Arabic-French bilinguals (i.e., bilinguals who learned their L2 very early in their childhood) are necessary to test this explanation. It has been shown that early bilinguals develop early on differentiated phonological systems for the L1 and L2 (e.g., Flege, MacKay, & Meador, 1999). This early phonological differentiation would possibly reduce interferences between the two languages. If the effect of phonological dissimilarity is diminished in highly proficient early bilinguals, then no interference effect should be found in the context of phonological distractors.

As in Experiment 1, the absence of a main effect of L2 proficiency and of a modulation of distractor type by proficiency level in L2 indicate that varying L2 proficiency levels within the sample did not affect the amount of L2 activation and interference. Additionally, none of the interference effects were affected by individual differences in L2 proficiency level, which is not surprising, since all distractors were presented in Tunisian Arabic in this experiment.

General discussion

The aim of the present study was to determine whether the lexical selection process operates differently (i.e., either in a language-specific or nonspecific way) in monolingual and bilingual language contexts among moderately proficient bilingual speakers of two dissimilar languages as Tunisian Arabic and French. We used a picture-word interference task in two experiments where we manipulated the language experimental context (monolingual in Experiment 1 vs. bilingual in Experiment 2). The results of both experiments taken together, as well as the between-experiment interaction found in the joint analysis, seem to suggest that lexical selection is a dynamic process modulated by the language context. In a purely monolingual setting (Experiment 1), lexical selection seems to proceed in a language-specific way with lexical competition taking place within the target language only. Consequently, only phonological distractors facilitated naming latencies. On the other hand, in a bilingual experimental setting, in which both languages are present (Experiment 2), lexical selection seems to be cross-linguistic with lexical items from both languages competing for selection. Thus, a phono-translation effect indexing cross-language competition was found, along with phonological and semantic effects indexing cross-language activation at the semantic and phonological levels. This is in line with Kroll et al.'s (2006) proposal that bilingual lexical selection is mainly language non-specific but may function in a language-specific way in some circumstances and depending on some factors, such as the modulation of the activation levels of the two languages by experimental language context (monolingual or bilingual), among others.

Unlike the results of Experiment 1 here, both Hoshino and Thierry (2011) and Hermans et al. (1998) found a phono-translation interference effect (though significant in the by-participants analysis only in the case of Hermans et al., 1998) in the monolingual picture-word interference task. By contrast, in our Experiment 1 phono-translation distractors did not affect performance at all. Conversely, in our Experiment 2, we found a phono-translation effect, indexing cross-language competition. One may wonder whether this absence of the phono-translation effect in Experiment 1 was due to a shallower (i.e., phonological but not semantic) depth of processing as was the case for the non-significant semantic effect. This is unlikely because the phono-translation distractor is phonologically related to the non-target picture name. This means that, when effective, this distractor sends additional activation to the L1 target lexeme which then spreads to the L1 target lemma, causing the expected interference. Therefore, if both languages were highly activated in Experiment 1, mere shallow, phonological, processing of this distractor should have been sufficient for it to exert its influence. Furthermore, the fact that the semantic effect approached significance, while the phono-translation effect did not when we introduced the L2 proficiency level as a co-variable, further shows that the absence of the phono-translation effect in Experiment 1 was not the result of participants' shallow processing of L2 distractors (as caused by their moderate level of L2 proficiency). Instead it seems to suggest that it was the fact that in a monolingual context as that of Experiment 1, only one language was sufficiently active. Consequently, little or no cross-linguistic competition, which would be indexed by a phono-translation interference effect, was present.

Unlike other studies (Hermans et al. 1998; Costa et al., 2003, Experiment 2), the SOA did not modulate distractor type in either experiment. One possible explanation for this difference may be due to the fact that the interaction was observed in studies that analyzed their data using a separate analysis for participants (F1) and items (F2). Conventionally, an effect is considered as being significant if both by-participants and by-items analyses are significant (Baayen et al., 2008; Baayen, 2008) (Baayen, 2008; Baayen et al., 2008). Only the study by Hermans et al. (1998) has reported this effect both by items and by participants in their Experiment 1. In both experiments of our study, we used a linear mixed effects model. Linear mixed effects modeling has increasingly become the gold standard in data analyses in the field of psycholinguistics, including studies on bilingualism, for the numerous benefits and advantages it offers over traditional analyses of variance ANOVA (Baayen, 2008; Baayen et al., 2008; Barr et al., 2013). In particular, one of the strengths of this type of analysis is that it controls for the crossed random effects of participants and items in one single model. Thus, separate analyses for participants and items are not necessary with mixed effects models. To test the idea that this difference in statistical methods among our study and other similar ones previously published had something to do with the absence of the SOA by distractor interaction, we ran by-participants (F1) and by-items (F2) analyses on our data. Results revealed a pattern similar to that of Costa et al. (2003), with the SOA modulating distractor type in the by-participants but not by-items analysis in Experiment 2 only, F_1 (6, 138) = 2.36, $p < .05$, F_2 (6, 126) = 1.35, $p > .05$. These results provide support for the idea that the type of analysis used can account for the different pattern described in our study as compared to previous ones.

The pattern of results found in both of our experiments can be accounted for in light of the language mode hypothesis (Grosjean, 2001) and models and theories of language control (Abutalebi & Green, 2007; Green, 1998). According to the language mode hypothesis (Grosjean, 2001), bilingual speakers are in constant movement on a continuum whose ends are the monolingual and bilingual modes. In a purely monolingual mode the target language is highly activated while the non-target language is at a much lower level of activation. In a bilingual mode, however, both languages are highly activated. In Experiment 1 of the present study, all instructions and stimuli were given exclusively in L2 and participants were clearly instructed not to speak in their native language under any circumstance and were not informed that the research was related to bilingualism, thus creating a monolingual context where the non-target language is not needed. Although, this is not to say that it is deactivated. As outlined in the introduction, there is consistent empirical evidence for cross-language activation in bilingual language processing, be it in a monolingual or bilingual context (e.g., Colomé & Miozzo, 2010; Colomé, 2001; Hermans et al., 2011). By contrast, in Experiment 2 both languages were involved in the task, and participants were allowed to speak in their native language and were told from the beginning that the research was on bilingualism. Additionally, the experimenter switched willingly between both languages while explaining the nature and instructions of the experiment. In such a bilingual context, we assume that both languages were highly activated.

Language control mechanisms handle cross-language activation in different ways depending on the specific demands of the monolingual or bilingual language context (e.g., Abutalebi & Green, 2007; Abutalebi et al., 2008). Some theoretical accounts of language control in the bilingualism literature have distinguished between two forms of control involved in bilingual language processing: local and global inhibitory control. Local control may be recruited to locally inhibit single language representations, while global control might be responsible for inhibiting the non-target language's entire sub-system (Baum & Titone, 2014; Christoffels et al., 2007; De Groot & Christoffels, 2006; Guo, Liu, Misra, & Kroll, 2011; Wang, Kuhl, Chen, & Dong, 2009). In a language-switching task with unbalanced, moderately proficient German-Dutch bilinguals, Chritoffels et al. (2007) found evidence for sustained proactive inhibition of L1 (i.e., longer-lasting inhibition of the whole language) which allowed balancing of the activation levels of the two languages. They also suggested that in addition to this sustained global inhibition of the non-target language, a transient control mechanism applies inhibition locally, namely at the level of single items within the language system, as opposed to the inhibition of the activation level of an entire language subsystem. In an fMRI study, Abutalebi et al. (2008) found greater engagement of areas in the neural network responsible for language control, namely the left prefrontal cortex, the left caudate, and left anterior cingulate cortices in a bilingual experimental context (switching in picture naming between L1 and L2). They also found extensive activation in the left anterior cingulate cortex (responsible for conflict monitoring) during L2 naming (in comparison with L1 naming). The authors concluded that this area might be recruited in the selection of words in the intended language of production (i.e., local control).

Based on the abovementioned behavioral and neuroimaging findings, we hypothesize that different cognitive control mechanisms played a role in modulating the relative activation levels of the L1 and L2 in both language settings in Experiments 1 and 2. In Experiment 1, proactive global control most likely inhibited the activation of the L1 to allow for production in L2, while the interplay of several control mechanisms, including local conflict monitoring, was required for the selection of the appropriate lexical alternative in Experiment 2 (Christoffels et al., 2007; Rodriguez-Fornells et al., 2006). Thus, this differential pattern of activation levels might explain the presence of cross-language interference in Experiment 2 and its absence in Experiment 1.

Let us now turn to the cross-language interference found in Experiment 2. Resolution of lexical competition depends on the relative activation levels of competitors, so the higher the activation of both languages (and by extension, of their lexical representations), the longer it would take to suppress the non-target representation and to allow selection of the L2 lexical alternative (Green, 1998). It is then plausible that the higher the activation level of both languages, the more control resources are recruited to locally inhibit L1 activation during word production in L2. This operation is more effortful and requires more control resources for lower proficient bilinguals, or in the present case moderately proficient ones (Abutalebi & Green, 2007; Abutalebi et al., 2008; Pivneva, Palmer, & Titone, 2012), thus resulting in cross-language competition, as the one found in Experiment 2. In other words, we assume that in Experiment 2 where the experimental setting was bilingual, the lexical selection process operated in a language non-specific way due to the high activation of both languages and the target language remained as such open to interferences from the non-target language. In Experiment 1(monolingual experimental setting) the activation level of L1 was much lower than that of L2 and the global inhibition applied to the L1 was sufficient to prevent interference.

Taken together, these findings seem to indicate that lexical selection among moderately proficient Tunisian Arabic-French bilinguals is a dynamic process that may function in a language-specific or non-specific way depending on the language context, as recently hypothesized by some researchers (e.g., Grosjean, 2013; Hermans et al., 2011; Kroll et al., 2006). They also provide support for the idea that the language experimental setting plays a role in modulating the relative activation of the bilinguals' languages (Grosjean, 2001), even when the task specifies the language of production. These findings highlight the need to reconsider the role and existence of a so-called *language cue* (a feature at the conceptual level that specifies the language of production), a component shared by most models of bilingual word production (e.g., Hermans, 2000; La Heij, 2005; Green, 1998) and that is hypothesized to play a key role in the lexical selection process. Our data suggest that the language cue is not sufficient to modulate and constrain cross-language activation or competition. Therefore, a mechanism that relies solely on language choice, as it is the case in most models of bilingual processing, cannot account for the full scope of bilingual processing in different contexts.

In conclusion, it seems that there is cross-language competition during lexical selection when the experimental setting involves both languages, as indexed by the phono-translation interference effect found in Experiment 2. When the setting involves the target language exclusively, however, the lexical selection process becomes language-specific. Such findings among moderately proficient bilinguals are of particular interest to models of bilingual language processing. Some researchers posit that proficiency is a determinant factor of how the lexical selection process operates. Costa et al. (2006) suggested that low-proficient bilinguals' lexical selection is language non-specific while among highly-proficient bilinguals it becomes a language-specific process as high proficiency in both languages prevents cross-language interferences. According to the authors this is why, in a language-switching task, highly-proficient bilinguals show symmetrical switching costs whereas low-proficient bilinguals produce asymmetrical switching costs. However, in their language-switching study, Christoffels et al. (2007) found symmetrical switching costs among moderately proficient bilinguals, which led the authors to conclude that factors such as frequency of use and daily switching may overpower the possible effects language proficiency may have on the functioning of the lexical selection process. Our study shows that it is not proficiency alone that determines how the lexical selection process functions, but rather its interplay with other factors like language context and language dissimilarity.

The present study offers new insights into bilingual language processing, as it shows that lexical selection is indeed a dynamic process that may function in different ways depending on the circumstances and the interplay of several variables.To the best of our knowledge, this study is the first to provide information on the nature of the lexical selection process among moderately proficient bilinguals of two distant languages and brings us a step closer to reconciling conflicting findings from previous research on the topic. Further studies should be conducted with moderately and low proficient bilinguals whose languages are typologically distant in order to ascertain the reliability of the present findings.

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Appendix

Picture names and French distractors used in Experiment 1

		Distractors			
Picture	TA translation	Phono-translation	Phonological	Semantic	Unrelated
chaîne (chain)	salsla	sabot (hoof)	chèvre (goat)	corde (rope)	fourmi (ant)
balançoire (swing)	dorʒi:ħa	dauphin (dolphin)	baleine (wheel)	chaise (chair)	table (table)
clé (key)	mɛfta:ħ	médaille (medal)	cloche (bell)	porte (door)	tonneau (barrel)
bougie (candle)	ʃamʕa	chapeau (hat)	bouée (buoy)	ampoule (bulb)	feuille (leaf)
canon (cannon)	mɛdfaʕ	mèche (wick)	casserole (pan)	pistolet (gun)	oignon (onion)
canard (duck)	batˤ:a	barre (bar)	camion (truck)	poule (chicken)	toupie (top)
couteau (knife)	sɛk:ina	cercle (circle)	couronne (crown)	lime (file)	tigre (tiger)
collier (necklace)	ʃarka	chat (cat)	cochon (pig)	bague (ring)	fromage (cheese)
coq (rooster)	sardu:k	sacoche (bag)	corne (horn)	oie (goose)	marteau (hammer)
cerveau (brain)	moχ	moto (bike)	cerf (stag)	tête (head)	pinceau (brush)
robinet (faucet)	sab:ɛ:la	satellite (satellite)	robe (dress)	arrosoir (watering can)	cœur (heart)
barbecue (grill)	maʃwa	marin (sailor)	balance (swing)	cuisinière (cook)	plume (feather)
soleil (sun)	ʃams	chapiteau (tent)	sauterelle (locust)	étoile (star)	église (church)
salière (salt-shaker)	mal:ɛħa	masque (mask)	sabre (saber)	bol (bowl)	crocodile (crocodile)
bouton (button)	fɛlsa	fée (fairy)	bouteille (bottle)	nœud (bow)	citron (lemon)
fleur (flower)	naw:ara	natte (braid)	flocon (flake)	vase (vase)	poubelle (bin)
tortue (turtle)	fakru:na	femme (woman)	tomate (tomato)	grenouille (frog)	aiguille (needle)
scie (saw)	monʃa:r	momie (mummy)	cible (target)	bois (wood)	poisson (fish)
barrière (fence)	su:r	souris (mouse)	bassine (basin)	arche (arch)	cuillère (spoon)
selle (saddle)	sarʒ	Sapin (pine)	serpent (snake)	tabouret (stool)	artichaut (artichoke)
banane (banana)	mu:za	mouche (fly)	barbe (beard)	raisin (grape)	pneu (tire)
canapé (sofa)	bank	ballon (ball)	cage (cage)	lit (bed)	drapeau (flag)

Note: TA translations of the picture names are transcribed using the International Phonetic Alphabet (IPA) conventions. English translations of all distractors are between parentheses.

Picture names and TA distractors used in Experiment 2

Picture	TA translation	Distractors			
		Phono-translation	Phonological	Semantic	Unrelated
chaîne (chain)	salsla	sal:a (basket)	ʃɛb:ɛ:k (window)	ħbal (rope)	nɛm:ɛla (ant)
balançoire (swing)	dorʒi:ħa	dob (bear)	batˤri:q (penguin)	korsi (chair)	tˤɑ:wlɑ (table)
clé (key)	mɛfta:ħ	mɛʕla:q (hanger)	kla:fɛs (celery)	bɛ:b (door)	birmi:l (barrel)
bougie (candle)	ʃamʕa	ʃabka (net)	bulu:na (screw)	ʔambu:ba (bulb)	warqa (leaf)
canon (cannon)	mɛdfaʕ	mɛʕza (goat)	Kalb (dog)	fard (gun)	bsˤal (onion)
canard (duck)	batˤ:a	batˤa:tˤa (potato)	kab:u:t (coat)	dʒɛ:ʒa (chicken)	ʒbɛn (cheese)
couteau (knife)	sɛk:ina	sɛbta (belt)	ku:ba (handle)	mɛbrɛd (file)	nɛmr (tiger)
collier (necklace)	ʃarka	ʃaʒra (tree)	Komidinu: (dresser)	χa:tɛm (ring)	zarbu:t (top)
coq (rooster)	sardu:k	sam:a:ʕa:t (earphone)	kol:ɛb (handle)	waz:a (goose)	mtˤarqɑ (hammer)
cerveau (brain)	moχ	moʃtˤ (comb)	sɛrwɛ:l (pants)	ra:s (head)	fu:ʃa (brush)
robinet (faucet)	sab:ɛ:la	sawtˤ (whip)	ʁoril:a (gorilla)	miraʃ:a (watering can)	qalb (heart)
barbecue (grill)	maʃwa	masˤtˤra (ruler)	bagra (cow)	ga:z (cook)	ri:ʃa (feather)
soleil (sun)	ʃams	ʃak:ɛl (pin)	sok:a:ra (locker)	nɛʒma (star)	Knisia (church)
salière (salt-shaker)	mal:ɛħa	marwħa (fan)	sal:u:m (ladder)	sˤaħfɑ (bowl)	tɛmsɛ:ħ (crocodile)
bouton (button)	fɛlsa	fɛlfɛl (pepper)	bufriwa (nut)	gorbi:ta (bow)	qa:rɛs (lemon)
fleur (flower)	naw:ara	naħlɑ (bee)	flu:ka (boat)	maħbɛs (vase)	zɛbla (bin)
tortue (turtle)	fakru:na	fargi:ta (fork)	tof:a:ħa (apple)	ʒra:na (frog)	ʔɛbra (needle)
scie (saw)	monʃa:r	mongɛ:la (watch)	siga:ru: (cigarette)	ħtˤab (wood)	ħu:ta (fish)
barrière (fence)	su:r	su:ria (shirt)	ba:nu: (basin)	qu:s (arch)	mʁarfa (spoon)
selle (saddle)	sarʒ	saratˤa:n (crab)	sɛnʒa:b (squirrel)	tˤabu:ria (stool)	gɛnɛria (artichoke)
banane (banana)	mu:za	mutˤu:r (bike)	bar:ɛ:d (pot)	ʕnɛb (grape)	ʕaʒla (tire)
canapé (sofa)	bank	bawsˤla (compass)	karhba (car)	farʃ (bed)	ʕalam (flag)

Note: TA translations of the picture names and distractors are transcribed using the International Phonetic Alphabet (IPA) conventions. English translations of all picture names and distractors are between parentheses.

Table 1

Characteristics of TA-French bilinguals in Experiments 1 and 2

	Experiment 1		Experiment 2	
	Mean	*SD*	*Mean*	*SD*
L2 proficiency level (*ΔM* score in lexical decision)	0.28	0.24	0.29	0.16
L2 self-rated production proficiency	5.58	1.14	5.67	0.92
L2 self-rated comprehension proficiency	6.46	0.78	6.42	0.58
L2 self-rated writing proficiency	5.71	1.00	5.54	0.83
L2 self-rated reading proficiency	6.42	0.83	6.25	0.53
Age of L2 acquisition	7.14	1.33	7.19	1.09
Frequency of L2 use (4-pt scale)	3.71	0.37	3.62	0.30
Frequency of switching (7-pt scale)	4.45	1.46	4.28	1.11
Length of immersion (months)	26.42	23.28	17	18.50

Table 2

Means (and standard deviations) of distractors and targets (pictures) used in Experiment 1

	Distractors				Pictures
Item variables	Phono-translation	Semantic	Phonological	Unrelated	
Subjective frequency	3.99 (1.01)	3.88 (0.87)	4.33 (1.11)	4.36 (1.12)	4.25 (0.99)
Imageability	6.28 (0.67)	6.41 (0.68)	6.39 (0.61)	6.57 (0.49)	6.46 (0.42)
Word length (in nb of phonemes)	3.95 (1.17)	4.50 (1.10)	4.05 (1.86)	4.64 (1.22)	4.73 (1.55)
Name agreement	–	–	–	–	0.15 (0.23)
Familiarity	–	–	–	–	3.90 (0.55)
Visual complexity	–	–	–	–	2.74 (0.95)

Note: Subjective frequency and imageability are given as 7-point subjective ratings. Values for these variables were taken from Ferrand et al.'s (2008) database. Familiarity and visual complexity are given as 5-point subjective ratings. Values for these variables were taken from Alario and Ferrand's (1999) normative databse. Name agreement is given as *H* statistic values (Snodgrass & Vanderwart, 1980). Length in phonemes is reported as an absolute value, taken from the *Lexique 3.0* database (New et al., 2005).

Table 3

Mixed model analysis (run in SPSS) estimates and tests of fixed effects in Experiment 1

Parameter	F	Numerator df	Demoninator df	Sig.
Intercept	1026.76	1	27.39	0.000**
SOA	47.80	2	5876.25	0.000**
Distractor type	3.758	3	5878.05	0.010*
SOA x Distractor type	.65	6	5876.19	0.694

*p < .05
**p < .01

Table 4

Mixed model analysis (run in SPSS) estimates and tests of simple effects for Distractor and SOA in Experiment 1

Parameter	F	Numerator df	Denominator df	Sig.
Distractor 1 vs 4	0.01	1	2907.78	0.910
Distractor 2 vs 4	2.37	1	2917.30	0.124
Distractor 3 vs 4	8.75	1	2935.72	0.003**
SOA 1 vs 2	91.60	1	3898.41	0.000

Note: Distractor 1. phono-translation distractor; distractor 2. semantic distractor; distractor 3. phonological distractor; distractor 4. unrelated distractor; SOA 1. SOA -150 ms; SOA 2. SOA 0 ms; SOA 3. SOA +150 ms.
**$p < .01$

Table 5

Summary of mixed-effects model (using lme4 in R) of naming RTs in Experiment 1

Fixed effects	Estimate	SE	t	p	95% Confidence Interval 2.5	97.5
Intercept	794.66	23.74	33.5	< .001	748.13	841.19
SOA (-150ms)	-46.41	5.06	-9.2	< .001	-56.32	-36.49
SOA (+150ms)	-38.23	5.07	-7.5	< .001	-48.16	-28.30
Distractor (phonological)	-17.67	5.82	-3.0	0.002	-29.08	-6.26
Distractor (phono-translation)	-1.79	5.85	-0.3	0.759	-13.27	9.68
Distractor (Semantic)	-8.19	5.84	-1.4	0.161	-19.64	3.26
Random effects						
	Variance	SD				
Subject (Intercept)	11708.00	108.20				
item (Intercept)	1101.00	33.19				
Residual	25246.00	158.89				

5932 observations, 24 participants, 22 items

Table 6

Mean latencies of correct responses (Mean), standard errors (SE), and errors in percentage (%E) as a function of distractor type and SOA condition in Experiments 1 and 2

	Distractor type											
Experiment 1												
	Phono-translation			Semantic			Phonological			Unrelated		
	Mean	*SE*	*%E*	Mean	*SE*	*%E*	Mean	*SE*	*%E*	Mean	*SE*	*%E*
SOA -150	739.17	7.56	3.03	739.62	7.85	3.98	737.48	8.37	3.6	748.72	7.97	2.27
SOA 0	797.12	9.37	3.79	778.63	8.48	4.17	774.67	9.1	3.98	795.12	8.75	3.79
SOA +150	755.49	9.35	3.6	750.53	9.6	3.98	735.52	8.67	3.03	752.11	9.34	3.79
Experiment 2												
	Phono-translation			Semantic			Phonological			Unrelated		
	Mean	*SE*	*%E*	Mean	*SE*	*%E*	Mean	*SE*	*%E*	Mean	*SE*	*%E*
SOA -150	912.41	11.9	4.36	891.96	10.95	5.87	897.25	11.38	3.79	878.7	11.01	4.17
SOA 0	994.86	13.63	4.92	942.75	13.01	4.17	945.69	13.65	3.6	927.7	12.63	4.55
SOA +150	987.67	13.44	4.92	968.65	13.08	5.11	972.07	13.55	4.73	948.9	12.81	5.3

Table 7

Means (and standard deviations) of distractors and targets (pictures) used in Experiment 2

	Distractors				Pictures
Item variables	Phono-translation	Semantic	Phonological	Unrelated	
Subjective frequency	4.25 (0.87)	4.40 (1.13)	4.34 (1.10)	4.45 (0.93)	4.25 (0.99)
Imageability	5.81 (0.84)	6.02 (0.71)	5.80 (0.94)	6.23 (0.40)	6.46 (0.42)
Word length (in nb of phonemes)	5.41 (1.10)	5.55 (0.96)	4.77 (1.31)	5.09 (0.92)	4.73 (1.55)
Name agreement	–	–	–	–	0.85 (0.70)
Familiarity	–	–	–	–	3.90 (0.55)
Visual complexity	–	–	–	–	2.74 (0.95)

Note: Subjective frequency and imageability are given as 7-point subjective ratings. Familiarity and visual complexity are given as 5-point subjective ratings. Name agreement is given as *H* statistic values (Snodgrass & Vanderwart, 1980). All these values were taken from Boukadi et al.'s normative database (under review). Length in phonemes is reported as an absolute value.

Table 8

Mixed model analysis (run in SPSS) estimates and tests of fixed effects in Experiment 2

Parameter	F	Numerator df	Demoninator df	Sig.
Intercept	604.06	1	25.29	0.000**
SOA	85.44	2	5752.25	0.000**
Distractor type	7.78	3	5755.75	0.000**
SOA x Distractor type	0.99	6	5752.17	0.425

***p* < .01

Table 9

Mixed model analysis (run in SPSS) estimates and tests of simple effects for Distractor and SOA in Experiment 2

Parameter	F	Numerator df	Denominator df	Sig.
Distractor 1 vs 4	33.35	1	3118	0.000**
Distractor 2 vs 4	4.70	1	3118	0.030*
Distractor 3 vs 4	7.35	1	3118	0.007**
SOA 1 vs 2	31.28	1	4172	0.000**
SOA 1 vs 3	40.48	1	4172	0.000**
SOA 2 vs 3	0.57	1	4172	0.025*

Note: Distractor 1. phono-translation distractor; distractor 2. semantic distractor; distractor 3. phonological distractor; distractor 4. unrelated distractor; SOA 1. SOA -150 ms; SOA 2. SOA 0 ms; SOA 3. SOA +150 ms.

*$p < .05$
**$p < .01$

Table 10

Summary of mixed-effects model (using lme4 in R) of naming RTs in Experiment 2

Fixed effects	Estimate	SE	t	p	95% Confidence Interval 2.5	97.5
Intercept	931.94	38.14	24.4	< 0.001	857.19	1006.68
SOA (-150ms)	-58.67	6.60	-8.9	< 0.001	-71.61	-45.73
SOA (+150ms)	15.05	6.64	2.3	0.023	2.04	28.06
Distractor (phonological)	20.29	7.64	2.7	0.008	5.32	35.26
Distractor (phono-translation)	44.22	7.67	5.8	< 0.001	29.19	59.25
Distractor (Semantic)	16.58	7.67	2.2	0.031	1.56	31.60
Random effects	Variance	SD				
Subject (Intercept)	32253.00	179.60				
item (Intercept)	1459.00	38.20				
Residual	41843.00	204.60				

5736 observations, 24 participants, 22 items

Figure / Figure
Click here to download Figure / Figure: BilingualLexicalSelection-R2-Figure1-16-06-2015.pdf

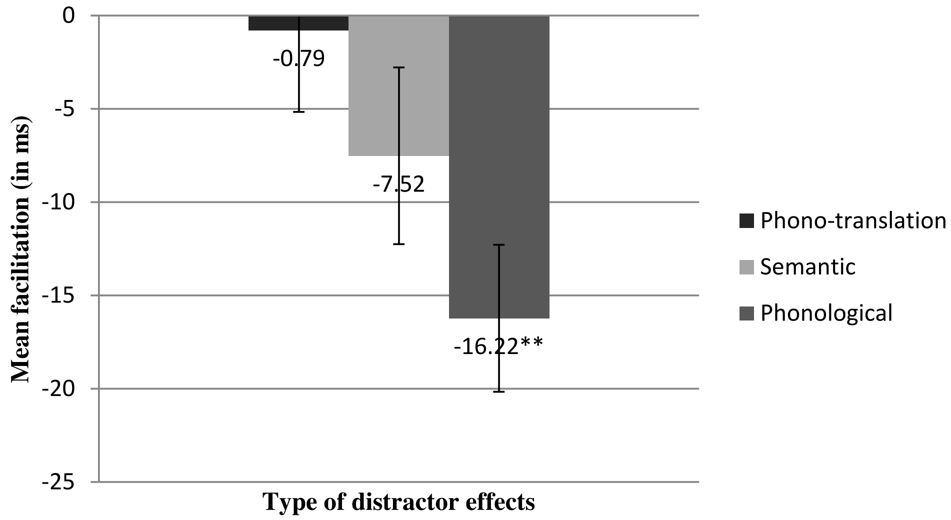

Figure 1. Mean distractor effects collapsed by SOA in Experiment 1. The effects were computed by subtracting the values of the unrelated condition from the related ones (phono-translation, semantic, and phonological). The error bars represent mean standard errors.

Note: The zero represents the unrelated condition. Positive values represent inhibition whereas negative values represent facilitation.

$^{**}p < .01$

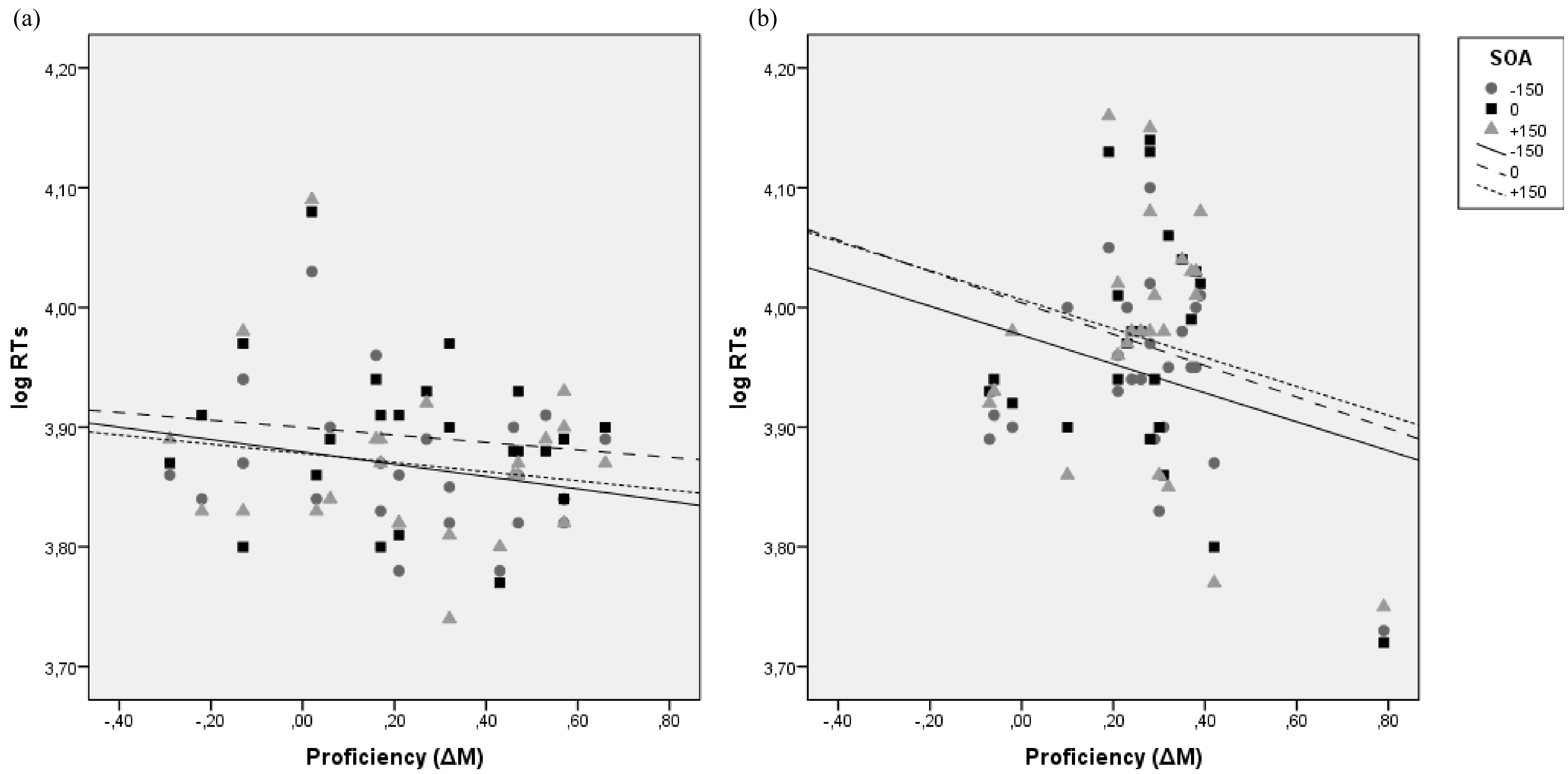

Figure 2. Graph showing the interaction between SOA (expressed in log-transformed RTs) and Proficiency (expressed by ΔM) in Experiment 1 (a) and Experiment 2 (b).

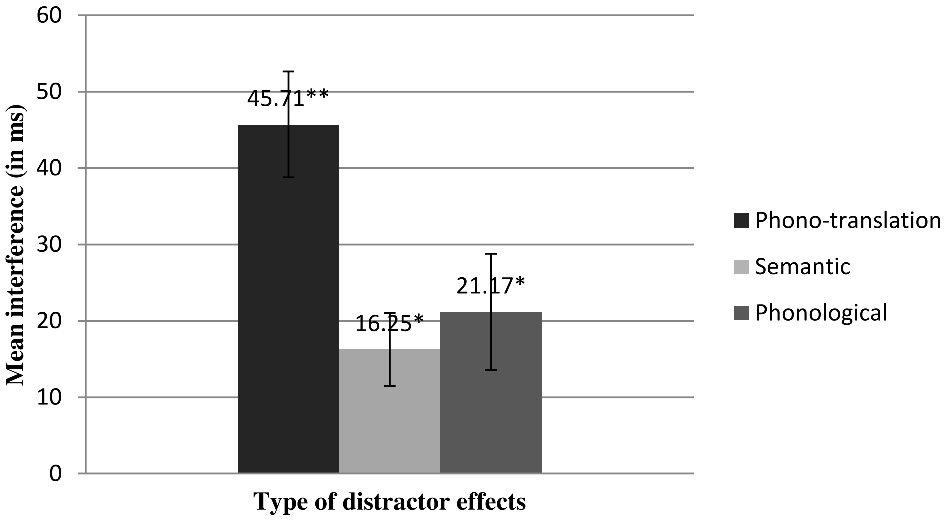

Figure 3. Mean distractor effects collapsed by SOA in Experiment 2. The effects were computed by subtracting the values of the unrelated condition from the related ones (phono-translation, semantic, and phonological). The error bars represent mean standard errors.

Note: The zero represents the unrelated condition. Positive values represent inhibition whereas negative values represent facilitation.

*$p < .05$
**$p < .01$