

Accessing and maintaining referents in L2 processing of *wh*-dependencies

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Abstract

This study considers the role of lexical access in the activation and maintenance of referents interacting with syntactic computations during the online processing of *wh*-dependencies in second language French by beginning ($N = 39$) and low ($N = 40$) and high ($N = 35$) intermediate learners. Two computer-paced reading tasks involving concurrent picture classification were designed to investigate trace reactivation during sentence processing: The first task targeted sentences that contained indirect object relative clauses, whereas the second task included indirect object cleft sentences. Response time profiles for sentences containing English-French cognates as antecedents were compared with those for sentences involving noncognate vocabulary. All learner participants produced differing response patterns for cognate and noncognate items. Intermediate learners' response patterns were consistent with trace reactivation for cognate items only; noncognate items induced inhibitions or erratic response patterns. Additionally, a (French-English bilingual) native speaker control group ($N = 35$) showed the predicted response pattern with the noncognate items only. These findings indicate that the role of lexical access in sentence processing merits further consideration.

Keywords: Sentence Processing, L2 French, Filler-Gap Dependencies, Lexical Access

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1. Introduction

The real-time processing of filler-gap dependencies—structures in which a verbal argument (the *wh*-filler) has been moved from its canonical position (the gap) to an earlier sentential position at some distance from the verb—involves not only the syntactic computation of the movement chain but also the activation (i.e., initial retrieval from the lexicon) and maintenance (e.g., temporary storage in memory) of the referent of the filler. Crucially, there is an interaction between these two mechanisms of sentence processing: The computation of a *wh*-trace triggers reactivation of its referent, thereby modulating the processing load and leading to efficiencies in computations. Such processing efficiencies are afforded by a specialized and (largely) universal computational system for human language (Dekydtspotter, 2009; Slabakova, 2008). Empirical research on the processing of filler-gap dependencies in a first language (L1) has revealed response patterns that are highly suggestive of mental reactivation of the filler at the structurally defined gap site from which it originated (Love & Swinney, 1996; Roberts, Marinis, Felser, & Clahsen, 2007). Among native speakers (NSs), evidence for this trace-induced reactivation is observed in longer reading times on segments that include a syntactic gap—thus indicating additional computations at this point—(e.g., Gibson & Warren, 2004) or in faster decision times in categorizing, at crucial moments, visually presented probes (images or words) that are related to the filler (e.g., Love, 2007).

Parsing routines do not necessarily need to be acquired concurrently with language; rather, it has been argued that the processing of linguistic input can serve as a trigger and a means for acquiring a language (Fodor, 1998). Thus, second language (L2) learners are expected to benefit from the efficiencies made available by a (largely) universal parser in the real-time processing of

the target language input. Indeed, the results of previous experimental studies have shown that online sentence processing in a L2 involves many of the same reflexes exhibited by NSs when processing L1 input: rapid structuring of the input (Juffs & Harrington, 1995; Williams, Möbius, & Kim, 2001), use of lexical subcategorization information (Frenck-Mestre & Pynte, 1997), knowledge of island constraints (Omaki & Schulz, 2011), and sensitivity to prosodic cues (Dekydtspotter, Donaldson, Edmonds, Liljestrang-Fultz, & Petrush, 2008). However, another body of research has argued that—despite universal parsing routines—incomplete or impaired (i.e., nonnative) access to the grammatical rules of a given language may hinder sentence processing in real time, effectively eliminating any benefit of the detailed structural computations that are involved in using movement traces to resolve long distance *wh*-dependencies (Clahsen & Felser, 2006a, 2006b).

Some previous L2 sentence processing studies have failed to detect robust evidence for traces in the structuring of input (Felser & Roberts, 2007; Marinis, Roberts, Felser, & Clahsen, 2005). This, however, does not necessarily indicate that the L2 learner's processing system in no way seeks to exploit the efficiencies afforded by the use of traces to reactivate antecedents in the treatment of L2 input. Lexical retrieval plays a crucial role in sentence processing, and difficulties or delays in L2 lexical access could lead to nonnativelike behavior in sentence processing research, irrespective of whether structurally based representations are available to L2 learners. Indeed, Angwin, Chenery, Copland, Cardell, Murdoch, and Ingram (2006) pointed out—in the context of L1 processing—that “since trace reactivation effects are dependent on rapid information processing, delays in semantic activation would be expected to interfere with both the initial activation of the antecedent and its subsequent reactivation” (p. 112). It is therefore imperative to also consider the role of lexical retrieval—which has been shown to be lacking in automaticity

among beginning and intermediate learners (Favreau & Segalowitz, 1983) and in speed among advanced learners (Segalowitz & Segalowitz, 1993)—in real-time sentence processing in a L2.

To investigate the interaction between syntactic computations and (re)activation of referents during online comprehension, the current study reports on a sentence processing experiment in L2 French that includes two tasks—one involving sentences with indirect object relative clauses and the other involving sentences with cleft structures—and two types of vocabulary. In both tasks, French-English cognate vocabulary or noncognates were used as antecedents in the dependency structure examined; the use of cognates was predicted to facilitate lexical access among L2 learners. Reaction time (RT) asymmetries in a picture classification during reading task were examined. Response patterns were compared across cognates and noncognates and across the two tasks. The results underline the importance of considering the full range of computations, syntactic and otherwise, that are involved in the online processing of filler-gap dependencies, in both L1 and L2.

2. Syntactic processing in L1 and L2

Evidence for the presence of traces as structural reflexes of (L1) sentence processing comes in part from studies that use the crossmodal priming methodology (Nicol & Swinney, 1989). In these experiments, participants seated at a computer make simple categorization decisions about probes (words or pictures) that are presented visually at specific moments while at the same time listening to an auditory stimulus for comprehension. Probes are timed to appear concurrently with the processing of the syntactic gap from which the *wh*-filler originated; at this point during processing, the computation of the trace triggers reactivation. Thus, classification decisions about probes that are semantically related or identical to the antecedent of the trace should be facilitated:

RTs to related probes at the gap position are expected to be faster than those to unrelated probes appearing in the same position, with no such facilitation effects predicted to occur in an earlier control position. Such a response pattern suggests temporary storage of the *wh*-filler in memory followed by its retrieval at the structurally defined gap site.

Roberts et al. (2007) tested adult and child English NSs on a crossmodal priming task using sentences containing indirect object relative clauses, as in (1).

- (1) *Jo knew the ostrich to which the black spider explained the difficult [#1] problem [#2] at school last Monday.*

While listening to these sentences for comprehension (which was verified by periodic follow-up questions), at the gap position (#2) or in a control position that occurred approximately 500 ms earlier (#1), participants pressed a button to classify identical and unrelated picture probes as alive or not alive. The identical probes matched the antecedent (e.g., a picture of an ostrich paired with this example), whereas the control probes depicted some unrelated inanimate object (e.g., a toothbrush or a carrot). In addition to the main experimental task, all participants also completed a working memory (WM) reading span test. Among the NS adults and children with higher WM capacity, RTs to identical probes in the gap position were faster than those for unrelated probes at the same position, whereas RTs to the same two probe types in the control position did not reflect this facilitation for identical targets. The children and adults with lower WM capacity failed to demonstrate such priming effects.

Felser and Roberts (2007) used the same stimuli from Roberts et al. (2007) to test 24 L1 Greek-L2 English advanced learners living and working in the United Kingdom. The L2 participants' RTs were shorter for identical versus unrelated targets in both gap and control position, which Felser and Roberts interpreted as evidence for maintained activation of the antecedent throughout the sentence—as opposed to reactivation triggered by the computation of a

trace. Furthermore, no effect of WM capacity was found among these learners. Felser and Roberts noted that the L2 participants behaved differently from all four subgroups of NSs in Roberts et al.'s study: The L2 learners exhibited facilitation effects for identical probes in both gap and control position. In contrast, there were no significant differences between RTs to identical versus unrelated targets among the low WM NS adults, and both the NS children and adults with high WM capacity showed a position-specific advantage for identical probes at the gap position only. Additionally, the low WM children showed inhibition rather than facilitation effects: RTs to identical probes in both positions were longer when compared with those for unrelated probes.

Felser and Roberts (2007) concluded that the across-the-board facilitation effect for matching probes pointed to a lack of structure—thus focusing only on the syntactic computations and overlooking the role of (nonautomatized) lexical access. However, the vocabulary used as antecedents in the experimental sentences included some exotic animals, such as *ostrich*, and *panda*, and *peacock*.¹ Although L2 learners may explicitly learn such vocabulary in the classroom, they probably will not encounter these words very often in everyday life, even at advanced stages of acquisition. It is not unreasonable to assume that learners' lexical access routines for such vocabulary would be underlearned, lacking speed or automaticity, or both, thus inducing processing lags, which in turn may have masked any benefit of structural computations.

As noted by Nicol, Fodor, and Swinney (1994), there may be a number of factors that can affect response patterns in such studies, regardless of whether syntactic representations are computed. The predicted response pattern of the crossmodal priming methodology relies on two major assumptions. First, this paradigm assumes that the integration of a displaced filler into the sentence structure is mediated by the movement trace (for arguments that filler integration is mediated by the verb's thematic structure, see, e.g., Pickering & Barry, 1991, Sag & Fodor, 1994).

The second assumption is that RTs to matching or related probes will reflect facilitation priming effects; this in turn assumes rapid and automatic lexical access. However, if lexical retrieval is underautomatized, inhibition effects may occur instead—that is, related probes may induce longer, rather than shorter, RTs (Dagenbach, Carr, & Barnhardt, 1990). Carr and Dagenbach (1990) argued that when a referent is only weakly activated—presumably due to difficulties associated with underlearned lexical access routines—a center-surround mechanism is activated to focus resources on preserving this referent in memory by dampening related concepts (thus excluding possible competitors). Perhaps even more important is the crucial assumption that there will be an exact overlap between the trace-induced reactivation of the filler and the facilitation exhibited in the shorter RTs. Nicol et al. commented on the limited window of opportunity that this methodology presents for capturing the relevant effects, even for research on L1. Processing lags may mean that any measurable priming effects could be masked.

3. Lexical retrieval and sentence processing in L1 and L2

Experimental research in bilingual lexical access has revealed facilitation effects for cognate vocabulary—that is, words that have overlapping orthographic and semantic representations across the two languages. When compared to noncognate control words, cognates have been shown to yield faster RTs among bilinguals in naming (Costa, Caramazza, & Sebastian-Galles, 2000) and word recognition tasks (Dijkstra, Grainger, & van Heuven, 1999), with no such facilitation effects observed for monolingual speakers. These effects have also been found during sentence reading (Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Libben & Titone, 2009). Such effects support a view of nonselective lexical access in which both languages are activated simultaneously during language comprehension (e.g., De Groot & Nas, 1991; Dijkstra, van

Jaarsveld, & Brinke, 1998); facilitation is due to the convergence of both languages on a single meaning. Cognates have thus been shown to speed comprehension among bilinguals.

Very few sentence processing studies have directly addressed the role of lexical access in a L2. Love, Maas, and Swinney (2003) tested for effects of lexical ambiguity in the processing of L2 English by advanced learners from various L1 backgrounds. The authors used a crossmodal naming task, a variant in the crossmodal priming paradigm. These results were compared with the NS results from Love and Swinney (1996) on the same task. The experimental items involved sentences as in (2), in which the antecedent (*pen*) was deemed lexically ambiguous (although the context of the sentence created a strong bias toward the assumed primary meaning of the antecedent).

- (2) *The professor insisted that the exam be completed in ink, so Jimmy used the new pen [#1] that his mother-in-law recently [#2] purchased [#3] because the multiple colors allowed for more creativity.*

Probe words were related to either the primary or secondary meaning of the antecedent, or they were unrelated. The related probes *pencil* and *jail* for the sentence in (2) reflected the primary and secondary meanings of *pen* as “writing implement” and “prison,” respectively; the unrelated probes, which were matched for frequency and length, were *jacket* and *tale*. At test position #1, the L2 learners failed to produce any significant priming effects for probes that were related to either meaning of the antecedent. This differed from the L1 results: The NSs produced faster RTs for probes related to both meanings. At test position #2, immediately preceding the verb, the L2 learner participants exhibited significant priming effects for probes related to the primary meaning only. The NSs did not show any evidence of priming at this point. At position #3 (i.e., the gap site), whereas the NSs demonstrated significant priming effects for probes related to the primary meaning only, the L2 learners produced significantly shorter RTs for probes related to the

secondary meaning of the antecedent.

With respect to lexical access during online sentence processing, the overall conclusion was that both primary and secondary meanings of lexically ambiguous words will be accessed during sentence processing, among NSs and L2 learners alike, even when the context is strongly biased toward the primary meaning—which suggests that L2 lexical access is also nonstrategic. However, beyond this similarity, the NS and L2 response patterns also seem to point to important differences in lexical retrieval routines—a point that Love et al. (2003) did not directly address. The NSs of Love and Swinney (1996) were able to quickly access both meanings of the ambiguous word, as indicated by the priming effects found at test position #1 (immediately following the antecedent), and then to focus on the relevant meaning, such that no priming effects occurred for the secondary meaning at the gap site in position #3. The lack of priming effects found in the L2 learner data at position #1 suggests that the initial activation of the corresponding referent was delayed, consonant with underautomatized lexical access in L2. Moreover, the pattern of priming effects found in positions #2 and #3 could indicate that L2 lexical access was not only slower but also staggered: The primary meaning was accessed first, followed by the secondary and—at least in the case of this example—more obscure meaning. Thus, the results of Love et al.’s study seem to suggest that lexical access plays an important role in (L2) sentence processing.

4. The current study

4.1. Materials

Motivated by the possibility that difficulties related to underautomatized lexical access routines may have masked the benefits of structural computations in previous studies on L2 sentence processing, the current study endeavors to explore the interaction between syntactic computations and lexical retrieval. To this end, two separate sentence processing tasks were

designed to investigate patterns of filler (re)activation during online sentence processing among L2 learners of French. Each of the two tasks involved a different sentence structure: One targeted sentences that included indirect object relative clauses as in (3)—similar to the sentences used by Felser and Roberts (2007) to examine L2 English processing—and one used indirect object cleft sentences as in (4).

- (3) *Vincent adore le gorille à qui Cécile a envoyé le petit cadeau chez lui jeudi matin.*
 “Vincent adores the gorilla to whom Cécile sent the small gift at his house Thursday morning.”
- (4) *C’est au renard que Charles a prêté le gros sac dans le magasin jeudi matin.*
 “It’s to the fox that Charles loaned the huge bag in the store Thursday morning.”

Given that the antecedent of the *wh*-filler receives sentential focus in the cleft structure (e.g., Sanford, Price, & Sanford, 2008), it may be more easily retained in memory, thus facilitating the real-time processing of these sentences.

To investigate the possible effects of under-routinized lexical retrieval, the current study compared RT patterns for sentences (of both structure types) that used English-French cognate animal names as antecedents with those for sentences that used noncognate animal names as antecedents. Thus, in both tasks, one half of the experimental items involved cognate antecedents (such as *gorille* “gorilla”) and the other half involved noncognate antecedents (such as *renard* “fox”). Although the frequency of specific lexical items may differ in L2 acquisition, the cognate and noncognate terms were matched for frequency, with mean occurrences of 5.21 and 5.23, respectively, per million words (New, Pallier, & Ferrand, 2005). The complete list of both cognate and noncognate animal names is given in Table 1.

INSERT TABLE 1 ABOUT HERE

All L2 participants received training on both cognate and noncognate vocabulary. The training consisted of a PowerPoint presentation that included photos of animals (which differed from the images used in the experimental task) labeled with their names in French, followed by a series of short and simple matching, association, and categorization activities that allowed the learners to use the new vocabulary. The training tasks were completed in a single session approximately one week prior to testing. Following completion of the experimental tasks, participants were given a list of the French animal names used in the experiment and were asked to provide an English equivalent for each one. Participants were able to recognize the vocabulary; it should be noted, however, that participants were not required to demonstrate active knowledge of these vocabulary items. The training activities were simply designed to ensure that the learner participants had at least had some prior exposure to the relevant vocabulary.

4.2. Methodology

In crossmodal priming experiments, participants listen to sentences and respond to comprehension questions (while at the same time classifying picture probes). This task is thus essentially an exercise in listening comprehension. However, given that classroom L2 learners receive much written input, such that the development of reading proficiency often precedes listening proficiency, the current study uses a reading task rather than crossmodal priming. Presenting experimental sentences visually might be more useful for the investigation of L2 processing of complex structures, assuming that the visual presentation will help to lessen the processing load. Alleviating some of the processing burden associated with crossmodal priming tasks also allows for testing at lower proficiency levels. The probe classification during reading task was developed for L2 by Dekydtspotter, Miller, Schaefer, Chang, and Kim (2010). This task pairs the classification of picture probes (as in the crossmodal priming methodology) with

segmented computer-paced reading aloud. Participants do not have the opportunity to pause or to reflect on the structure as they read—as they might with self-paced reading—but instead must try to keep up as each segment appears on the screen. A similar all-visual presentation has been used to investigate L1 sentence processing (McKoon, Albritton, & Ratcliff, 1996; McKoon & Ratcliff, 1994; McKoon, Ratcliff, & Ward, 1994). However, these L1 studies paired silent (computer-paced) reading with a lexical decision task and also required participants to respond to comprehension questions. Having participants read aloud offers a simple alternative means of focusing attention on the experimental stimuli, therefore removing some of the task complexity—and for some learners, the stress—and allowing for more resources to be focused on sentence processing.

A potential concern with this task is that it might induce more superficial reading, especially if learner participants were to focus attention on correct pronunciation of the words. The participants of the current study were asked to read quietly (but not silently) and were explicitly told that the researcher would not be listening to evaluate their pronunciation (this was meant to make the learners feel more relaxed during testing). However, with no comprehension checks to hold participants accountable for reading attentively, how can we be sure that participants are accessing syntactic and semantic representations as they read aloud? The experimental design assumes that access to phonetic representations will induce mandatory firing of the processing system (Fodor, 1983). As people typically engage in reading aloud, they seem to access abstract representations mediating between sound and meaning. Participants were monitored to ensure that they were reading aloud naturally and were reminded to do so if the researcher noticed that they had stopped (although for the most part, participants did not need to be reminded to read aloud).

For the purposes of the current study, the reading modality also better allows for the

cognate-noncognate comparison: Although the cognate forms share similar orthography in English and French, the pronunciation of these words in the two languages can differ quite a bit. For example, the word *hamster*, pronounced [hæmstə] in American English, is pronounced [amstɛR] in French. Thus, it is possible that these cognate words would not be as quickly and easily recognizable when encountered aurally in a crossmodal priming experiment. It should be noted that, while reading aloud, it is possible that some learners—especially at the lower levels of proficiency—may have anglicized their pronunciation. Nevertheless, this is not expected to interfere much with processing; indeed, the similarities between the two languages with respect to the cognate vocabulary are predicted to facilitate L2 lexical access via the L1 lexicon.

The experimental stimuli for both tasks consisted of 32 critical items, with a cleft and a relative clause version of each sentence, of which 16 used cognate animal names as antecedents and 16 involved noncognate antecedents. Picture probes were cartoon images of animals that matched the referent of the filler or depicted unrelated inanimate objects. A 2×2 design crossed probe type (filler matching or nonmatching) with position (gap or control) to create four versions of each sentence structure. Each participant encountered only one version of each sentence, but equal numbers of sentences in all four conditions. An example cognate item (from the clefts task) is given in (5), and a noncognate item (from the relative clauses task) is given in (6). The slashes represent the segmentation of each item.²

(5) Cognate example from clefts task

a. Condition 1 (C1): filler-matching probe in gap position

C'est / à l'éléphant / que / Sarah / a expliqué / le nouveau / jeu / [picture probe: ELEPHANT] / chez lui / vendredi matin.

b. Condition 2 (C2): nonmatching probe in gap position

C'est / à l'éléphant / que / Sarah / a expliqué / le nouveau / jeu / [picture probe: BICYCLE] / chez lui / vendredi matin.

c. Condition 3 (C3): filler-matching probe in control position

C'est / à l'éléphant / que / Sarah / a expliqué / le nouveau / [picture probe: ELEPHANT] / jeu / chez lui / vendredi matin.

d. Condition 4 (C4): nonmatching probe in control position

C'est / à l'éléphant / que / Sarah / a expliqué / le nouveau / [picture probe: BICYCLE] / jeu / chez lui / vendredi matin.

“It’s to the elephant that Sarah explained the new game at his house Friday morning.”

(6) Noncognate example from relative clauses task

a. Condition 1 (C1): filler-matching probe in gap position

Charlotte / critique / le papillon / à qui / Robert / a offert / le nouveau / ballon / [picture probe: BUTTERFLY] / dans le jardin / lundi soir.

b. Condition 2 (C2): nonmatching probe in gap position

Charlotte / critique / le papillon / à qui / Robert / a offert / le nouveau / ballon / [picture probe: CALCULATOR] / dans le jardin / lundi soir.

c. Condition 3 (C3): filler-matching probe in control position

Charlotte / critique / le papillon / à qui / Robert / a offert / le nouveau / [picture probe: BUTTERFLY] / ballon / dans le jardin / lundi soir.

d. Condition 4 (C4): nonmatching probe in control position

Charlotte / critique / le papillon / à qui / Robert / a offert / le nouveau / [picture probe: CALCULATOR] / ballon / dans le jardin / lundi soir.

“Charlotte criticizes the butterfly to whom Robert gave the new ball in the garden Monday evening.”

Examples of the picture probes used with these items are shown in Figure 1.

INSERT FIGURE 1 ABOUT HERE

An additional 48 sentences were created as distracters. The distracter sentences included direct and indirect object cleft or relative clause structures and, like the main experimental items, involved probes that depicted animals and inanimate objects. However, the picture probes appeared in various positions throughout the distracter sentences, thus giving participants the impression that either type of probe could appear at any point during reading.

Another potential criticism of the reading methodology is that it may be more susceptible to congruency effects than in the crossmodal paradigm: The interrupting probe may be integrated as part of the sentence structure. Recall that in crossmodal priming, there is no interruption to the auditory stimulus—the sentence continues as the probes are presented visually—and thus less chance of probe integration into the sentence. Using a unimodal priming task, Nicol, Swinney, Love, and Hald (2006) showed that participants exhibited faster RTs when the probe word was compatible with the immediate context of the sentence and could be easily integrated into the structure (e.g., following the word *folded*, the probe word *newspaper* elicited faster RTs as compared with *technique*). This finding is potentially problematic as it could conceivably create an illusion of priming or mask any priming effects that may emerge. However, the current study uses pictures instead of words as probes to minimize such an effect. Nevertheless, to ensure that any RT asymmetries in the main experimental task would not be due to baseline responses to the picture probes themselves, a picture classification pretest involving the same pictures and *alive-not alive* classification decision was administered. A one-way ANOVA revealed no significant effect of animate, $F(3, 141) = 1.830, p = .144$, or inanimate probes, $F(3, 141) = 0.728, p = .538$.

4.3. Participants and procedures

Participants sat at a computer and were asked to read aloud to themselves in a low voice, paying careful attention to the sentences, and to indicate whether an interrupting image depicted something alive or not alive by pressing a button as quickly as possible. DMDX software (Forster & Forster, 2003) was used to measure RTs and to control reading speed. Each sentence segment appeared in the center of the screen for 500 ms + 20 ms per letter (e.g., *le papillon* “the butterfly” appeared for 700 ms). Each sentence was preceded by a small red star, and the end of each sentence was indicated by a period following the final word. Picture probes were displayed for 650 ms. To

render the sentences more felicitous—given that they involved animals interacting with people in very humanlike ways—a context was provided in which a group of French schoolchildren had just returned from a week-long trip to an enchanted zoo, where they had befriended the animal inhabitants. Back in class, they were talking about the events of the previous week with their teacher.

Three groups of L2 French learners and a group of NS controls participated in the current study. The L1 of all learner participants was American English. The L2 learners were undergraduate students at a large Midwestern university, enrolled in a second-semester (beginning), fourth-semester (low intermediate), or 300-400-level (high intermediate) course at the time of testing. However, as can be seen by the average length of study reported in Table 2, many of the learners had had some high school French (all had begun their study of French at or after the age of 12). The NSs were, for the most part, graduate students or post-doctoral researchers at the same university, with a few additional participants from the community. It should be noted that these were L1 French-L2 English bilinguals immersed in an L2 environment at the time of testing. All NS participants had arrived in the United States as adults and had lived there for an average of 3.35 years (range 1.25-8.00, $SD = 1.97$). Participant characteristics are reported in Table 2. In all four proficiency groups, participants were randomly assigned to complete either the clefts task or the relative clauses task.

All participants completed a WM reading span test adapted for L2 French from Harrington and Sawyer (1992). Because preliminary analysis revealed that WM capacity was not found to have a significant effect on RT patterns (thus echoing Felser and Roberts's, 2007, findings), the results of this task (the total number of words recalled out of 42) are reported here in Table 2 only to show that there were no significant WM differences across similar proficiency groups that

completed the two different tasks.³

INSERT TABLE 2 ABOUT HERE

4.4. Analysis and predictions

Only RTs for which an image was identified correctly as alive or not alive were included for analysis. Within each participant group, any RT that fell outside two standard deviations from the mean was removed and replaced by the new group mean. An ANOVA investigated the effects and interactions of probe position (gap or control) and probe type (matching or nonmatching) modulated by the cognate status of the antecedent. Planned paired-samples *t* tests, with one-tailed α (given expectations of facilitation due to matching probes) set at .05, were used to determine whether RT asymmetries were statistically significant.

If L2 learners are able to exploit the efficiencies afforded by a universal processing mechanism to compute filler-gap dependencies as they read in their L2, RTs are expected to be shorter when a picture probe appearing concurrently with the gap matches the antecedent than when the image does not match. Crucially, this asymmetry between RTs to matching and nonmatching pictures is not expected to hold at the earlier control position. Response patterns are predicted to vary according to participant group and cognate status of the antecedent: If cognate antecedents facilitate lexical retrieval (as well as maintenance in memory and reactivation), targetlike priming patterns are expected to emerge first for cognate items—especially among less proficient learner groups. Additionally, the cleft sentences are predicted to be more easily processed by the learner participants, given the focalized nature of the antecedent.

5. Results

A repeated measures ANOVA with position, probe, and cognate status as within-subject factors and structure (cleft or relative clause) and participant group as between-subject factors revealed a significant three-way interaction between position, probe, and cognate status, $F_1(1, 137) = 5.070, p < .05$ —further qualified by participant group, $F_1(3, 137) = 18.421, p < .001, F_2(3, 120) = 10.743, p < .001$ —as well as a marginal three-way interaction between position, probe, and structure, $F_1(1, 137) = 3.297, p = .072$. The Position \times Probe \times Cognate interaction was maintained in all participant groups: beginning, $F_1(1, 37) = 11.781, p < .005$; low intermediate, $F_1(1, 38) = 5.430, p < .05$; high intermediate, $F_1(1, 30) = 25.595, p < .001, F_2(1, 30) = 20.806, p < .001$; natives, $F_1(1, 31) = 15.882, p < .001, F_2(1, 30) = 8.538, p < .01$. Among the learner groups, sentence structure was found to interact significantly with position and probe in the beginning group data, $F_1(1, 37) = 5.165, p < .05$, and to exhibit a marginally significant effect in the low intermediate learner data, $F_1(1, 38) = 3.143, p = .084$. Among high intermediate learners and NSs, sentence structure was not a significant factor.

5.1 Relative clauses task

Group mean RTs for cognate and noncognate items for the relative clauses task are reported in Table 3 and illustrated in Figure 2. As can be seen in Figure 2, RT patterns to cognate and noncognate items differed across all participant groups.

INSERT TABLE 3 ABOUT HERE

INSERT FIGURE 2 ABOUT HERE

The beginning learners exhibited shorter RTs to matching probes in both gap, $t(18) = 3.67, p <$

.005, and control position, $t(18) = 2.50, p < .05$ —in response to cognate items only. For noncognate items, these learners responded more quickly to matching probes in control position, $t(18) = 3.073, p < .01$. The low intermediate learners exhibited the predicted priming effects, with faster RTs to matching versus nonmatching probes in gap position only, $t(19) = 2.398, p < .05$, with no significant asymmetries in RTs to the same probes in the earlier control position, $t(19) = 0.819, p = .423$. Again, however, this effect is only found for the cognate items; for noncognate items, these learners responded most quickly to matching pictures in the control position, $t(19) = 3.53, p < .005$. The high intermediate learners, however, produced flat RTs with a spike for nonmatching probes in gap position, $t(17) = 3.208, p < .01$, in response to cognate items. With noncognate items, RTs to matching probes were facilitated in the control position, $t(17) = 2.63, p < .05$. Finally, although the NSs also produced differing patterns for cognate and noncognate items, these differences contrast with those exhibited by the learner groups in that the NSs produced inhibited RTs in response to cognate items, with longer RTs to probes that matched cognate antecedents as compared with those that did not match, $t(16) = 4.905, p < .001$. This asymmetry was reversed with noncognate items, where NSs exhibited the predicted priming effects, with faster RTs to matching probes in gap position, $t(16) = 3.372, p < .005$, with no such asymmetry at the earlier control position, $t(16) = 0.168, p = .869$.

5.2 Clefts task

Group mean RTs for cognate and noncognate items for the clefts task are reported in Table 4 and illustrated in Figure 3. Again, all participant groups exhibited differing RT patterns to cognate and noncognate items.

INSERT TABLE 4 ABOUT HERE

INSERT FIGURE 3 ABOUT HERE

The beginning learners responded more quickly to picture probes that matched cognate antecedents in both gap, $t(19) = 2.988, p < .01$, and control position, $t(19) = 2.401, p < .05$. However, with noncognate items, these learners exhibited the shortest RTs to matching probes in the control position, $t(19) = 3.035, p < .01$. Both groups of intermediate learners exhibited the predicted priming effects, with faster RTs to matching versus nonmatching probes in gap position only, low intermediate, $t(19) = 2.658, p < .05$, high intermediate, $t(16) = 2.866, p < .05$, with no significant asymmetries in RTs to the same probes in the earlier control position, low intermediate, $t(19) = 1.118, p = .277$, high intermediate, $t(19) = 0.848, p = .409$. However, this effect is only found for the cognate items; with noncognate items, the low intermediate learners exhibited mostly flat RTs across all conditions, whereas the high intermediate learners responded more quickly to the matching probes in the control position, $t(16) = 2.038, p = .058$. Finally, the NSs again exhibited longer RTs to probes that matched cognate antecedents, $t(15) = 1.947, p = .071$; whereas in control position, RTs to matching probes were facilitated, $t(15) = 2.303, p < .05$. With noncognate items, in contrast, the NSs exhibited RTs that were marginally faster for matching probes in the gap position, $t(15) = 1.595, p = .064$ (one tailed), with no such facilitation effects exhibited in the earlier control position $t(15) = 0.541, p = .597$.

Table 5 presents a summary of the results of the paired-samples t tests comparing RTs to antecedent-matching and nonmatching picture probes in each participant group.

INSERT TABLE 5 ABOUT HERE

6. Discussion

The current study explored whether L2 learners are able to exploit the efficiencies afforded by a universal processing mechanism to compute filler-gap dependencies while reading in their L2. RTs were predicted to be shorter when a picture probe appearing concurrently with the gap matched the antecedent than when there was no match. This asymmetry was not expected to appear at the earlier control position. However, given the crucial interaction between syntactic computations and (re)activation of referents, response patterns were predicted to vary according to sentence structure and cognate status of the antecedent. These predictions were partially borne out in the data: Cognate status of the antecedent interacted significantly with test position and probe type throughout the data and had an important impact on the results. However, despite the marginal main effect of structure revealed in low intermediate learner data and the significant interaction between structure, position, and probe, in the beginning learner data, the results on the two tasks were largely similar across all participant groups. Thus, the structural differences in the two particular sentence structures under investigation did not seem to have much of an effect on the results.

Interpreting the Response Patterns

Three distinct response patterns emerged in the results of both tasks. The first of these was the predicted facilitation priming pattern, with faster RTs to matching versus nonmatching probes in the gap position, and no such facilitations effects exhibited at the earlier control position. Low and high intermediate learners produced this pattern in response to cognate items, as did the NSs in response to noncognate items. It is crucial to note that this pattern cannot be attributed to the salience of the filler—which would manifest itself in shorter RTs in both positions, as in the pattern produced by the beginning learners for the cognate items—or to linear distance—which would

presumably lead to shorter RTs in the earlier control position, similar to the pattern produced by both beginning and intermediate learners with noncognate items. Instead, this priming pattern, which has been found for NSs in L1 processing studies (e.g., Felser & Roberts, 2007; Love, 2007), is consistent with temporary storage of the filler during processing and subsequent reactivation triggered by the trace. Crucially, however, facilitation priming was not observed in any L2 learner group in response to noncognate items.

The second pattern was similar to that produced by the advanced learners in Felser and Roberts (2007), with shorter RTs—in both test positions—to picture probes that matched cognate antecedents than to nonmatching probes. This pattern was exhibited by the beginning learners in both the relative clauses and clefts tasks. For Felser and Roberts, this pattern pointed to maintained activation of the *wh*-filler throughout processing as opposed to trace-induced reactivation of the filler from temporary storage in memory and indicated an absence of structure in the learners' computations. However, this pattern may simply reflect the fact that the matching probes depicted an animal that corresponded to a referent that had just been encountered in the experimental stimulus, and thus activated into the discourse context, whereas the nonmatching probes depicted something unrelated that seemed to come out of the blue. Thus, this type of pattern would seem to reflect the salience of the filler. In the current study, this pattern was only produced with cognate items and among the least proficient learners.

A third pattern reflected faster RTs for matching probes in the control position, with no such asymmetry observed in the gap position. This pattern was produced by the beginning learners and intermediate learners on both the clefts and relative clauses tasks, and always in response to noncognate items. A similar pattern was produced by the NSs, but in response to cognate items on both tasks. This RT pattern may indicate an activation that fades as processing proceeds: Recall

that the control position occurred earlier in the sentence; the linear distance between the filler and the gap position was thus greater than that between the filler and the control position. It may be assumed that the activation began to decay as processing proceeded. This type of pattern could thus be attributed to the recentness of the filler, with the shortest RTs associated with the closest test position (i.e., the control position). If this were the case, however, we might also expect to find a (slightly lesser) facilitation effect at the gap position just one segment (approximately 650 ms) later. However, this is not borne out in the results. Indeed, the opposite is true: In the gap position, RTs appear flat or reflect inhibition for matching probes.

Another possible explanation, especially relevant for the L2 data, is that this pattern reflects a delay—rather than decay—in the initial activation of the referent. If the initial activation of the referent was slowed as a result of underautomatized lexical access to the noncognate vocabulary (which is assumed to be newly acquired—recall that the learner participants received vocabulary training only one week prior to testing—and thus underlearned), the effects may be reflected in the shorter RTs to the matching probes in the control position. Furthermore, reactivation at the gap site may have similarly been delayed. It may seem surprising that the NSs would also produce such a pattern, given that nonautomaticity of lexical access should not be a problem for these participants processing in their L1. However, it should be recalled that these NS participants were L1 French-L2 English bilinguals living and working in the United States at the time of testing. The NS results' patterns for the cognate items on both tasks may be due to an interference effect from the participants' L2 English induced by the use of this cognate vocabulary. With noncognate items, however, the L2 could have been more easily suppressed (e.g., Green, 1998; Kroll & Stewart, 1994), yielding the expected priming results. Such cognate effects were not anticipated for the NSs and would not be expected with a group of monolingual French participants.

Perspectives

The results of this study indicate that evidence for detailed structural sentence processing can be found even among intermediate classroom L2 learners. Indeed, a response strategy based on linear distance between referent and picture probes would yield shorter RTs in the earlier control position relative to the gap position; the salience of the relative clause head should induce faster RTs for matching probes relative to nonmatching probes. Both of these possible response patterns should be available to (both native and nonnative) participants regardless of their processing routines; however, these exact patterns were not found in the data of the intermediate learner participants. The predicted trace-induced facilitation priming pattern was revealed in intermediate learners' responses to cognate items. This is presumably because lexical access was facilitated through the use of easily accessible vocabulary items. The same pattern emerged in the NSs' responses to noncognate items, presumably because processing was not inhibited by the use of cognates. These patterns are consistent with a sentence processing theory involving reactivation induced by movement traces, indicating detailed processing (e.g., Love & Swinney, 1996; Nicol & Swinney, 1989).

As noted by Nicol et al. (1994), there are many different factors that may affect the results of such experiments. These factors may be completely unrelated to the syntax, ranging from background noise, quality of the visual stimulus, clarity of experimental instructions, and so on, to congruency of probes or timing of their presentation. The comparison of the current study's results by cognate status of the antecedent seems rather striking and has potentially important implications for research on L2 sentence processing. That the same participants produced distinct response patterns for cognate and noncognate items strongly suggests that lexical access routines can affect the results of processing experiments. Given that the abstract syntactic representations are expected

to remain constant—that is, they should not vary based on cognate status, this clearly suggests that nontargetlike behavior in online sentence processing tasks does not necessarily constitute evidence for nonnativelike representations or for some kind of limitation in real-time syntactic analysis. The findings of the current study provide *prima facie* support for the argument that the efficiencies of universal processing routines are indeed available during L2 sentence processing (e.g., Dekydtspotter et al., 2008; Frenck-Mestre & Pynte, 1997; Juffs & Harrington, 1995; Omaki & Schulz, 2011; Williams, Möbius, & Kim, 2001).

7. Conclusion

Previous research on L2 sentence processing has focused on grammatical computations as the presumed source of L1-L2 differences in the processing of movement dependencies, with little consideration for the possible effects of slower and more effortful lexical access routines in a L2. However, the results of the current study suggest that difficulties or delays associated with (underautomatized) lexical access can affect priming patterns produced by L2 learners in experimental research—even with possible effects of L2 on L1 for bilinguals. When the range of priming patterns and the circumstances in which each occurs are considered, the results of the current study suggest that classroom L2 learners can exploit the processing efficiencies made available by detailed syntactic computations during online sentence processing. *Prima facie* evidence for such computations can be found whenever lexical access and consequences for the maintenance of referents are taken into account. This finding highlights the importance of considering the full range of computations—syntactic and otherwise—that are involved in the (L2) processing of filler-gap dependencies.

Notes

1. In the British National Corpus (2007), the words *ostrich*, *panda*, and *peacock* have frequencies of 1.29, 1.76, and 4.80 occurrences per million words, respectively.
2. It should be noted that the relative clause sentences were one segment longer than the corresponding cleft sentences (due to the additional referent in the relative clause sentence); however, there was an equal number of segments between the antecedent and the test positions in both tasks. Another difference is the placement of the preposition *à* “to,” which appears with the antecedent itself in the cleft structure (*à l’éléphant* “to the elephant”) but with the relative pronoun in the relative clause structure (*à qui* “to whom”). Although this adds an additional word (the *à*) between the antecedent and the test position in the relative clauses task as compared to the clefts task, this is not expected to make a significant difference in processing, as *à qui* “to whom” and *que* “that” represent roughly equivalent segments.
3. A one-way ANOVA revealed a significant main effect of participant group on WM scores, $F(3, 140) = 28.176, p < .001$, which reflects the higher scores of the NS group. This finding may seem problematic, given that previous research has found a processing advantage for participants with higher WM capacity—at least for L1 sentence processing. However, this might simply be due to the fact that the test was administered in the L2 (French). WM measures based on reading span in a L2 may be inherently problematic, given that WM capacity becomes confounded with reading abilities. Nonetheless, for the purposes of the current study, a conscious decision was made to test reading span in the target language to maintain consistency with previous research. Felsler and Roberts (2007) found that L2 reading span did not influence the learner participants’ results on the main experimental task, a finding reflected in the current study.

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Table 1. *Cognate and Noncognate Vocabulary Used as Antecedents*

Cognates		Noncognates	
French	English	French	English
<i>crocodile</i>	crocodile	<i>abeille</i>	bee
<i>éléphant</i>	elephant	<i>araignée</i>	spider
<i>girafe</i>	giraffe	<i>baleine</i>	whale
<i>gorille</i>	gorilla	<i>canard</i>	duck
<i>hamster</i>	hamster	<i>chèvre</i>	goat
<i>hippopotame</i>	hippopotamus	<i>corbeau</i>	crow
<i>léopard</i>	leopard	<i>cygne</i>	swan
<i>lézard</i>	lizard	<i>fourmi</i>	ant
<i>lion</i>	lion	<i>grenouille</i>	frog
<i>panda</i>	panda	<i>hibou</i>	owl
<i>panthère</i>	panther	<i>hirondelle</i>	swallow
<i>rat</i>	rat	<i>papillon</i>	butterfly
<i>rhinocéros</i>	rhinoceros	<i>phoque</i>	seal
<i>serpent</i>	snake	<i>renard</i>	fox
<i>tigre</i>	tiger	<i>requin</i>	shark
<i>zèbre</i>	zebra	<i>singe</i>	monkey

Table 2. *Participant Characteristics*

Group	Age	Years of study	Months abroad	Working memory
Relative clauses task				
Beginning ($n = 19$)	19.2 (0.9)	4.1 (1.2)	0.2 (0.5)	26.2 (4.5)
Low intermediate ($n = 20$)	21.8 (2.6)	5.0 (2.0)	0.2 (0.5)	26.2 (5.2)
High intermediate ($n = 18$)	20.4 (1.6)	6.5 (1.6)	2.6 (3.9)	26.0 (8.4)
Native ($n = 17$)	29.0 (2.5)	<i>n.a.</i>	<i>n.a.</i>	36.2 (4.5)
Clefts task				
Beginning ($n = 20$)	18.8 (0.9)	4.3 (1.2)	0.2 (0.3)	25.5 (4.2)
Low intermediate ($n = 20$)	19.4 (1.2)	5.6 (1.6)	0.2 (0.4)	27.8 (5.6)
High intermediate ($n = 17$)	21.3 (4.3)	7.0 (2.0)	3.1 (3.2)	28.1 (5.5)
Native ($n = 16$)	28.8 (2.6)	<i>n.a.</i>	<i>n.a.</i>	36.3 (4.7)

Note: Standard deviations are in parentheses.

Table 3. *Response Times (in ms) on the Relative Clauses Task*

Condition	Beginning	Low	High	Native
	(<i>n</i> = 19)	intermediate (<i>n</i> = 20)	intermediate (<i>n</i> = 18)	(<i>n</i> = 17)
Cognate items				
C1: Matching, gap	493 (41)	488 (45)	516 (51)	527 (85)
C2: Nonmatching, gap	540 (50)	513 (47)	553 (58)	493 (74)
C3: Matching, control	514 (43)	498 (52)	519 (54)	507 (83)
C4: Nonmatching, control	537 (53)	507 (50)	520 (44)	523 (87)
Noncognate items				
C1: Matching, gap	521 (38)	502 (44)	530 (58)	482 (44)
C2: Nonmatching, gap	534 (54)	510 (42)	533 (55)	522 (62)
C3: Matching, control	509 (41)	495 (59)	501 (38)	514 (92)
C4: Nonmatching, control	536 (50)	519 (45)	522 (27)	511 (43)

Note. Standard deviations are in parentheses.

Table 4. *Response Times (in ms) on the Clefts Task*

Condition	Beginning	Low	High	Native
	(<i>n</i> = 20)	intermediate (<i>n</i> = 20)	intermediate (<i>n</i> = 17)	
Cognate items				
C1: Matching, gap	493 (63)	507 (26)	500 (73)	515 (66)
C2: Nonmatching, gap	530 (53)	532 (50)	527 (81)	491 (78)
C3: Matching, control	495 (60)	521 (65)	516 (66)	483 (49)
C4: Nonmatching, control	516 (56)	531 (48)	504 (72)	522 (70)
Noncognate items				
C1: Matching, gap	527 (62)	526 (42)	526 (94)	494 (91)
C2: Nonmatching, gap	514 (54)	526 (52)	511 (76)	521 (75)
C3: Matching, control	489 (58)	523 (50)	492 (78)	492 (63)
C4: Nonmatching, control	531 (75)	537 (55)	528 (77)	498 (65)

Note. Standard deviations are in parentheses.

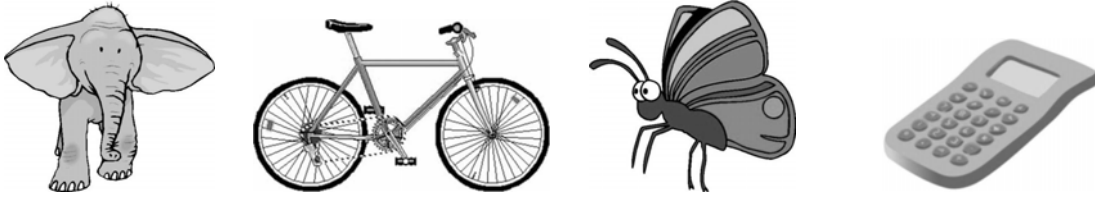
Table 5. Summary of Results of Paired-Samples *t* Tests Comparing RTs to Matching and Nonmatching Picture Probes

Group	Cognate		Noncognate	
	Gap	Control	Gap	Control
Beginning				
Relative clauses	$p < .005$	$p < .05$	$p = .317$	$p < .01$
Clefts	$p < .01$	$p < .05$	$p = .206$	$p < .01$
Low intermediate				
Relative clauses	$p < .05$	$p = .423$	$p = .438$	$p < .002$
Clefts	$p < .05$	$p = .277$	$p = .971$	$p = .225$
High intermediate				
Relative clauses	$p < .01$	$p = .966$	$p = .819$	$p < .05$
Clefts	$p < .05$	$p = .409$	$p = .242$	$p = .058$
Native				
Relative clauses	$p < .001^a$	$p = .370$	$p < .005$	$p = .869$
Clefts	$p = .071^a$	$p < .05$	$p = .064^b$	$p = .597$

Note. Unless otherwise noted, the significant asymmetries reported here reflect the predicted facilitation effects (shorter RTs for matching probes).

^a Response times were longer for antecedent-matching picture probes, reflecting inhibition rather than facilitation.

^b One-tailed.



*Figure 1. Examples of *alive* and *not alive* picture probes.*

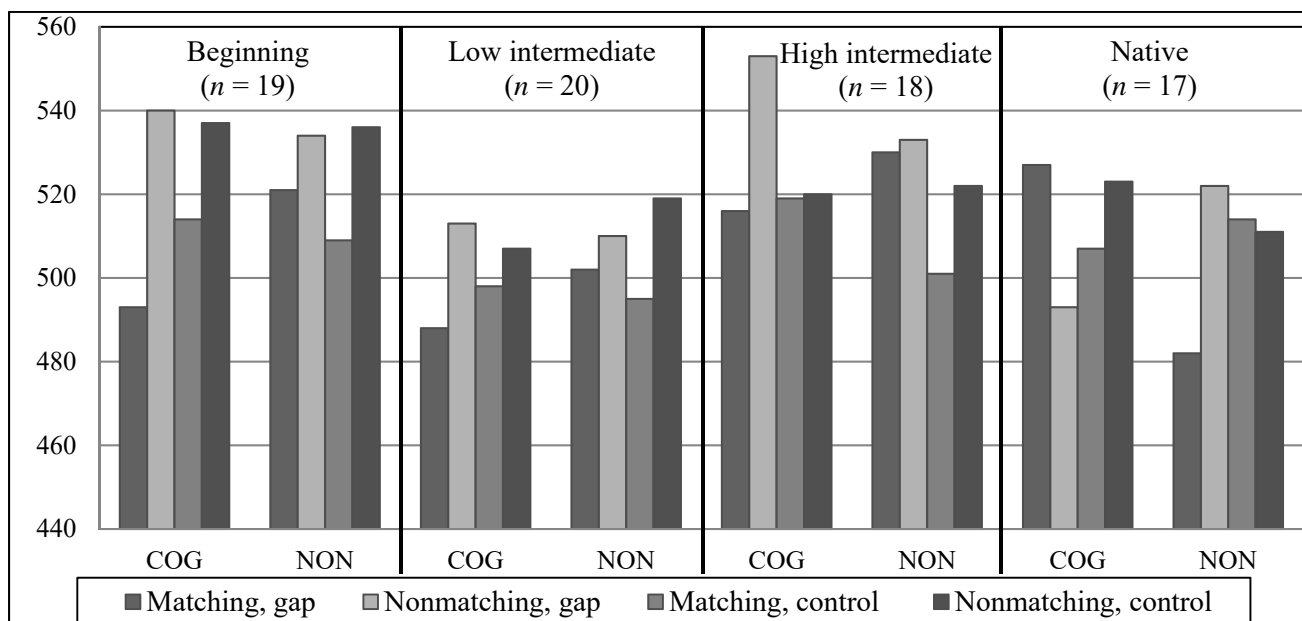


Figure 2. RTs (in ms) to picture probes for cognate (COG) and noncognate (NON) items with relative clause sentence structure.

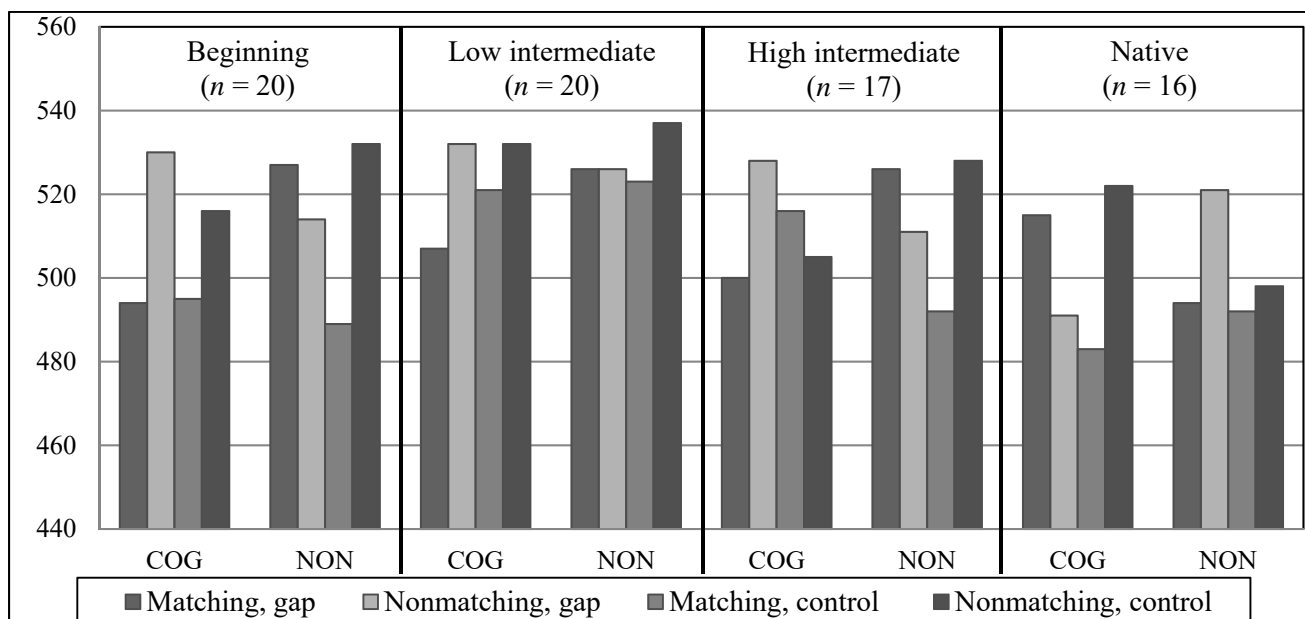


Figure 3. RTs (in ms) to picture probes for cognate (COG) and noncognate (NON) items with cleft sentence structure.