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ALINE PEREIRA DOS PASSOS

EFFECTS OF AMBIGUITY AND LANGUAGE COACTIVATION ON THE PRODUCTION OF FALSE MEMORIES IN BILINGUALS

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Dissertação de Mestrado submetida ao Programa de Pós-Graduação em Letras da Universidade Federal do Rio Grande do Sul, como requisito parcial para a obtenção do título de Mestra em Letras, na linha de pesquisa da Psicolinguística.
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RESUMO

Memórias falsas são criadas com o intuito de preencher um espaço na memória (Bartlett, 1932). Através do paradigma Deese-Roediger-McDermott (DRM) (Roediger; McDermott, 1995), é possível induzir a criação de memórias falsas por meio de listas de associações semânticas entre palavras em bilíngues (Bialystok *et al*., 2020). O objetivo deste estudo foi testar o efeito da ambiguidade lexical e da coativação linguística na produção de memórias falsas por bilíngues, por meio do paradigma DRM. Dessa forma, 27 bilíngues português-inglês ouviram listas de palavras exclusivamente em inglês e, posteriormente, relembravam e reconheciam essas listas, as quais poderiam elicitar memórias falsas. Resultados mostram que houve um efeito de ambiguidade para os itens estudados no teste de *recall*, no qual os participantes relembraram mais palavras das listas relacionadas a palavras críticas não apresentadas não-ambíguas, do que ambíguas. Considerando o efeito de status cognato, os participantes recordaram palavras críticas não apresentadas (*critical lures*) com mais frequência quando fossem não-cognatas, o que não era esperado. No entanto, os participantes criaram mais memórias falsas quando *critical lures* eram ambíguas, o que era esperado. Efeitos de similaridade ortográfica e proficiência também foram observados. Esses resultados foram discutidos de acordo com teorias de memória e de acesso lexical bilíngue.

PALAVRAS-CHAVE: bilinguismo; memórias falsas; coativação linguística.

ABSTRACT

False memories are created in order to fill a gap in memory (Bartlett, 1932). Through the Deese-Roediger-McDermott (DRM) paradigm (Roediger; McDermott, 1995), it is possible to induce the creation of false memories through lists of semantic associations between words in bilinguals (Bialystok *et al*., 2020). The objective of this study was to test the effect of lexical ambiguity and linguistic coactivation on the production of false memories by bilinguals, using the DRM paradigm. Therefore, 27 Portuguese-English bilinguals heard lists of words exclusively in English and subsequently recalled and recognized these lists, which could elicit false memories. Results show that there was an ambiguity effect for the items studied in the recall test, in which participants recalled more words from the (studied) lists related to unambiguous, critical non-presented words than ambiguous ones. Considering the effect of cognate status, participants recalled critical non-presented words (critical lures) more frequently when they were noncognates, which was not expected. However, participants created more false memories when the critical lures were ambiguous, which was expected. Orthographic similarity and proficiency effects were also observed. These results were discussed according to theories of memory and bilingual lexical access.

KEYWORDS: bilingualism; false memories; linguistic coactivation.

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

1 INTRODUCTION

Memory processing is popularly compared to the processing of a computer. Through a computer, people are able to access and store information, just as what we do in our brain, concerning memories. According to Baddeley, Anderson, and Eysenck's review (2011), any memory system — human or not — must have the following qualities: encoding, storage and retrieval. Encoding means perceiving and learning information, it is the first contact one has with an event, while storage is the ability to keep information through time, creating then memory traces. Finally, retrieval is the access to knowledge, information or experiences (for a deeper review, see Roedger; McDermott, 2014). Depending on how well a memory is encoded, it can determine the quality of retrieval.

Besides, memory is not stored in separate files in our brain (Dehaene, 2020); when it comes to memories, the processing is not linear, as it occurs via multiple networks, regarding lexical and neural levels. In addition, encoding and retrieving information is not as easy for a human as it is for computers, since humans have to make sense of what they are encoding (in order to retrieve it), and not simply store new information. Because encoding and retrieving are closely related and such intricate processes, they are prone to error.

Research shows that human beings can have around 6,000 thoughts per day (Tseng; Poppenk, 2020). Remembering all the things we think about or that we see during the day is a hard task; remembering what happened years ago is even more difficult. But what about remembering information, scenes, actions, words that one has lived or seen? Bartlett (1932) presented two categories to define the kinds of memories people can present. The first one is called *reproductive memory*, which is a real memory, an accurate situation, that is, something that actually happened. The second one is *reconstructive memory*, which is made of elements that the individual creates in order to fill a gap in memory. The focus of this study is on reconstructive memory, which underpins the study of false memories.

False memories is a subject that can be explored in multiple ways in Psycholinguistics, notably in monolingual and bilingual studies. Regarding bilingual studies though, the usual approach is to compare bilingual's performance in both their first and second languages. In the present study, however, we sought to analyze bilinguals' languages coactivation through the production of false memories using only the second language during the experiment, filling a gap in the field. More specifically, the objective of the present study was to investigate if cognate status and ambiguity status have influence on the creation of false

memories through the coactivation of Portuguese in a memory test in English.

2 THEORETICAL BACKGROUND

2.1 False memories

False memories is a rich field of psychological research. A pioneer in the field, professor Elizabeth Loftus, led multiple studies regarding the implantation of false memories. In her 1995 study, she was able to convince a quarter of participants, through many interviews, that they got lost in a shopping mall when they were kids, and proceeded to be rescued by an elderly man, coming back home safely. In another study, Loftus and Palmer (1975) induced false memories of acts through the type of words they used in questions: "about how fast were the cars going when they *smashed* into each other?" The use of the verb *smashed* instead of *hit* or *bumped* made the participants create a false memory about the accurate speed of the car. Participants reported higher speed when the verb used in the question was *smashed*, compared to *hit* or *bumped*. People can also be convinced and confess that they committed a crime (such as theft, assault or aggressive act) they were not involved at all (Shaw; Porter, 2015; Laney; Takaragi, 2012), that they had been a victim of an animal attack or had an accident at a family wedding (Porter *et al*., 1999; Hyman Jr. *et al*., 1995 *apud* Loftus, 2005, p. 363).

Therefore, individuals should not blindly believe in their memories, because they are subject to error. Also, the production of false memories may be influenced by many factors, such as the age of the participant (Howe; Wilkinson, 2010), their emotional state (Toffalini *et al*., 2015), word concreteness (Pérez-Mata; Read; Diges, 2010), emotional content (Yeh; Lu, 2019; Chang; Brainerd, 2021) and pregnancy (Berndt *et al*., 2014), for instance.

As seen in the studies previously cited, language has a strong role in the creation of false memories. However, it is not only through the use of suggestive questions that false memories may be induced. Bartlett was the first researcher credited for conducting a false memory test. In his 1932 study, participants were English monolinguals who read a Canadian Indian Folklore called *War of the Ghosts* and were asked to remember it and retell it many times. The participants would replace pieces of the story with other elements that were culturally more familiar to them. For example, the word *canoe* would be replaced by *boat*. That is, participants created false memories as if to complete a gap in memory, since people are subject to errors when remembering situations.

Yet, besides completing gaps in stories, people are able to create memories of situations or things that never happened to them when induced to do so. For this reason, Deese (1959) created a procedure that gave the studies about false memories a new impulse: testing memory through the recall of semantically related word lists. For instance, the words *pin, thread, sewing, sharp, pin, eye, point, prick, thimble, haystack, thorn, hurt, injection, syringe, cloth* and *knitting* are all semantically related to the word *needle.* When a subject is presented to the words cited above, they are likely to think of the word *needle* as well because it is strongly associated with the other words in the list. Deese's paradigm intended to lure participants to think they studied the word *needle* when they did not, they actually studied only the other words referred before: that would be the creation of a false memory. In order to do so, the author developed 36 lists in which 12 words semantically associated with a critical non-presented word (as known in literature as critical lure[1]), e.g. *needle*. Therefore, in this study, participants would listen to a list and recall the words orally, as much as they could, right after listening to it (a single trial, free recall paradigm). As a result, the author observed that some of the lists indeed induced participants to produce a false memory (the critical lure), that is, to recall words that were not studied before.

Later on, Roediger and McDermott (1995) replicated Deese's method, using the lists that succeeded at producing high levels of false memory in recall trials. In addition, the authors added new words to the lists and also included recognition tests after the recall tests. In the recall tests, differently from Deese's 1959 study, participants would write down the words they recalled instead of an oral production. In the recognition test, participants read 12 studied (including the critical non-presented words) and 30 non-studied words (words that were presented in the recall task), and judged the words as old or new. This procedure enhanced Deese's testing method, and has since been called the Deese-Roediger-McDermott (DRM) paradigm.

The paradigm has been replicated in several studies since then, with some variations to it. For instance, the words may be presented either through auditory or visual stimuli. Also, instead of a semantic relationship amongst the words, researchers have tested the effect with phonologically associated stimuli (Bialystok *et al*., 2020). For example, the words *cat* and *cap* sound similar, with the change of only one letter. Therefore, when presented with a list of

[1] In the present study, the terms *critical non-presented word* and *critical lure* are interchangeably used.

such similarly sounding words, participants may recall and-or recognize the word *cab* because of the activation of the phonological network.

When creating lists for the DRM paradigm, many aspects are taken into consideration: the type of stimuli, as mentioned above, whether the language of the study phase matches the test phase (Beato *et al*.;, 2023; Gurrola, forthcoming) and also the speed of presentation of the stimuli (Smith; Kimball, 2014).

2.2 Fuzzy-trace theory and Activation-monitoring theory

One of the possible explanations for the occurrence of false memories is given by the Fuzzy-Trace Theory (Brainerd; Reyna, 1996, 1998, 2002), which discusses access to information and level of memory processing. The theory states that there are two levels of parallel memory processing: the verbatim trace and the gist trace. The verbatim feature is the real, veridical memory of the word form. The gist trait is a generalized memory, which refers to the meaning of the word and causes a feeling of familiarity. As the verbatim feature tends to have a shorter duration in memory, the individual will often rely on the gist feature to recall relevant information. Depending on the type of task participants are performing, they may rely more on either verbatim or gist traces.

> When a task demands the processing of the information to match the exact representation, verbatim traces are used and the distracting information that shares similar meaning is rejected. On the other hand, when a task requires the retrieval of meaning, there is reliance on both the verbatim traces and meaning-consistent gist traces (Reyna, 2012 *apud* Arêas da Luz Fontes *et al*., 2023, p. 44).

In the case of the DRM paradigm, little production of false memory is expected if participants make more use of the verbatim feature to remember the words in the list. However, if participants make more use of the gist trait, this could lead to a greater number of false memories.

Nonetheless, there is another possible explanation for the false memory effect. The activation-monitoring (Gallo; Roediger, 2001; Roediger; Balota; Watson, 2001) theory relies on semantic spreading activation of words. The activation of a word during encoding can elicit other words semantically related, hence creating a big network, as a domino effect. Therefore, when it comes to remembering words (retrieval stage) presented during the study phase, it is easy to get tricked into thinking that one studied a word that they actually did not; there is a failure to monitor the source of activation of a memory. Since it is hard to distinguish the root of a particular word while retrieving it, one is susceptible to produce

errors and false memories. Both fuzzy-trace and activation-monitoring theories can help explain false memory findings in bilingual contexts.

2.3 Bilingual language processing

Before introducing studies of false memories including bilinguals, it is important to comprehend how bilinguals process language. A meaningful issue concerning bilingual research is whether there is co-activation of languages in the processing of abilities such as writing, speaking, listening and reading. In a task, do bilinguals simply "turn off" the language that is not needed in that experiment or do they activate it in parallel with the target language? This coactivation may be investigated experimentally by manipulating the type of word chosen for the task. In many languages, there are words that look alike: cognates have the same origin; same or similar spelling and mean the same as another word in another language. For example, the word *human*, in English, is considered a cognate of the word *humano*, in Portuguese. Sometimes it is difficult to tell whether words are cognate or not because the spelling is similar but they do not share the same meaning. In other words, they are false cognates, also known as interlingual homographs. The words *mayor*, in English, and *major*, in Portuguese, are not cognates because they do not share the same meaning, although the spelling is similar. The first means "the political ruler of a city" and the second is "a rank in the army", for example. Whether a word is cognate or not can influence the understanding and production of words in another language. More specifically, cognates facilitate word recognition in reading and oral production (Ortiz-Preuss; Arêas da Luz Fontes; Finger, 2014), as they can be accessed more quickly than non-cognates by bilinguals because they receive double activation of both languages (Van Hell; De Groot, 1998). Many researchers include cognate words in their studies in order to analyze whether bilinguals access only one language at a time (corroborating the selective lexical access hypothesis) or both languages at the same time (which supports the nonselective lexical access hypothesis), even if it is not the same level of activation (Grosjean, 2013).

Caramazza and Brones (1979) conducted one of the first studies to find evidence corroborating the selective language access hypothesis. In this study, the 12 Spanish-English bilinguals performed a lexical decision task, where they pressed a key if the word displayed was in English or in Spanish and another key if it was a non-word. The stimuli were two lists (one in English and one in Spanish) composed of 120 words each (60 nonwords and 60 words, including 15 cognates). The results showed there was no significant difference in

reaction time (RT) between cognate words and non-cognates in Spanish. This was interpreted as evidence that, during the task, only one lexicon was accessed and the cognate status did not provide a facilitation in processing. Nonetheless, the bilinguals recognized cognate words faster than non-cognate words, in English. Therefore, the study also corroborated the nonselective lexical hypothesis.

Another study with evidence of selective access was conducted by Gerard and Scarborough (1989). It compared Spanish-English bilinguals and monolinguals and, in addition to cognates and non-cognate words, the test also included interlinguistic homographs. The reaction time between monolinguals and bilinguals was not significant for cognates nor for interlinguistic homographs. Again, this study suggested that the participants were processing language in a selective way because they were able to access only the lexicon needed for the task.

The studies cited above supported the selective language access hypothesis; more recent studies, however, provide evidence supporting the non-selective lexical access hypothesis. Dijkstra, Grainger, and Van Heuven (1999) tested the language non-selective hypothesis with Dutch-English bilinguals in a progressive demasking task with six conditions involving a manipulation of orthography (O), semantics (S) and phonology (P). Three of these conditions were established in order to analyze different types of language overlap in word recognition; therefore, cognate words and interlingual homographs were tested. Results showed that cognates were recognized faster than control, noncognate words, and while orthographic and semantic overlaps resulted in faster RTs, phonological overlaps led to slower RTs.

Schwartz and Arêas da Luz Fontes (2008) also investigated whether semantics and orthography could cause language co-activation. Through a mediated priming task (in single-word and sentence context), undergraduate students who were native speakers of Spanish and had English as a second language had to tell whether pairs of words (prime-target) in English were related in meaning. The words were related to Spanish through semantics or orthography. For instance, the words in English bark-BOAT are related to Spanish through orthography, because in Spanish *bark* looks like *barco*. However, the pair boat-BARK has a semantic connection with Spanish (*barco* means *boat*). The word bark might elicit strong activation of the word *barco*, because they have similar forms. Results showed that RT was slower when there was a mediator (in Spanish, *barco*), which provides

evidence supporting the non selectivity of bilingual lexical access, since the mediator was never shown to the participants.

The majority of studies concerning bilingual language co-activation is conducted with undergraduate students. Trying to extend findings to a different sample, Brenders, Van Hell, and Dijkstra (2011) tested the influence of cognate words and false cognates on the lexical access of Dutch children who were early learners of English. The processing of language might differ because the children in the study were learning both languages at the same time. The researchers tested three groups of children who had been in English classes for different amounts of times (5 months, 3 years and 5 years). The children completed a lexical access task in English and Dutch. Results showed that the children were faster to recognize cognate words in the English task (in both beginners and advanced level). However, there was no such effect in the Dutch task. It is then possible to say that proficiency had a role in co-activation in this test. The Dutch language was capable of influencing the processing of English, but not the other way around.

All of these studies providing evidence to the non-selective lexical access hypothesis support the Bilingual Interactive Activation + Model (Dijkstra; Van Heuven, 2002). The BIA+ (The Bilingual Interactive Plus Model) covers two different word recognition systems: 1) a task/decision control system and 2) a word recognition system. The task/decision control system can be affected by nonlinguistic information, such as characteristics and strategies of the interlocutor (Arêas da Luz Fontes, 2018).

> On the other hand, the word recognition system "adds representations and components in lexical processing, addressing aspects related to the inclusion of semantic representations, the representation of cognate words and interlinguistic homographs, language nodes, among others aspects" (Pickbrenner, 2017, p. 54).

Besides orthography and semantic representation, the model also acknowledges the role of phonological information on word recognition. First, orthographic and phonological information are activated, then semantic representations of both languages are activated too. Also, Dijkstra *et al*. (2002) affirm that since L2 representations are "on average of a lower subjective frequency than L1 codes, they are activated somewhat more slowly than L1 representations". (Dijkstra *et al*., 2002, p. 182).

Some researchers go further and investigate language co-activation in trilinguals. Trilinguals have vaster lexicons to be activated and compete for selection. Therefore, would cognate words be triply activated (and more intensely activated than in bilinguals)? Or would

the addition of a lexicon be distracting to the trilingual, since it is one more lexicon competing for activation? In Barcelos' (2016) study, participants spoke Portuguese (L1), English (L2) and French (L3). The purpose of the research was to investigate whether there would be a cognate facilitation effect across languages, focusing on the influence of the L1 on the L3, and the L2 on the L3, through a lexical decision task. Results revealed that there was greater accuracy of response for cognates between the L1 and the L3, and the L2 and the L3, but RT's were not faster for cognate words, as was expected. A triple cognate facilitation effect was also expected, but it was also not found. Thus, the results mentioned above show that trilinguals in this study would have no advantage on lexical access over bilinguals. However, since the accuracy of response for cognates was greater, this study contributes with evidence to support the non-selective lexical access hypothesis.

Regarding lexical access in multilinguals, Toassi, Mota and Teixeira's (2020) study investigated the effect of triple cognates (cognate words in three languages) in speakers of Portuguese (L1) German (L2) and English (L3). Participants performed a reading task with English as target language, while having their eye movements tracked. The stimuli words were either triple cognates, double cognates Portuguese-English or double cognates German-English. Participants would read sentences including the cognates and also answer comprehension questions afterwards as a way to verify if they were paying attention. Through the eye-tracking, it was possible to confirm that multilinguals processed triple cognates faster than controls, which supports the non-selective access hypothesis.

In contrast to Barcelos' (2016) study, Pickbrenner (2017) also tested trilinguals, but the researcher's objective was only to check cognate facilitation between the L2 (English) and the L3 (German). However, the hypothesis was not corroborated. The participants did not recognize cognate words faster than control words. The researcher pointed out that maybe the participants were not fluent enough in German to perform the test in that language, even though the words selected to the test had a high frequency.

After this review of bilingual and trilingual lexical access, it may be suggested that there is a large body of evidence showing that bilinguals access lexical and semantic representations from both languages in parallel, even when processing in only one of the languages, corroborating the hypothesis of non-selectivity of bilingual lexical access (Rigatti; Arêas da Luz Fontes, 2022).

Thinking of the word *blue*, an ambiguous word, a monolingual English speaker might coactivate two possible meanings: the color shade and the feeling of sadness. This parallel activation comes with a cost of time processing, since there is competition between meanings, in order to be the first one accessed (Duffy; Rayner, 1988). What defines if one meaning is accessed before the other can be summed up in two factors: the frequency of the meaning (whether it is subordinate or dominant, least frequent or most frequent) and the contextual bias (whether it has semantic information around the word or it is an isolated/single word processing) (Kaltsa; Papadopoulou, 2023; Ishida, 2019).

However, what happens when an ambiguous word is processed by a bilingual? According to the nonselective lexical access hypothesis (Grosjean, 2013), the lexicons of the two languages are coactivated at all times (even if at different levels). In case an ambiguous word shares at least one meaning between languages, bilinguals will coactivate meanings/associations to an ambiguous word regarding both languages, which tends to slow down their lexical access. It is important to point out though, that in the present study, ambiguity does not contemplate polysemic words. While ambiguous words have two completely different meanings (as the word *blue*, cited previously), polysemic words have many related interpretations (Haber; Poesio, 2024), which can elicit multiple interpretations from the same concept. For instance, the word *window* in English is usually referred to as a physical opening frame in a wall, but it still carries this sense of opening in other subjective ways.

Bilinguals processing of ambiguous words "[...] requires lexical representations that are detailed and precise in order to minimize competition from words across languages that may share a high degree of form but map on to distinct meanings." (Arêas da Luz Fontes; Schwartz, 2015, p. 641).

Rigatti and Arêas da Luz Fontes' 2022 study investigated ambiguous processing in Portuguese-English bilinguals through a second language meaning decision task, in a single-word context. In order to check language coactivation, they manipulated ambiguous words, creating four conditions: cognate ambiguous words that shared the subordinate meaning across languages (arms - *arma*); non-cognate ambiguous words that did not share any of the two meanings (fast - *rápido*); cognate unambiguous words (guitar - *guitarra*) and non-cognate unambiguous words (alike - *parecido*). As a result, there was a frequency effect, in which dominant meanings were associated with more accuracy on answers and quicker response time, something that was expected. However, in general, ambiguous words were processed with some delay compared to unambiguous, which is an ambiguous interference

effect. Besides, there was a cognate facilitation effect since cognates raised the level of accuracy on responses.

2.4 False memories in bilinguals

The DRM paradigm was formerly idealized in English, but it has been replicated in several languages since then (e.g. Dutch: Van Damme; d'Ydewalle, 2009; Spanish: Beato; Díez, 2011; Mandarin: Yeh; Lu, 2017; Portuguese: Albuquerque, 2005; French: Dubuisson; Fiori; Nicolas, 2012; Polish: Ulatowska; Olszewska, 2013). Not long ago, researchers have started to delve into the role of bilingualism on false memories.

One of the first studies investigating the production of false memories by bilinguals was conducted by Kawasaki-Miyaji, Inoue and Yama (2003). In this study, bilinguals who had Japanese as the dominant language studied 12 DRM lists, 6 of which were visually presented in English and 6 in Japanese; the latter was translated from English. Participants were given a recognition test in which they had to identify the words from the lists they had studied in either the same language (study in English - test in English or study in Japanese - test in Japanese) or in a different language (study in English - test in Japanese or study in Japanese - test in English). The results revealed that participants recognized more words correctly when the language of study and the language of test corresponded, and that there was a greater propensity for false memories when both study and test were in Japanese. One limitation of this study, which was pointed out by the authors, was that some of the participants might not have had a high enough level of proficiency in English to produce false memories across languages. The study classified the participants as unbalanced bilinguals, "because they were not raised in an English environment or born in an English speaking country" (Kawasaki-Miyaji; Inoue; Yama, 2003, p. 258). The results may have arisen due to a lack of linguistic ability, since participants had learned English as a second language and were more competent in Japanese. Another limitation is that the lists in Japanese were translated from English, which may have disregarded the specific semantic associations of the Japanese language.

Similar to Kawasaki-Miyaji, Inoue and Yama (2003), Sahlin, Harding and Seamon (2005) also translated DRM lists from English, but in this case, into Spanish. However, the participants of Sahlin,, Harding and Seamon's study (2005) were bilinguals who had a more balanced level of proficiency than those of Kawasaki-Miyaji, Inoue and Yama's (2003), since they had learned both languages, English and Spanish, at home since birth. Another

difference between the two studies lies in the procedure and materials used by the researchers. Participants in Sahlin, Harding and Seamon's (2005) study would hear the lists for recall (just like in the original experiment testing the DRM paradigm), rather than read them. The researchers were also a little more attentive about the type of words selected for the experiment: "some words were not used because their membership in a list was based on an idiomatic association that was culturally constrained or language specific (e.g., the needle–haystack association does not exist in Spanish)" (Sahlin; Harding; Seamon, 2005, p. 1415). In their test, bilinguals studied the lists in one language and, during the recognition test, they read studied words, non-studied (words that were not presented in the recall task) and critical non-presented words (the expected false memory) in the same language or in another language. Results revealed higher rates of false memories when there was a match between study and test language, but a significant number of false memories were also found when there was no such correspondence. The researchers concluded that false memories can be observed across languages regardless of whether the test language matches the study or not.

In contrast to Kawasaki-Miyaji, Inoue and Yama (2003) and Sahlin, Harding and Seamon (2005), Anastasi *et al*. (2005, Experiment 2) used DRM lists in Spanish that were created by native Spanish speakers, enabling the maintenance of natural semantic associations of the language. For this task, 38 native speakers of Spanish wrote down the first three words that came to their minds when they saw a word that would later be a critical non-presented word. For example, for the critical non-presented word *silla*, some of the associates were: descanso (rest), sentarse (sit) and mesa (table). Fifteen words out of all responses were selected to compose the lists. These lists were then used to investigate the creation of false memories in Spanish-English bilingual individuals who used Spanish more frequently at home and English at work and also with friends. Participants had to read aloud words displayed on a computer screen in both languages and then performed a recognition test in which they were instructed to select only words that appeared in the same language previously studied. The bilinguals correctly recognized an equivalent number of words presented in the study lists in English and Spanish, but produced a greater number of false memories in English than in Spanish, which was not expected. However, the authors explain that experience and linguistic exposure were not tested in the experiment, and the greater effect of false memories in the second language may have occurred due to their immersion in

an English context primarily, which may result in a change of dominance from the native language to the second language.

In Anastasi *et al*.'s (2005) study, bilinguals studied the DRM lists in each of their native languages (English and Spanish) and they should indicate, later in the recognition test, if they had studied those words in a specific language. In contrast, in the study by Marmolejo, Diliberto-Macaluso and Altarriba (2009), bilinguals studied DRM lists in both Spanish and English, but were instructed to indicate whether they had studied that word before in either of the languages, with a yes or no answer. Also, they should point out how confident they were about their response. Again, the results showed that bilinguals recognized a greater number of words presented on the list when the study and recognition test were performed in the same language. In addition, bilinguals produced more false memories, and reported a higher index of misconfidence when the languages of study and test were different than when they were the same.

These results highlight the importance of compatibility between the language used in encoding and retrieval of information. In other words, when the encoding language and the retrieval language were not compatible, there was a higher frequency of false memories and misconfidence in recognition. These results also suggest that bilinguals activate conceptual representations of both languages when performing a task in the DRM paradigm, which contributes to the current knowledge about bilingual memory processing.

The study by Arndt and Beato (2017) contributes to the discussion that bilinguals activate concepts between languages in studies of false memories. More specifically, these authors suggest that proficiency and dominance in a language have an effect on the automaticity of access to concepts in bilingual memory. In their study, Arndt and Beato (2017) conducted three experiments that demonstrated that Spanish-English bilinguals produced more false memories when tested in their native/dominant language than in their non-dominant language. In addition, bilinguals who were more proficient in the second language produced more false memories than the less proficient. The authors suggest that these results are consistent with research that suggests that greater proficiency in the second language increases the automaticity with which lexical representations activate conceptual representations in bilingual memory.

In Bialystok *et al*.'s recent study (2020), the authors conducted three experiments with monolinguals (English speakers) and bilinguals who spoke different languages as their second language. In the first experiment, during the study phase, participants listened to lists of phonologically related words (in English). In the recognition test phase, bilinguals

generated more false memories than monolinguals. In the second experiment, new monolingual and bilingual participants took part in the study. This time, participants listened to lists of semantically related words (in English). In the recognition phase, it was observed that monolinguals were more susceptible to the creation of false memories than bilinguals. In the third experiment, new participants were divided into four groups: young adult monolinguals, young adult bilinguals, older adult monolinguals, and older adult bilinguals. Additionally, the stimulus presentation mode was different in the study phase: the lists (semantically related, as in Experiment 2) were read by the participants. In the recognition phase, it was observed that lists with higher backward association strength (BAS) led to greater recognition of studied words overall, unlike Arndt and Beato (2017), where there was no significant difference in recognition of studied words between BAS and forward association strength (FAS). There was also an age effect, where older adults produced more false memories than young adults. In this experiment, monolinguals generated more false memories than bilinguals, similar to Experiment 2. Taken together, the most successful experiment was the first one, where bilinguals excelled in the creation of false memories.

In Riesthuis, Otgaar, and Wang's study (2019), different from the studies mentioned earlier, a new presentation structure of the DRM paradigm was introduced. In this study, participants were monolingual Spanish speakers and bilingual Spanish-Catalan speakers who read lists in Spanish, translated from English. The authors presented word lists along with "contextual details," such as shapes and colors. For example, the word *físico* (physical) was presented within a heart-shaped format in blue. The words and shapes/colors had no significant relationship (the word *físico* does not automatically evoke a memory of a heart or the color blue). The drawings of the shapes were simple, just a thin line. The authors speculated that these contextual details might increase the participants' confidence in creating false memories, meaning that the presentation of shapes and colors along with the studied words would facilitate their creation. However, as a result, there was no significant difference in the creation of false memories between monolinguals and bilinguals, whether or not the contextual details were included. Yet, bilinguals performed better in recalling studied words (without the contextual details).

More recently, Beato, Suarez and Cavidad (2023) and Suarez and Beato (2023) drew special attention to aspects about the creation of the lists that compose the DRM paradigm, such as vocabulary knowledge. In Suarez and Beato's (2023) study, the DRM paradigm was created with lists in the L2, in which the majority of the participants knew the meaning of the

words. It seems frivolous that this matter of vocabulary knowledge would be frequently and certainly controlled in studies with bilinguals, but it is actually not so common.

As seen previously in Kawasaki-Miyaji, Inoue and Yama (2003) and Sahlin, Harding and Seamon (2005), lists used to be translated to either participants' L1 or L2 without further deliberation. This allowed for DRM lists which did not adequately represent the semantic relationships of specific languages, and that possibly contained words not known to participants in their L2. To control whether participants knew the meanings of the words in the test, in Suarez and Beato's (2023) study, participants performed a "translation test" right after doing the DRM paradigm in their L2. In that task, they were asked to translate the lists they had just studied, from English (L2) to Spanish (L1). It is worth noting that participants were also asked to translate the critical lures of the lists. Furthermore, the authors compared the translations from the test to a pilot they conducted before, where participants, again, were asked to translate lists from second language to first language. Finally, by doing so, it was possible for the authors to check whether participants knew the correct meaning of the words. Indeed, the percentages of accuracy on the translations were very similar on both pilot (85.56%) and actual test (86.05%). In fact, participants knew the meaning of critical lures better than the associates. All this attention to detail minding critical lures goes hand in hand with Beato, Suarez and Cavidad's (2023) study, in which the authors considered the ability of participants in identifying the critical lure from the words of the lists, i.e. theme identifiability. If participants could easily realize what the critical lure of a list was because of its associates, it was likely that the subjects will not be prone to pull off a false memory (Carneiro *et al*., 2009, 2012 *apud* Beato; Suarez; Cavidad, 2023, p. 179).

In addition, the study manipulated the strength of semantic association from studied items to the critical lure, that is, their backwards association strength (BAS). Previous studies have shown that lists with high BAS tend to produce more false memories than those with low BAS (Gallo; Roediger, 2002; Roediger *et al*., 2001) due to the intensity of activation of the associates during encoding. However, in Suarez and Beato's (2023b) study, when it comes to vocabulary knowledge, it seems that it does not have an effect on BAS. No significant variation between lists in the percentage of words with known meanings between high-BAS and low-BAS lists was observed, both for the words that were studied and the crucial lures (Suarez; Beato, 2023b, p. 21).

The above-described research indicates that bilingualism can influence the production of false memories. However, these studies rely on comparing groups of monolinguals and bilinguals and examining the difference in false memory creation

between their first and second languages. In the present study, we tested the coactivation of languages in bilinguals using a version of the DRM paradigm conducted exclusively in the participants' second language. The aim of this study is to investigate the role of coactivation of a non-presented language during the task in creating false memories for Portuguese-English bilinguals. In other words, bilinguals performed the DRM paradigm entirely in English, but the activation of Portuguese was explored by manipulating the type of critical non-presented word: cognate with Portuguese (e.g., piano-piano) or not (e.g., pencil-lápis).

3 METHOD

The present study progressed through some steps in order to develop into a final experimental study. In the norming study (Step 1), participants filled out a Google forms document concerning associates to ambiguous and cognate words. That step was done completely online. Later on, other participants collaborated on the second step of the norming study, which was to rate the semantically associated pairs conceived in the first step. This part of the study was completed in person, at UFRGS. Finally, after Steps 1 and 2, it was possible to rank and pick the words that would compose the lists of the experimental study, where new participants recalled and recognized lists of semantically associated words. The experimental study was performed online on a host platform.

3.1 Norming study

The purpose of this study was to create lists of semantically associated words in English that were natural to Portuguese-English bilinguals. Semantic associations are, at least to a certain degree, language specific. For example, when Brazilians think of the word *elevator*, they most frequently associate it to the word *building* whereas U. S. Americans associate it to the word *escalator* (Anastasi *et al.*, 2005). One may question, then, the types of semantic associations that are formed when there are two languages represented in the brain, as is the case of bilinguals. Because we worked with Portuguese-English bilinguals, and there were no previous semantic associations norms for such a group, we normed a set of stimuli to be used in the false memory experiment. The goal was to ensure that the semantic associations shown in the experiment reflected those of the sample studied. To achieve such a goal, a two-step norming study was conducted, in which we collected both forward and backward association data on a set of linguistic stimuli.

3.2 Step 1

3.2.1 PARTICIPANTS

Participants were 14 Portuguese-English bilinguals, all of them students at Universidade Federal do Rio Grande Do Sul (UFRGS) and Universidade Federal de Pelotas (UFPel).

3.2.2 MATERIALS

The task was elaborated on a Google Forms document. Participants were asked to write as many words as they could think of related to both ambiguous (such as *letter* and

mold) and unambiguous (e.g. *piano* and *actor*) critical lures. In total, the thirty-six critical lures were divided in four conditions: 9 ambiguous cognate words, 9 ambiguous noncognate words, 9 unambiguous cognate words and 9 unambiguous noncognate words.

3.2.3 PROCEDURE AND RESULTS

Participants completed the task online. They would read the following instructions: "Below, there is a list of words in English. We would like you to think about other words that you can ASSOCIATE semantically with these words. Do not think too much about each word, just write down the associations that come to mind automatically.
Here is an example: Letter - alphabet, word, spell, mail, postman, paper, writer, etc.
Write as many words (associations) as you can think of. If you do not know a word, please leave it blank." Participants could take as much time as they wished writing the answers.

Participants suggested from zero up to thirteen words for each critical lure (forward association norms). For instance, the words *"caution, beware, sign, toxic, explosive, limit"* were suggested for the critical lure *danger*. In case the participants did not provide enough words for setting the lists (at least 12 words per list), words (associates) from different corpora were selected in order to complete the lists. In total, 0,5% of the total number of words were selected from the *University of South Florida Free Association Norms* (Nelson, McEvoy & Schreiber, 1998). They were two words only: *dandelion*, from the *rose* (critical lure) list and *layer*, from the *brick* (critical lure) list. Also, less than 2% of associates were selected from the *Thesaurus dictionary*. They were seven words in total: *trinket, bauble, ornament, adornment* and *pin*, from the *charm* (critical lure) list and *pocket* and *Swiss,* from the *watch* (critical lure) list.

3.3 Step 2

3.3.1 PARTICIPANTS

Participants were 25 Portuguese-English bilinguals, all of them students of the Modern Languages course at Universidade Federal do Rio Grande Do Sul (UFRGS), who were enrolled in the English 8 course in 2017.

3.3.2 MATERIALS

The stimuli were the ones selected in Step 1. Students were given sheets of paper containing pairs of semantically associated words selected from Step 1. They were requested to point out on a scale from 1 to 5 (with 1 being *extremely unlikely* and 5 being *extremely*

likely) how likely they were to think of the second word, given the first word of the pair. For example, they saw the pair *beautiful - beauty* and had to rate how likely they were to think of *beautiful* when they saw *beauty* (see Table 1). In addition to the pairs selected from the first phase of the norming study, other pairs of words previously normed by the research group were also rated in this second step.

Table 1

Pairing of words to select stimuli

How likely are you to think of the word in the second column when you see the word in the first column?						
		1= extremely unlikely	2 = unlikely	3 = neutral	4 = likely	5 = extremely likely
smile	beauty	1	2	3	4	5
eyes	beauty	1	2	3	4	5
natural	beauty	1	2	3	4	5
charm	beauty	1	2	3	4	5

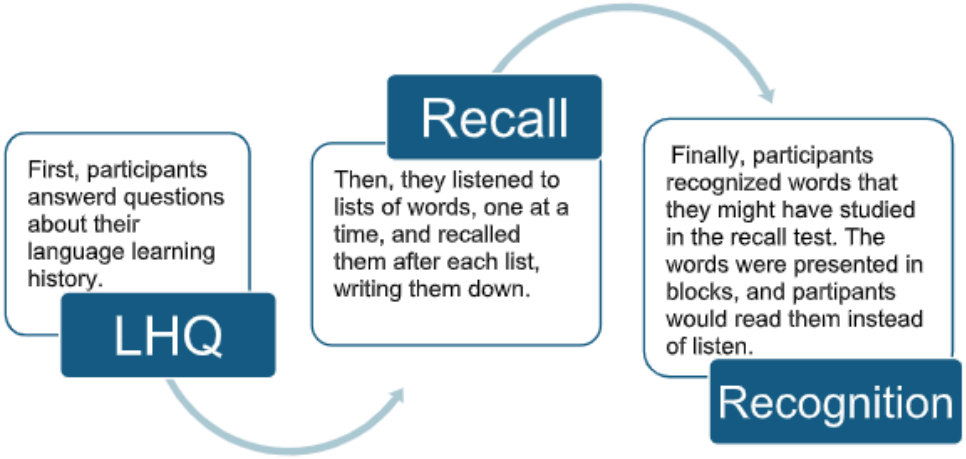
3.3.3 PROCEDURE AND RESULTS

Participants performed the task at UFRGS, in a single room. They were given sheets of paper including the pairs of semantically associated words and were instructed to rank the pair of words from 1 to 5 (as explained above). The test lasted about one hour. After they finished the test, we thanked them for their time. The mean of each pair was then calculated and ranked (backward association data). It was the last step to select the stimuli for the experimental study. The experimental lists were then created according to the backward association data such that the first item presented was always the one with stronger association, and so on.

3.4 Experimental study

Figure 1

Overview of the experimental study



The objective of the present study was to investigate the role of coactivation of a non-presented language during the task in creating false memories for Portuguese-English bilinguals, through the DRM paradigm entirely in English. The first hypothesis of the study was that cognate words (critical lures) would lead to a greater production of false memories than non-cognate ones. The second hypothesis was that ambiguous words (critical lures) would lead to a greater production of false memories than unambiguous words.

3.4.1 DESIGN

This was a within-subjects design, in which all participants were presented to both levels of the manipulated independent variables: the cognate and ambiguous status of the critical lure. Dependent variables were the total number of correctly recalled and recognized studied items, the total number of incorrectly recalled and recognized critical lures, and the total number of incorrectly recalled and recognized unstudied items.

3.4.2 PARTICIPANTS

Participants were 31 Portuguese-English bilinguals (22 females and 9 males), all native speakers of Portuguese. Spanish, Italian and French were also reported as additional languages. However, four participants spoke Spanish as their second language and rated themselves higher in that language than in English. Thus, they were excluded. Twenty-seven participants were, therefore, included in the final sample (20 females and 7 males). Eleven of them (40.7%) spoke a third language. The average age of the participants was $M = 28.1$ years old ($SD = 5.9$). Participants' proficiency was assessed through a self-evaluation language proficiency questionnaire that enabled them to report their linguistic background.

Participants started learning English approximately at age 11 (SD = 3.2), and 81.5% of them learned English in either school or free courses, that is, through formal instruction. Participants' self-assessed English proficiency showed scores on the higher end of the 1-7 likert scale, ranging from *M* = 5. 8 (*SD* = 1,1) in writing to *M* = 6,4 (*SD* = 0.8) in reading. Participants used social media or the internet for 2.6 (*SD* = 1.5) hours per day and played video games or online games for 0.7 (*SD* = 1.4) hours per day. Four participants left the language questionnaire incomplete; therefore, participants' linguistic background information is based on 25 responses. More information concerning the participants' experience and usage of the second language are presented in Table 2.

Table 2

Self-rated proficiency in the four skills and language background information of the Portuguese-English bilinguals (N = 25).

	Mean (SD)
Self-rated proficiency	
Speaking	6.1 (0.8)
Reading	6.4 (0.8)
Writing	5.8 (1.1)
Listening comprehension	6.2 (1.0)
Hours reported using English	
Watching TV or streaming	2.5 (1.3)
Listening to music or podcasts	2.0 (1.6)
Reading for pleasure	1.3 (1.0)
Reading for work or school	2.1 (1.5)
Using social media or the Internet	2.6 (1.5)
Writing for work or for school	1.4 (1.4)
Playing video game or online games	0.7 (1.4)
Age of onset of acquisition of English	
	11.0 (3.2)
Time, in months, of English study	
	182.8 (87.7)

Note. Self-rated proficiency was measured on a 1-7 scale, with 1 = very poor, 2 = poor, 3 = limited, 4 = average, 5 = good, 6 = very good and 7 = excellent.

3.4.3 MATERIALS

3.4.3.1 Online platform

The experiment was hosted and completed on the *Lapsi* (Psycholinguistics Laboratory on the Web) platform (www.lapsi2.davi.solutions), a digital laboratory, which allowed participants to carry out the experiment online (Oliveira, 2023). See Figure 2.

Figure 2

Layout of the platform

3.4.3.2 Language History Questionnaire

The Language History Questionnaire (LHQ) (Li; Zhang; Tsai; Puls, 2014; Li; Zhang; Yu; Zhao, 2020) consists of a series of questions that explores linguistic data, such as language skills (reading, listening, writing, speaking), age of acquisition, context and frequency of language use through self-reports. The participants rated their proficiency on a scale of 1 (*very poor*) to 7 (*excellent*). Frequency was measured in two questions. The first asked participants to estimate how many hours a day they spent doing a variety of activities in English, such as listening to music, playing video games, etc. This question was measured on a scale from 0 to 5, in which 0 = "I don't do this activity"; 1 = "up to one hour"; 2 = "up to 2 hours"; 3 = "up to 3 hours"; 4 = "up to 4 hours" and 5 = "more 5 hours". The second question considered context as well as frequency. It asked participants to estimate how many

hours per day they spent speaking to different groups of people, such as family, friends and coworkers. This was measured on a scale from 0 to 6, in which 0 = "I don't speak the language with this group"; 1 = "up to one hour"; 2 = "up to 2 hours"; 3 = "up to 3 hours"; 4 = "up to 4 hours" and 5 = "more 5 hours". See the complete test in Appendix A.

3.4.3.3 Stimuli

Stimuli were auditory and were selected from the norming study previously described. Thirty two lists were created, each containing 12 words (384 words total), in addition to the 32 critical lures (one for each list). The critical lures were divided in four conditions: 14 ambiguous cognate words, 6 ambiguous noncognate words, 6 unambiguous cognate words and 6 unambiguous non cognate words. All cognate ambiguous had only their dominant (i.e.. most frequent) meaning shared with Portuguese (e.g.: *contract* (document) - *contrato*). In the lists with ambiguous critical lures, all items were related to their dominant meaning, e.g. the list of *plant* (critical lure) was composed of *root*, *garden*, *ivy* and etc., all words concerning greenery, not architecture-wise (the least frequent meaning). The forward and backward associative strength between the critical lures and the words on the list were previously measured and controlled in the norming study presented earlier. The frequency, length, concreteness and cognateness for the words that compose the lists were not controlled because the most important factor for the creation of the lists was the semantic association strength between the items on the lists and the critical lure. Both Step 1 and 2 of the norming study focused on collecting forward and backward association data. If the variables cited above were also taken into consideration, then the semantic association strength might have been compromised. In addition, the options of items available to include in the lists would be reduced. See examples of critical lures and associates in Table 3.

Table 3

Example of stimuli used in the DRM paradigm.

	List items
ambiguous cognate critical lure	
date	calendar, month, day, year, deadlines, birthday, holiday, period, week, late, tonight, era

ambiguous noncognate critical lure	
blue	sky, sea, color, ocean, beach, lagoon, navy, space, red, shade, green, lilac
unambiguous cognate critical lure	
poet	poem, literature, writer, rhyme, rhythm, inspiration, emotions, passion, novel, dreamer, culture, faker
unambiguous noncognate critical lure	
rabbit	bunny, easter, alice, animal, carrot, fluffy, ears, chocolate, white, eggs, jumps, teeth

3.4.3.4 Recall test

In preparation for the recall test, all words of all lists were recorded by a Portuguese-English bilingual woman who had never had any contact with the participants. She recorded the lists in .wav format, on her cellphone, and later the stimuli were edited in the *Audacity* app. In the study phase of the recall test, participants heard each word of a given list only once, one at a time. The words were presented with an interval of two seconds between them. Since the study was carried out online, participants were instructed to just listen to the words and to not write them down as they heard them. At the end of each list, participants saw a screen with the word "RECALL", which indicated they should type on the computer keyboard all the words they remembered hearing. They had up to one and a half minutes to type as many words as they could recall, in no particular order. They pressed the Enter key or clicked on the "Continue" button when they finished and a new list started; this procedure continued until they finished all 32 lists. The lists were presented in random order across participants, but words within the lists were always in the same order as they were ranked from stronger to weaker backward association strength.

3.4.3.5 Recognition test

Stimuli were written lists of words, selected from the recall test and from Roediger's (2001) study. The conditions of the recognition test were the same as the recall test, but this

time the critical lures were also added in the test. Therefore, three lists from each of the four conditions (12 lists total) were selected for the recognition test. Words in positions 1, 6 and 11 from these 12 lists, which had been presented in the recall test, were chosen to compose the recognition test (as in Bialystok's 2020 study, Experiment 3). Thus, there were 3 studied words from each of the selected lists, adding up to 36 studied words. The 12 critical lures associated with these lists were also presented in the recognition test. Furthermore, another 24 non-studied words were selected from Roediger's (2001) study, 12 of which were critical lures and 12 that were words associated with each of these critical lures. Participants were presented with 72 words in total. Words were presented in groups of 12 [6 lists of 12 words]. Participants had to select and click on one of two buttons ("Yes" and "No"), presented below each word, whether they had seen it during the study phase of the recall test, or not. Lists and words were presented in the same order across participants. See the complete list in Appendix C.

3.4.4 PROCEDURE

Participants were sent an individual email with a link to access the research instrument. We sent them alphanumeric codes through which we identified them later. This ensured their participation was anonymous. After registering in *Lapsi,* the platform where the experiment was hosted, they agreed to the consent form. Next, they answered the *Language History Questionnaire.* Afterwards, participants received the following instructions about the recall test:

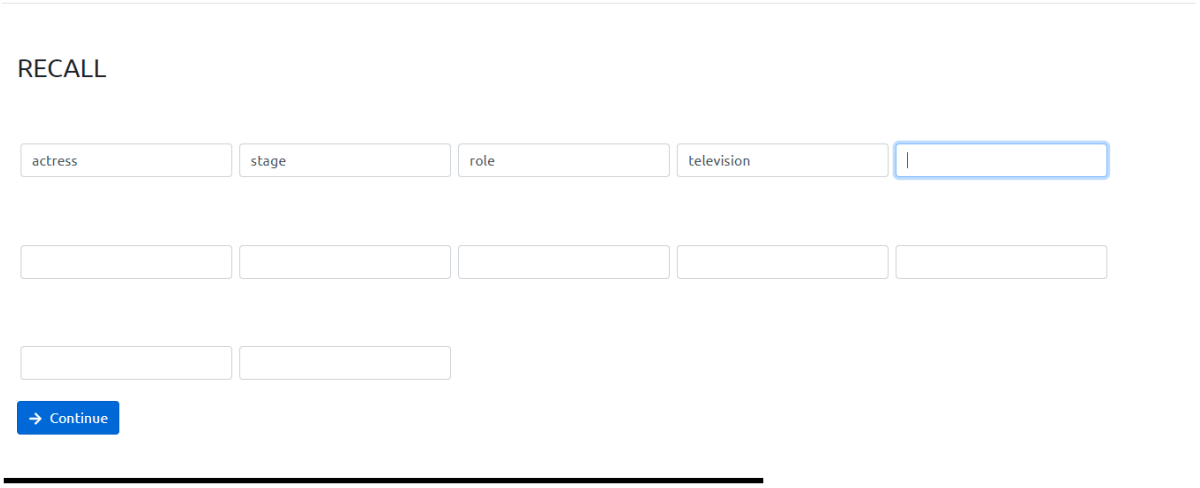
"In this recall task you will listen to lists of words. Please be sure the volume of your computer is loud enough for you to understand the words properly. Each list will start with a presentation of a plus sign (+) in the middle of the screen. This sign indicates a new trial. When you are ready to start a trial, press the spacebar to start hearing the list of words. After you listen to all the words in the list, a RECALL screen will appear and you should type as many words as you can remember from the list you just heard.

This is a memory test, so please pay attention and try your best at remembering the words. You should only type them after you hear the entire list (see Figure 3). Following these instructions is really important for the reliability of our experimental results. You will have one and a half minutes to type all the words you can recall. Afterwards, a new trial will begin with a plus sign, a new list will be presented and a RECALL screen will follow and so on.

You will first have a chance to complete practice trials to get familiar with the task. After those trials, the experiment will begin. When you are ready, press the spacebar."

Figure 3

Screenshot of the recall test

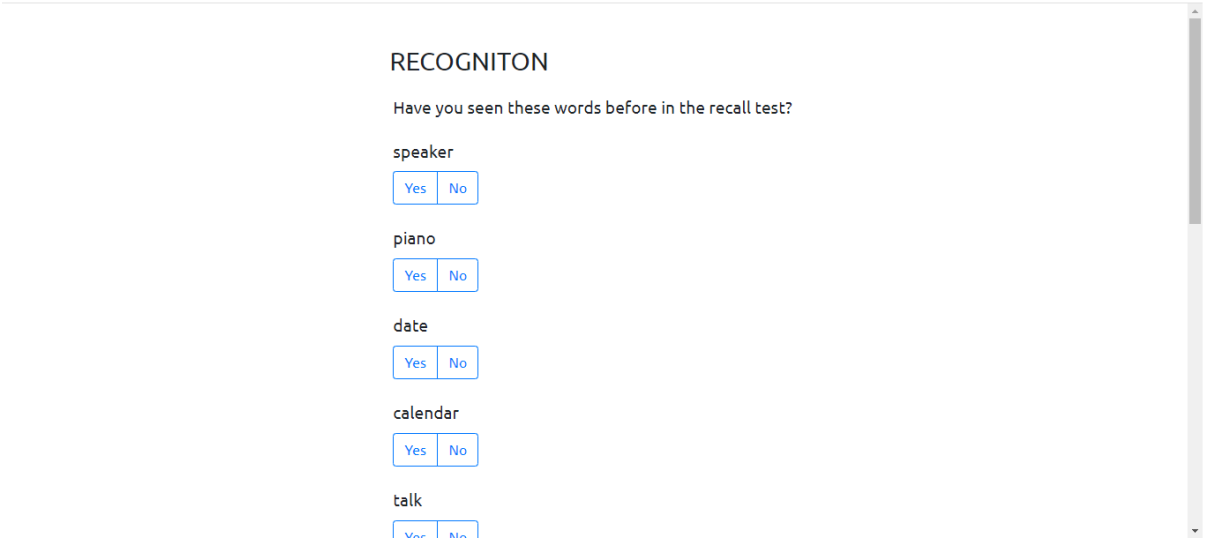


Participants then completed two practice trials and saw a screen that indicated the end of practice and asked them to press the spacebar to continue. When they finished all 32 lists, a screen announced it was the end of the recall test and instructed them about the recognition test. The instructions were the following:

"This is a memory recognition test related to the recall test you have just completed. On this recognition test, you will read each word below and decide whether you have seen it during the recall test you have just finished. If you believe you have seen the word before, please select 'yes'. If you believe you have not seen the word before, please select 'no'." See Figure 4.

Figure 4

Screenshot of the recognition test



The entire experiment was about two hours long. When participants finished all parts of the experiment, they were thanked again for their participation on the computer screen. Data was saved automatically on the platform's server and later downloaded, organized and analyzed.

4 RESULTS

4.1 Descriptive analyses

Descriptive analyses were conducted for every level of the independent variable, that is, the total amount of correctly recalled and recognized studied items, incorrectly recalled and recognized critical lures and incorrectly recalled and recognized unstudied items (See Table 4 and Table 5 below).

Table 4

Descriptive Statistics of Participants' Responses to Experimental Conditions in the Recall Test

	Mean recalled items (SD)*		
	Studied	Unstudied	Critical lure
Ambiguous cognate	99.8 (23.1)	5.14 (3.13)	0.862 (0.953)
Ambiguous noncognate	44.5 (10.1)	3.19 (2.87)	0.655 (0.857)
Unambiguous cognate	44.2 (9.79)	3.08 (2.94)	0.448 (0.632)
Unambiguous noncognate	45.7 (9.79)	2.41(1.50)	0.414 (0.568)

*Total number of words per condition: Ambiguous cognate: 168 (studied), 14 (critical lures); Ambiguous noncognate, Unambiguous cognate and Unambiguous noncognate: 72 (studied) each, 6 (critical lures) each.

Table 5

Descriptive Statistics of Participants' Responses to Experimental Conditions in the Recognition Test

	Mean recalled items (SD)		
	Studied	Unstudied	Critical lure
Ambiguous cognate	7.68 (0.979)	1.29 (1.01)	1.10 (0.790)
Ambiguous noncognate	7.19 (1.08)	1.77 (1.09)	1.39 (0.955)
Unambiguous cognate	7.65 (1.43)	1.32 (1.40)	1 (0.894)

Unambiguous noncognate	7.61 (1.26)	1.39 (1.26)	1.19 (1.05)

*Total number of words per condition: Ambiguous cognate, Ambiguous noncognate, Unambiguous cognate and Unambiguous noncognate: 12 (studied) each, 3 (critical lures) each.

Overall, participants performed well in both recall and recognition tests when it comes to correct recall of items: they correctly recalled studied items at an average rate of 61.4% (showing better performance in the unambiguous noncognate condition, reaching a rate of 63.5%) and accurately recognized studied items at an average rate of 84% (showing better performance in the ambiguous cognate condition, reaching a rate of 85.6%) (See Table 6).

However, in general, participants did not create high rates of false memories in neither tests: the average rate in the recall test for the critical lures was 7.8% (higher rate in the ambiguous noncognate condition: 10.9%). In the recognition test, the average rate was 39% (higher rate also in the ambiguous noncognate condition: 46,2%), which is a low rate considering the small number of items in the test. Finally, descriptive statistics indicate minimal discrepancies in all dependent variables between the cognate status and ambiguous status conditions for both tests.

Table 6

Descriptive Statistics of Participants' Responses to Experimental Conditions in the Recall Test

	Mean recalled items		
	Studied	Unstudied	Critical lure
Ambiguous cognate	59.1%	4.5%	6.16%
Ambiguous noncognate	61.8%	4.6%	10.9%
Unambiguous cognate	61.4%	2.5%	7.47%
Unambiguous noncognate	63.5%	0%	6.90%

Table 7
Descriptive Statistics of Participants' Responses to Experimental Conditions in the Recognition Test

	Mean recalled items (SD)		
	Studied	Unstudied	Critical lure
Ambiguous cognate	85.6%	14.4%	36.6%
Ambiguous noncognate	80.2%	19.8%	46.2%
Unambiguous cognate	85.3%	14.7%	33.3%
Unambiguous noncognate	84.6%	15.4%	40.2%

4.2 Inferential analyses

The following analyses were based in linear mixed-effect logistic models, with a significance level of $\alpha = .05$. *The R Project for Statistical Computing* (R Core Team, 2023) was the software that executed the analyses. At each step, two models were created: one with studied items as response and another with critical lures as response. First, possible effects of proficiency were tested and the variable was kept in further steps only if the effect was statistically significant. The same procedure was followed for orthographic similarity. Then, cognate status and ambiguity were included in the models, in the same step. Finally, interactions between cognate status and ambiguity were included and kept in the final models if they were statistically significant. Models failed to converge or resulted in singular fit with random intercepts for items and random slopes for predictors. Thus, all the models were fit only with random intercepts for participants.

4.2.1 EFFECTS OF PROFICIENCY

Previous studies show that proficiency can be a predictor of false memories; for that reason, before analyzing the independent variables, effects of proficiency were tested. In models where this variation was significant, it was maintained in subsequent models. For

studied items, both for recall (*log-odds* = 0.15; *p* = 0.191) and recognition tests (*log-odds* = 0.03; *p* = 0.691), there was no effect of proficiency (See Table 8 and Table 9, respectively). That indicates that proficiency was not a predictor for remembering studied words on the list.

Table 8

Fixed and random effects of proficiency on recall for studied items.

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-0.41	0.72	(-1.81, 1.00)	-0.57	0.570
proficiency	0.15	0.11	(-0.07, 0.37)	1.31	0.191

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.56

Model: recall ~ proficiency (9623 Observations). Residual standard deviation: 1.000 (df = 9620). Conditional R2: 0.092; Marginal R2: 0.006.

Table 9

Fixed and random effects of proficiency on recognition for studied items.

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.75	0.52	(-0.26, 1.77)	1.46	0.144
proficiency	0.03	0.08	(-0.13, 0.20)	0.40	0.691

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.27

Model: recognition ~ proficiency (1244 Observations). Residual standard deviation: 1.000 (df = 1241). Conditional R2: 0.021; Marginal R2: 3.155e-04.

A proficiency effect was also not observed for the critical lures in the recognition test (*log- odds* = -0.04; *p* = 0.814) (See Table 10). However, there was a statistically significant

effect of proficiency on the recall test (*log-odds* = 0.36 ; *p* = < .001) for critical lures (See Table 11 and Figure 5), which indicates that participants with higher levels of proficiency were more likely to create false memories in the recall test.

Table 10

Fixed and random effects of proficiency on recognition for critical lures

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-0.31	1.19	(-2.63, 2.02)	-0.26	0.795
proficiency	-0.04	0.19	(-0.42, 0.33)	-0.24	0.814

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.72

Model: recognition ~ proficiency (311 Observations). Residual standard deviation: 1.000 (df = 308). Conditional R2: 0.136; Marginal R2: 5.189e-04.

Table 11

Fixed and random effects of proficiency on recall for critical lures

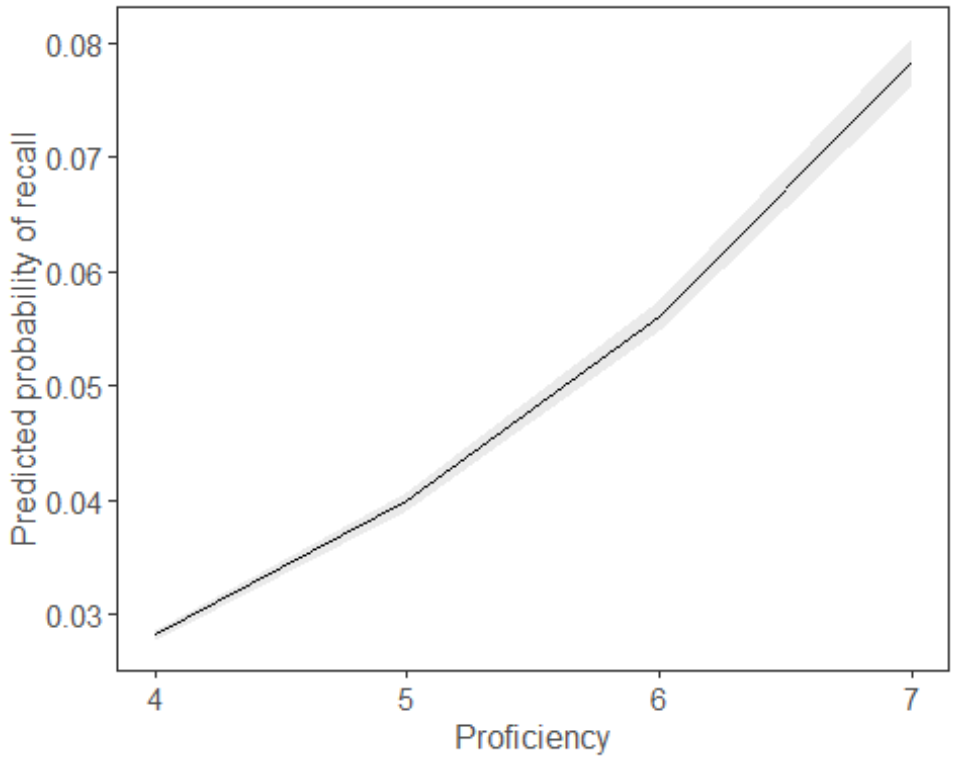
Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-4.91	2.14e-03	(-4.91, -4.90)	-2287.90	< .001
proficiency	0.36	2.15e-03	(0.35, 0.36)	166.18	< .001

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.62

Model: recall ~ proficiency (800 Observations). Residual standard deviation: 1.000 (df = 797). Conditional R2: 0.133; Marginal R2: 0.032.

Figure 5

Predicted probability of recall of critical items according to proficiency



4.2.2 EFFECTS OF SIMILARITY

As it was not possible to control whether the words that made up the lists were cognate or noncognate beforehand, it was calculated the Levenshtein distance between each item on the list and its translation to Portuguese in order to investigate if there was a possible effect of orthographic similarity. It would be possible, for example, that lists containing a greater number of words with greater similarity between languages would be remembered differently from lists with less similar words between Portuguese and English.

It was possible to observe a similarity effect for studied items, but only on the recall test (*log-odds* = -0.13; p = 0.049) (See Table 12 and Figure 6). This result shows that the more similar the studied items were to Portuguese, the less participants would recall them. There was no statistically significant effect of similarity on the recognition test (*log odds* = -0.32; p = 0.691) (See Table 13).

Table 12

Fixed and random effects of similarity on recall for studied items

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.53	0.11	(0.31, 0.75)	4.74	< .001
similarity	-0.13	0.06	(-0.25, -4.88e-04)	-1.97	0.049

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.58

Model: recall ~ similarity (11109 Observations). Residual standard deviation: 1.000 (df = 11106). Conditional R2: 0.092; Marginal R2: 4.326e-04.

Figure 6

Predicted probability of recall of studied items according to orthographic similarity

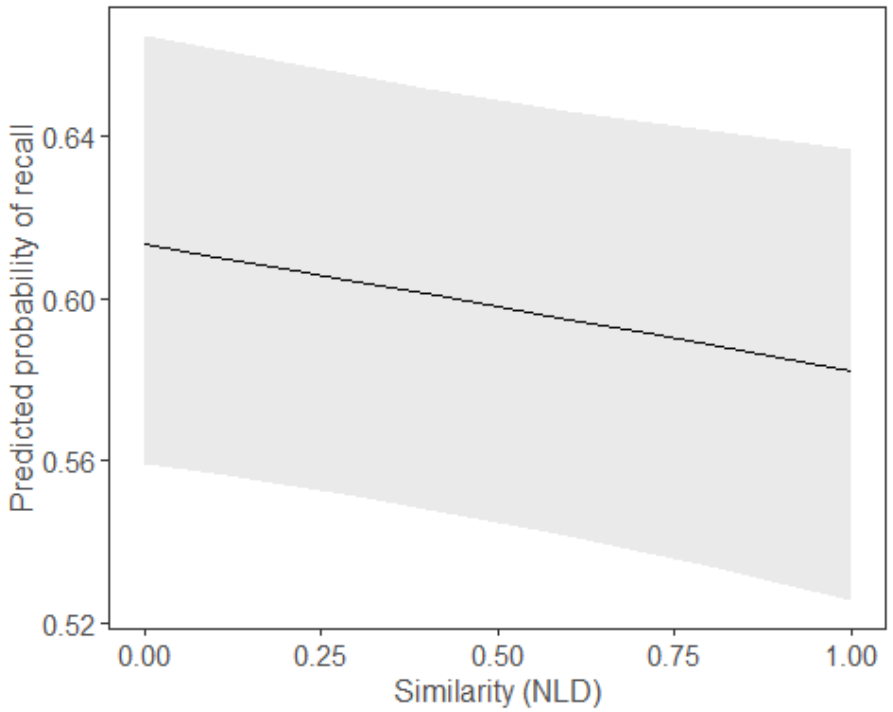


Table 13

Fixed and random effects of similarity on recognition for studied items

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	1.13	0.11	(0.92, 1.35)	10.26	< .001
similarity	-0.32	0.18	(-0.67, 0.03)	-1.78	0.076

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.28

Model: recognition ~ similarity (1484 Observations). Residual standard deviation: 1.000 (df = 1481). Conditional R2: 0.026; Marginal R2: 0.003.

On the other hand, for critical lures, a similarity effect was observed on the recognition test (*log-odds* = -0.64; *p* = 0.042) (See Table 14), and not in the recall one (*log-odds* = -0.17 ; *p* = 0.657) (See Table 15). This result shows that the more similar the studied items were to Portuguese, the less participants would recognize them, just as the result described for studied items in the recall test.

Table 14

Fixed and random effects of similarity on recognition for critical lures.

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-0.19	0.23	(-0.65, 0.26)	-0.83	0.408
similarity	-0.64	0.32	(-1.26, -0.02)	-2.03	0.042

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.76

Model: recognition ~ similarity (371 Observations). Residual standard deviation: 1.000 (df = 368). Conditional R2: 0.162; Marginal R2: 0.014.

Table 15

Fixed and random effects of similarity on recall for critical lures

Fixed Effects					
Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-2.65	0.26	(-3.15, -2.15)	-10.31	< .001
similarity	-0.17	0.39	(-0.93, 0.58)	-0.44	0.657

Random Effects	
Parameter	Coefficient
SD (Intercept: Participante)	0.75

Model: recall ~ similarity (899 Observations) Residual standard deviation: 1.000 (df = 896)
Conditional R2: 0.146; Marginal R2: 8.499e-04

4.2.3. EFFECTS OF COGNATE STATUS AND AMBIGUITY STATUS

On the recall test, statistically significant effects were observed for both studied items and critical lures. For studied items, there was a statistically significant effect of ambiguity status (*log-odds* = 0.11 ; *p* = 0.014) and orthographic similarity (*log-odds* = -0.13; *p* = 0.047), but not of cognate status (*log-odds* = 0.08 ; *p* = 0.052) (See Table 16). Regarding the ambiguity status, this result shows that participants were more likely to remember studied items when they were related to an unambiguous critical lure (See Figure 7). For critical lures, however, statistically significant effects of all three variables were observed: cognate status (*log-odds* = 0.26; *p* = < .001) (See Figure 8), ambiguity status (*log-odds* = -0.12; *p* = < .001) (See Figure 9) and proficiency (*log-odds* = 0.36 ; *p* = < .001) (See Table 17). Considering the cognate effect, participants would recall critical lures more frequently when they were noncognate, which was not expected. Nonetheless, participants would create more false memories when the critical lure was ambiguous, which was expected. In addition, proficiency was a predictor for recalling critical lures: the higher the proficiency level, the higher the possibility of creating false memories.

Table 16

Fixed and random effects of cognate status and ambiguity status on recall for studied items

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.46	0.11	(0.24, 0.69)	4.05	< .001
cognate status [non_cognate]	0.08	0.04	(-7.77e-04, 0.17)	1.94	0.052
ambiguity status [unambiguous]	0.11	0.04	(0.02, 0.19)	2.45	0.014
similarity	-0.13	0.07	(-0.26, -1.78e-03)	-1.99	0.047

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.58

Model: recall ~ cognate.status + ambiguity.status + similarity (11109 Observations). Residual standard deviation: 1.000 (df = 11104). Conditional R2: 0.093; Marginal R2: 0.002.

Figure 7

Predicted probability of recall of studied items according to ambiguity status

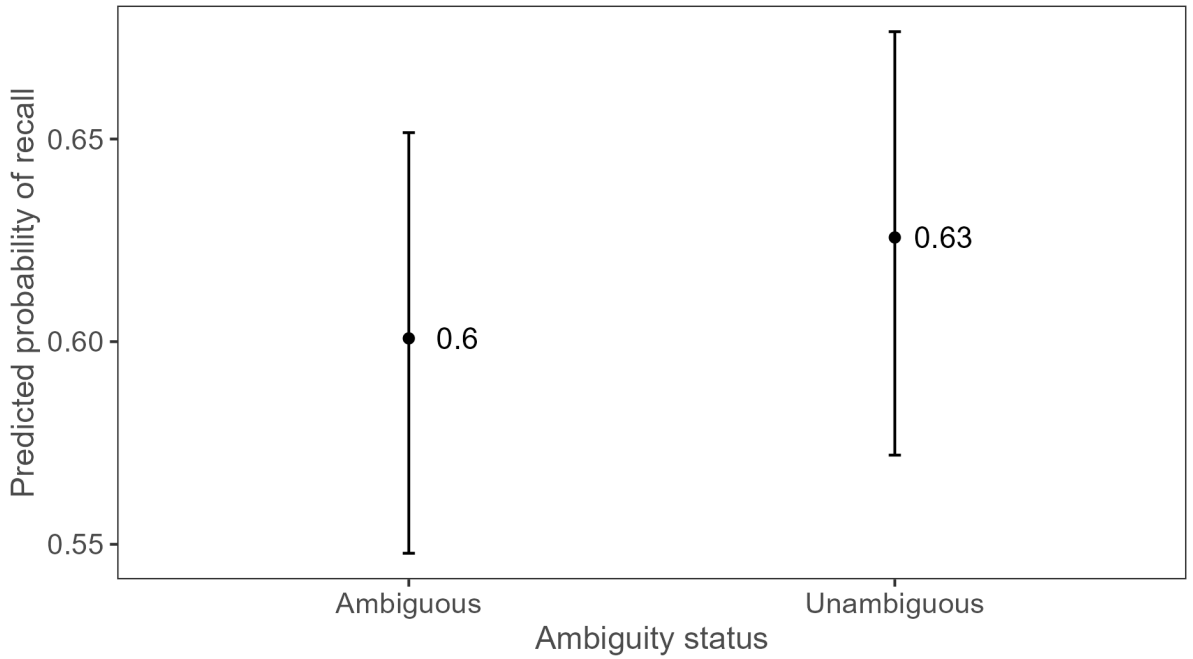


Table 17

Fixed and random effects of cognate status and ambiguity status on recall for critical lures

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-4.97	2.14e-03	(-4.97, -4.97)	-2319.03	< .001
cognate status [non_cognate]	0.26	2.14e-03	(0.26, 0.27)	122.85	< .001
ambiguity status [unambiguous]	-0.12	2.14e-03	(-0.13, -0.12)	-57.15	< .001
proficiency	0.36	2.15e-03	(0.35, 0.36)	166.55	< .001

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.62

Model: recall ~ cognate.status + ambiguity.status + proficiency (800 Observations) Residual standard deviation: 1.000 (df = 795). Conditional R2: 0.137; Marginal R2: 0.037.

Figure 8

Predicted probability of recall of critical lures according to cognate status

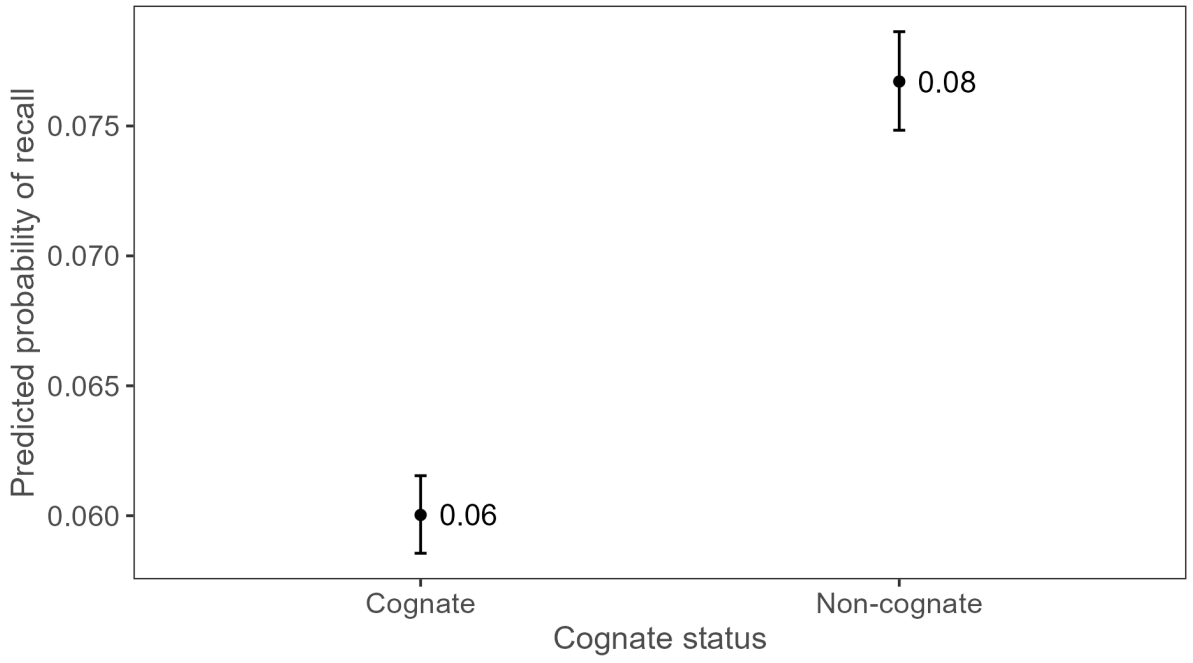
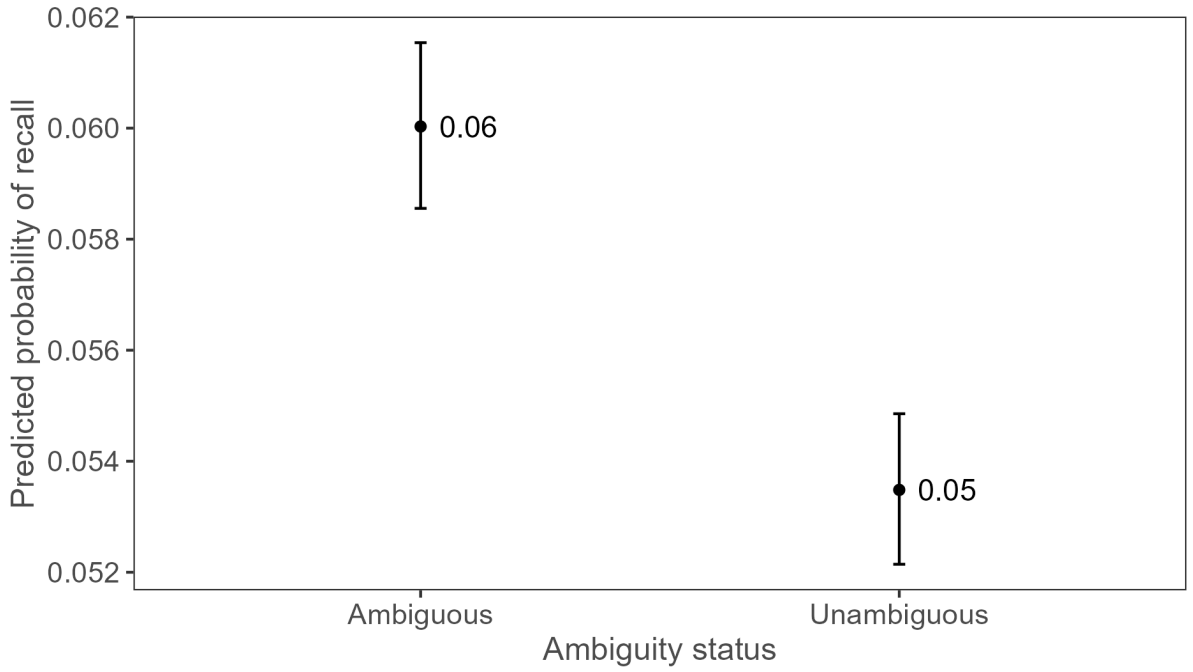


Figure 9

Predicted probability of recall of critical lures according to ambiguity status



Nonetheless, on the recognition test, there were no effects of cognate status nor ambiguity for neither studied items (cognate status: *log-odds* = -6.77e-03 ; *p* = 0.954; ambiguity: *log-odds* = 0.02 ; *p* = 0.861) (See Table 18) nor critical lures (cognate status: *log-odds* = -0.68; *p* = 0.397 ; ambiguity: *log-odds* = -0.24; *p* = 0.285) (See Table 19). Such results reveal that though manipulating studied items and critical lures, whether words were cognate or noncognate, ambiguous or unambiguous, it did not make a difference in the recognition test.

Table 18

Fixed and random effects of cog. status and ambiguity status on recognition for studied items

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.99	0.11	(0.77, 1.21)	8.73	< .001
cognate status [non_cognate]	-6.77e-03	0.12	(-0.24, 0.22)	-0.06	0.954

Parameter	Log-Odds	SE	95% CI	z	p
ambiguity status [unambiguous]	0.02	0.12	(-0.21, 0.25)	0.18	0.861

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.28

Model: recognition ~ cognate_status + ambiguity_status (1484 Observations). Residual standard deviation: 1.000 (df = 1480). Conditional R2: 0.023; Marginal R2: 3.485e-05.

Table 19

Fixed and random effects of cog. status and ambiguity status on recognition for critical lures

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.72	0.97	(-1.19, 2.62)	0.74	0.461
cognate status [non_cognate]	-0.68	0.80	(-2.25, 0.89)	-0.85	0.397
ambiguity status [unambiguous]	-0.24	0.23	(-0.69, 0.20)	-1.07	0.285
similarity	-1.56	1.12	(-3.76, 0.64)	-1.39	0.164

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.77

Model: recognition ~ cognate_status + ambiguity_status + similarity (371 Observations). Residual standard deviation: 1.000 (df = 366). Conditional R2: 0.169; Marginal R2: 0.020.

4.2.4. INTERACTION BETWEEN COGNATE STATUS AND AMBIGUITY STATUS

On the recall test, there was no statistically significant interaction between cognate status and ambiguity status for neither studied items (cognate status: *log-odds* = 0.09 ; *p* = 0.125 ; ambiguity: *log-odds* = 0.11 ; *p* = 0.055; cognate status x ambiguity status: *log-odds* = -5.56e-03 ; *p* = 0.949) (See Table 20) nor critical lures (cognate status: *log-odds* = 0.53 ; *p* =

0.129; ambiguity: *log-odds* = 0.21 ; *p* = 0.574; cognate status x ambiguity status: *log-odds* = -0.73 ; *p* = 0.208) (See Table 21).

Table 20

Fixed and random effects for interaction between cognate status and ambiguity status on recall for studied items

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	0.46	0.11	(0.24, 0.69)	4.03	< .001
cognate status [non_cognate]	0.09	0.06	(-0.02, 0.20)	1.53	0.125
ambiguity status [unambiguous]	0.11	0.06	(-2.24e-03, 0.22)	1.92	0.055
similarity	-0.13	0.07	(-0.26, -1.85e-03)	-1.99	0.047
cognate status [non_cognate] × ambiguity status [unambiguous]	-5.56e-03	0.09	(-0.18, 0.16)	-0.06	0.949

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.58

Model: recall ~ cognate.status + ambiguity.status + cognate.status:ambiguity.status + similarity (11109 Observations). Residual standard deviation: 1.000 (df = 11103). Conditional R2: 0.093; Marginal R2: 0.002.

Table 21

Fixed and random effects for interaction between cognate status and ambiguity status on recall for critical lures

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-4.99	1.39	(-7.72, -2.26)	-3.58	< .001
cognate status [non_cognate]	0.53	0.35	(-0.16, 1.22)	1.52	0.129
ambiguity status [unambiguous]	0.21	0.38	(-0.53, 0.96)	0.56	0.574
proficiency	0.34	0.22	(-0.08, 0.77)	1.60	0.111

Parameter	Log-Odds	SE	95% CI	z	p
cognate status [non_cognate] × ambiguity status [unambiguous]	-0.73	0.58	(-1.86, 0.40)	-1.26	0.208

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.62

Model: recall ~ cognate.status + ambiguity.status + cognate.status:ambiguity.status + proficiency (800 Observations). Residual standard deviation: 1.000 (df = 794). Conditional R2: 0.140; Marginal R2: 0.040.

Furthermore, similarly to the recall test, there was no statistically significant interaction between cognate status and ambiguity status for neither studied items (cognate status: *log-odds* = -0.08; *p* = 0.617; ambiguity: *log-odds* = -0.06; *p* = 0.737; cognate status x ambiguity status: *log-odds* = 0.15; *p* = 0.516) (See Table 22) nor critical lures (cognate status: *log-odds* = 0.45; *p* = 0.154; ambiguity: *log-odds* = -0.16 ; *p* = 0.624; cognate status x ambiguity status: *log-odds* = -0.13 ; *p* = 0.783) (See Table 23) on the recognition test.

However, it was expected that there would be interactions between cognate status and ambiguity status, for both recall and recognition tests. Taking into consideration all the conditions in the experiment for critical lures (ambiguous cognate words, ambiguous noncognate words, unambiguous cognate words and unambiguous noncognate words), it was likely that at least one of the conditions cited above would have higher potential to elicit false memories, and that would be the ambiguous cognate condition. Ambiguous cognate words such as *mold*, for instance, have semantic, orthographic and phonological overlap (the cognate status factor); in addition, they have more than one meaning (the ambiguity status factor). It was supposed to be an ideal combination for the creation of a false memory, based on the non-selective hypothesis.

Table 22

Fixed and random effects for interaction between cognate status and ambiguity status on recognition for studied items

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	1.03	0.13	(0.78, 1.28)	8.00	< .001
cognate status [non_cognate]	-0.08	0.17	(-0.41, 0.24)	-0.50	0.617
ambiguity status [unambiguous]	-0.06	0.17	(-0.38, 0.27)	-0.34	0.737
cognate status [ncog] × ambiguity status [namb]	0.15	0.23	(-0.31, 0.61)	0.65	0.516

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.28

Model: recognition ~ cognate_status + ambiguity_status + cognate_status:ambiguity_status (1484 Observations). Residual standard deviation: 1.000 (df = 1479). Conditional R2: 0.023; Marginal R2: 4.664e-04.

Table 23

Fixed and random effects for interaction between cognate status and ambiguity status on recognition for critical lures.

Fixed Effects

Parameter	Log-Odds	SE	95% CI	z	p
(Intercept)	-0.62	0.27	(-1.15, -0.10)	-2.34	0.019
cognate status [non_cognate]	0.45	0.32	(-0.17, 1.08)	1.42	0.154
ambiguity status [unambiguous]	-0.16	0.33	(-0.80, 0.48)	-0.49	0.624
cognate status [ncog] × ambiguity status [namb]	-0.13	0.45	(-1.01, 0.76)	-0.28	0.783

Random Effects

Parameter	Coefficient
SD (Intercept: Participante)	0.76

Model: recognition ~ cognate_status + ambiguity_status + cognate_status:ambiguity_status (371 Observations). Residual standard deviation: 1.000 (df = 366). Conditional R2: 0.161; Marginal R2: 0.013.

5 DISCUSSION

The objective of the present study was to investigate whether the cognate status and ambiguity status of critical lures influence the creation of false memories by Portuguese-English bilinguals, through the coactivation of Portuguese during a memory test in English. In order to do so, participants performed the DRM paradigm, listening to lists of semantically related words. In general, as seen in the results section, participants did not produce as many false memories as expected, neither in the recall test nor in the recognition test. In the current study, the average rate of false memories on recall was 7.8%, compared to 46% in Marmolejo *et al.*'s (2009) study. For recognition, the average rate was 39% compared to the range of 43% to 87% in previous studies (Anastasi *et al.*, 2005; Kawasaki-Miyaji; Yama, 2003; Bialystok *et al.*, 2020).

It was hypothesized that lists of words related to cognate critical lures would induce more false memories than lists of words related to noncognate critical lures, due to their stronger activation. Results of the recall test, however, showed the opposite of what was expected: participants were more likely to produce false memories when lists were related to a noncognate critical lure. One possible explanation for such an effect, according to the Fuzzy-Trace theory (Brainerd; Reyna 1996, 1998, 2002), could be that participants relied on *verbatim* traces for retrieval, which is the factual description, instead of meaning, in the DRM paradigm. Thus, cognates, which in the present study shared orthographic form between languages, could have been easier to distinguish as a non-studied item than noncognate critical lures precisely because of their stronger activation. It could also be that the lists of semantically related words establish a specific context, one with high constraints, which may have been capable of reducing language coactivation (Lauro; Schwartz, 2017; Schwartz; Kroll, 2006; Titone *et al.*, 2011). This result also goes in hand with Bialystok et al. (2020)'s study, where they found that phonologically related lists induced more false memories in bilinguals than in monolinguals, which could mean that participants in their study also relied more on the form of words instead of meaning associations.

On the other hand, for the ambiguity status of the critical lures, the hypothesis was corroborated. Bilinguals in the present study were more likely to create a false memory when the lists were associated to an ambiguous critical lure than when they were related to an unambiguous critical lure. Since ambiguous words carry more than one meaning, it is plausible to assume that the lexical competition between meanings caused bilinguals to create more false memories. Even though the chosen meanings of ambiguous words of the current

study were the dominant ones, lexical representations may not have been strong enough to deactivate subordinate meanings, thus creating competition. In other words, although the creation of a semantic context for the dominant meaning was carefully considered, it did not stop participants from activating the subordinate meaning of the ambiguous word. Such parallel activation of multiple meanings may have led bilinguals to create more false memories when lists were associated to ambiguous critical lures.

However, participants did well in the recall and recognition of studied items, just as in Riesthuis *et al*. 's (2019) and Marmolejo *et al.*'s (2009) recall tests and in Anastasi *et al*. 's 2005 (experiment 1, bilingual condition) recognition study. Furthermore, for studied items, there were effects of both ambiguity status and orthographic similarity of the list items in the recall test. Participants were more likely to recall studied items that were related to unambiguous critical lures than ambiguous ones (which goes hand in hand with the creation of more false memories for lists related to ambiguous critical lures). In regards to the orthographic similarity effect, it goes along the lines of the finding regarding recall of cognate critical lures: participants were more likely to recall studied words that were less similar across Portuguese and English than the more similar ones. That is despite a cognate status effect for studied items in the recall test. Therefore, the observed pattern of results is unlikely to be attributed to the influence of words with similar orthography in the lists. Still, it is worth noting that the frequency of words within the lists was not controlled (only critical lures had this aspect taken account), which can possibly indicate a frequency effect. To explore this further, future research should delve into this aspect.

Considering the level of proficiency of the participants, it was not observed any significant effect regarding studied items (similarly to Passos, 2018), which means that even with participants' higher knowledge of the second language, proficiency would not affect nor be an advantage for remembering words from the lists. Nonetheless, proficiency was a predictor for false memories (critical lure level) on the recall test, which aligned with Suarez and Beato's (2021) review of literature regarding the relationship between proficiency and performance on the DRM paradigm in a second language. In the present study, the likelihood of producing false memories increased with participants' self-rated proficiency, which suggests that a certain threshold of language knowledge is necessary for false memories to emerge in an L2.

Taking into consideration the tests themselves, the recognition test failed to present effects in some variables: there were no effects of cognate status and ambiguity status for neither studied items nor critical lures. It was expected that participants would have a higher

sense of familiarity with the words (relying on a gist trait) because they had previously studied them in the recall test. However, being presented to the lists previously was not enough in order to elicit the effects cited above. It might have been a matter of frequency (although less plausible) of the words that composed the lists. If the words were sufficiently frequent, it would have been easier for bilinguals to process them in their second language.

In addition, the recognition test was not listened to by the participants, only read. Even though phonological representations can be activated when reading a word in a second language (a spelling-sound correspondence in the case of cognate words, for instance) as it is explained in the BIA+ model (Dijkstra *et al*., 2002,), this was not a distinctive factor or facilitator of encoding and/or retrieving words in the recognition test.

On the other hand, the recall test was composed of lists that were listened to by the participants, not read. Phonological representations from one language can activate words in other languages (Jared; Kroll, 2001). Therefore, phonological input (alongside semantic and orthographic input) must have potentialized language coactivation in the recall test, playing a role and facilitating encoding and retrieving words.

6 CONCLUSION

This research had some methodological limitations. For instance, even though the DRM lists were created with the hope of keeping the natural semantic association of the English language for Portuguese-English bilinguals, they might just not be strong enough to replicate the results from other studies using simple translations of the original Roediger *et al*.'s 2001 study. Still considering the lists composition, some variables were controlled only for critical lure items. Nevertheless, due to the potential null effects arising from the quantity of cognates in the lists, orthographic similarity was included as a predictor in the linear mixed-effect logistic models.

There might also have been some limitations concerning the procedure of the experiments. Since the study was not performed in person, it was not possible to control if participants were actually paying attention to the experiment and not getting distracted or even taking breaks. They could also be taking notes on the words of the lists during the experiment. Besides, the number of participants was very low compared to other studies. For future studies, especially the ones that are executed on an online platform, there should be a way to keep track of what the participants are doing while participating in the study (in case they are doing something besides the experiment), or maybe insert a survey after the study, asking párticipants about it.

Regardless of limitations, the current study presents a new way to test language coactivation, that is, through the use of only one language during the DRM paradigm. Also, the lists crafted specifically for this study will be available for potential replications.

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Appendix A

L2 Language History Questionnaire (Version 3.0, 2015) See http://blclab.org/ for online use and credit

Participant ID: _____

1. Age (in years): _____

2. Sex (Circle one): Male / Female

3. Education (your current or most recent educational level, even you have not finished the degree) (Circle one):

- Graduate school (PhD/MD/JD)
- Graduate school (Masters)
- College (BA/BS)
- High school
- Middle school
- Other (specify):

4. Have you ever studied or learned a second language in terms of listening, speaking, reading, or writing? (Circle one):

Yes / No

5. Indicate your native language(s) and any other languages you have studied or learned, the age at which you started using each language in terms of listening, speaking, reading, and writing, and the total number of years you have spent using each language.

Language	Listening	Speaking	Reading	Writing	Years of use[a]

a. You may have learned a language, stopped using it, and then started using it again. Please give the total number of years.

6a. Country of residence: _____

6b. Country of origin: _____

6c. If 6a and 6b are different, then when did you first move to the country where you currently live? _____

7. If you have lived or travelled in countries other than your country of residence or country of origin for three or more months, then indicate the name of the country, your length of stay, the language you used, and the frequency of your use of the language for each country.

Country	Length of stay[a] [month(s)]	Language	Frequency of use[b]
			1 2 3 4 5 6 7
			1 2 3 4 5 6 7
			1 2 3 4 5 6 7
			1 2 3 4 5 6 7

a. You may have been to the country on multiple occasions, each for a different length of time. Add all the trips together.

b. Please rate according to the following scale (circle the number in the table)

Never	*Rarely*	*Sometimes*	*Regularly*	*Often*	*Usually*	*Always*
1	2	3	4	5	6	7

8. Indicate the age at which you started using each of the languages you have studied or learned in the following environments.

Language	At home	With friends	At school	At work	Language software	Online games

9. Indicate the language used by your teachers for instruction at each educational level. If the instructional language switched during any educational level, then also indicate the "Switched to" language.

	Language	(Switched to)
Elementary school		
Middle school		
High school		
College/university		

10. Rate your language learning skill. In other words, how good do you feel you are at learning new languages, relative to your friends or other people you know? (circle one)

Very poor	*Poor*	*Limited*	*Average*	*Good*	*Very good*	*Excellent*
1	2	3	4	5	6	7

11. Rate your current ability in terms of listening, speaking, reading, and writing in each of the languages you have studied or learned. Please rate according to the following scale (circle the number in the table)

Very poor	Poor	Limited	Functional	Good	Very good	Native-like
1	2	3	4	5	6	7

Language	Listening	Speaking	Reading	Writing
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

12. If you have taken any standardized language proficiency tests (e.g., TOEFL), then indicate the name of the test, the language assessed, and the score you received for each. If you do not remember the exact score, then indicate an "Approximate score" instead.

Test	Language	Score	(Approximate score)

13. Rate the strength of your foreign accent for each of the languages you have studied or learned. Please rate the strength of your accent according to the following scale (circle the number in the table):

None	Very weak	Weak	Moderate	Strong	Very strong	Extreme
1	2	3	4	5	6	7

Language	Strength of accent
	1 2 3 4 5 6 7
	1 2 3 4 5 6 7
	1 2 3 4 5 6 7
	1 2 3 4 5 6 7

14. Estimate how many hours per day you spend engaged in the following activities in each of the languages you have studied or learned.

	Language: _____	Language: _____	Language: _____
Watching television:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Listening to radio:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Reading for fun:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Reading for school/work:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Writing emails to friends:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Writing for school/work:	_____ (hrs)	_____ (hrs)	_____ (hrs)

15. Estimate how many hours per day you spend speaking with the following groups of people in each of the languages you have studied or learned.

	Language: _____	Language: _____	Language: _____
Family members:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Friends[a]:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Classmates:	_____ (hrs)	_____ (hrs)	_____ (hrs)
Coworkers[b]	_____ (hrs)	_____ (hrs)	_____ (hrs)

a. Include significant others in this category if you did not include them as family members (e.g., married partners).
b. Include anyone in the work environment in this category (e.g., if you are a teacher, include students as co-workers).

16a. Do you mix words or sentences from different languages when you speak? *(This includes, for example, starting a sentence in one language but using a word or phrase from another language in the middle of the sentence.)* (Circle one)

Yes / No

16b. If you answered "Yes" to 16a, then indicate the languages that you mix and estimate the frequency of mixing in normal conversation with the following groups of people. Please estimate the frequency of mixing according to the following scale (circle the number in the table):

	Language 1	Language 2	Frequency of mixing
Family members			1 2 3 4 5 6 7
Friends			1 2 3 4 5 6 7
Classmates			1 2 3 4 5 6 7
Coworkers			1 2 3 4 5 6 7

17. In which language do you communicate best or feel most comfortable in terms of listening, speaking, reading, and writing in each of the following environments?

	Listening	Speaking	Reading	Writing
At home				
With friends				
At school				
At work				

18. How often do you use each of the languages you have studied or learned for the following activities? Please circle the number in the table according to the scale below.

Never	Rarely	Sometimes	Regularly	Often	Usually	Always
1	2	3	4	5	6	7

Language	Thinking	Talking to yourself	Expression emotion[a]	Dreaming	Arithmetic[b]	Remembering numbers[c]
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

a. This includes shouting, cursing, showing affection, etc.
b. This includes counting, calculating tips, etc.
c. This includes telephone numbers, ID numbers, etc.

19. What percentage of your friends speaks each of the languages you have studied or learned? *(The total percentage should add up to 100%.)*

Language	Percentage
	%
	%
	%
	%

20a. Do you feel that you are bicultural or multicultural? *(This includes, for example, growing up with parents or relatives from different cultures or living in different cultures for extensive periods of time.)* (Circle one)

Yes / No

20b. If you answered "Yes" to 20a, then which cultures/languages do you identify with more strongly? Rate the strength of your connection in the following categories for each culture/language. Circle the number in the table according to the following scale.

None	Very weak	Weak	Moderate	Strong	Very strong	Extreme
1	2	3	4	5	6	7

Culture/Language	Way of life	Food	Music	Art	Cities/ towns	Sports teams
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

21. Please comment below to indicate any additional answers to any of the questions above that you feel better describe your language background or usage.

22. Please comment below to provide any other information about your language background or usage.

Appendix B

Stimuli used in the recall test, both critical lures and semantically related words in each list.

Critical lure	Condition	List of items
actor	unambiguous_cognate	movies television script oscars character actress artist role hollywood fame stage celebrity
diet	unambiguous_cognate	fat diabetic calories fit food eat weight healthy vegetables carbohydrates nutrition nutrients
hero	unambiguous_cognate	marvel superman powers dc brave savior fearless courageous mask fly duty help

piano	unambiguous_cognate	classical music orchestra Beethoven instrument keyboard notes talent harmony fingers songs strings
poet	unambiguous_cognate	poem literature writer rhyme rhythm inspiration emotions passion novel dreamer culture faker
symbol	unambiguous_cognate	icon code representation mark message concepts avatar riddle idols font brand badge

beauty	unambiguous_non_cognate	beautiful pretty handsome makeup elegance beast eyes natural inner stereotypes fair radiate
brick	unambiguous_non_cognate	wall concrete build hard material base shelter mud protection layer foundation cube
danger	unambiguous_non_cognate	risk criminals caution beware accident toxic explosive warning burglar hazard safety distress

farmer	unambiguous_non_cognate	plantation agriculture chickens harvester countryside cows lands horse apple organic field orange
holy	unambiguous_non_cognate	sacred bible jesus god saint religion miracle church christ trinity pray cross
rabbit	unambiguous_non_cognate	bunny easter alice animal carrot fluffy ears chocolate white eggs jumps teeth

Critical lure	Condition	List of items
arms	ambiguous_cognate	hands strength hugs armpits shoulders pulse elbows skin veins sports gloves tattoos
charm	ambiguous_cognate	talisman amulet jewerly bracelet necklace brooch gadget trinket bauble ornament adornment pin
contract	ambiguous_cognate	clauses business signature document law deal negotiate official commitment company pact compromise

current	ambiguous_cognate	nowadays now recent present today actuality modern contemporary news updated ongoing mood
date	ambiguous_cognate	calendar month day year deadlines birthday holiday period week late tonight era
figure	ambiguous_cognate	illustration picture image draw painting photograph art shadow comics geometry cards graphs

grave	ambiguous_cognate	cemitery funeral death mausolium dead coffin memorial zombies mourn tomb mortality necrosis
interest	ambiguous_cognate	want curiosity feeling desire like love attention wish eagerness romance joy will
letter	ambiguous_cognate	writing mailman type communication sending mail envelope email stamps pencil number postcard

mold	ambiguous_cognate	fungi humidity wet dirty allergy dirt old black warm stale mildew mustiness
plane	ambiguous_cognate	airplane flight trip passangers traveling aircraft pilot seats transportation wings cabinet steward
plant	ambiguous_cognate	root garden grow seed biologist herb soil cactus bush ivy stem shrub

rose	ambiguous_cognate	flower petals vase blossom pink bloom violet thorn daisy tulip dandelion lily
term	ambiguous_cognate	long short end period college university semester register test list school appointment
blue	ambiguous_non_cognate	sky sea color ocean beach lagoon navy space red shade green lilac

broke	ambiguous_non_cognate	break damaged crash repair destroyed glass shattered bones heart fragile fix crack
bullet	ambiguous_non_cognate	gun riffle shot bulletproof projectile weapon pistol murder gunpowder handgun caliber missile

foot	ambiguous_non_cognate	toes shoes walk feet sock boots run flipflops soccer sneakers nails football

speaker	ambiguous_non_cognate	speech spokesperson dialogue conversation voice talk orator person discourse interlector loud listener
watch	ambiguous_non_cognate	clock hours minutes time watchmaker wrist pointer twelve precision machinery pocket Swiss

Appendix C

Stimuli used in the recognition test: critical lures, studied semantically related words and critical lures and unstudied semantically related words from Roediger's (2001) study.

Critical lure	Condition	List of items
diet	unambiguous_cognate	fat eat nutrition
hero	unambiguous_cognate	marvel saviour duty
piano	unambiguous_cognate	classical keyboard songs
beauty	unambiguous_non_cognate	beautiful beast fair
brick	unambiguous_non_cognate	wall base foundation
danger	unambiguous_non_cognate	risk toxic safety
charm	ambiguous_cognate	talisman brooch adornment
date	ambiguous_cognate	calendar birthday tonight

figure	ambiguous_cognate	illustration photograph cards
blue	ambiguous_non_cognate	sky lagoon green
speaker	ambiguous_non_cognate	speech talk loud
watch	ambiguous_non_cognate	clock wrist pocket
bitter	–	sweet
butterfly	–	moth
city	–	town
trouble	–	bad
citizen	–	alien
cottage	–	cabin
king	–	dictator
sleep	–	wake

carpet	–	chair
bread	–	crust
rubber	–	latex
stove	–	coal