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The Bilingual Moses Illusion: Evidence for Semantic Illusions in Spanish-Catalan Bilingual Speakers

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Abstract

The tendency to overlook semantic inaccuracies in questions like 'How many animals of each kind did Moses take on the ark?', also known as the Moses illusion, was introduced into research almost forty years ago. However, the cross-linguistic validation of this effect has been limited, and studies regarding bilingual speakers are still sparse and controversial, even though some theoretical accounts predict that processing in a second language may modulate the rates of semantic illusions by either boosting or hindering the detection of inaccuracies. The present investigation specifically addressed these two concerns, firstly by examining whether the Moses illusion takes place in Spanish native speakers, and subsequently by exploring how it is elicited in the languages of early and highly proficient Spanish-Catalan bilingual speakers. Implemented in the form of a sentential judgement task for semantically correct and incorrect sentences adding the Self-Paced reading technique, the experiments' results revealed that the Moses illusion happened in Spanish (Experiment 1), and with no statistical differences across Spanish and Catalan (Experiment 2). These findings indicate that semantic illusions take place similarly in both languages of Spanish-Catalan bilingual speakers. Further research is required to consolidate these findings and to build a more solid conceptual framework for the bilingual Moses illusion and second language processing.

Keywords: Semantic illusions, Moses illusion, Sentential judgement task, Self-Paced reading technique, Language processing, Bilingualism

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Introduction

The study on the Moses illusion

Back in 1981, Thomas Erickson and Mark Mattson provided the first scientific demonstration of what they called the 'Moses illusion'. In this type of semantic effect, when people read or listen to the question 'How many animals of each type did Moses take in the ark?', they normally do not notice that it was not Moses but Noah who took the animals in the ark. In consequence, under experimental conditions in which participants are instructed to point out mistakes, subjects still answer '2' failing to realize there was a semantic inconsistency in the original question. As significant as this finding was, it introduced a prosperous line of research on semantic illusions, providing very important insights on why the information that individuals process is not exhaustively inspected for semantic adequacy. Ultimately, the investigation regarding the Moses illusion offers a rich perspective on the mechanisms involved in language comprehension.

Not only did Erickson and Mattson (1981) develop the first systematic study on the topic, but also performed several experiments searching into some of the mechanisms that could be responsible for the Moses illusion. In their first experiment, they intended to rule out the assumption that the critical incorrect term (i.e., 'Moses') had not been encoded by the subjects, asking them to read the sentences out loud. They still found that the participants fell for the Moses illusion, so they concluded that the incorrect segments are at least minimally processed by the readers. Secondly, the authors converted the questions into statements that needed to be categorized as 'correct' or 'incorrect', and reported that the illusion still took place, although in a notable lower proportion. They resolved that the effect appears regardless of the phrasing type (questions or statements), and that it was not related with the position of the incorrect term in the phrase, therefore not due to a misdirection of the attentional focus. Also, the authors discarded the hypothesis of it being a result of an implicit cooperative principle of communication (Grice, 1975) causing subjects to not speak up in front of distortions, since the illusion still took place when the task required them to point out mistakes. Finally, they provided important insights on how this illusion is most likely caused by the semantic similarity between the inaccurate term (i.e., 'Moses') and the correct one (i.e., 'Noah'), rather than its phonological relatedness. Altogether, Erickson and Mattson's (1981) original findings and their interpretations set the starting foundations of the field and triggered subsequent investigations that continued to test some of their postulations.

Part of such posterior studies expanded on the idea that the Moses illusion was due to a misdirection of the attentional focus during processing. In this regard, Baker and Wagner (1987) criticized how the original study by Erickson and Mattson (1981) disregarded the focus of attention hypothesis by transforming the questions into sentences. Baker and Wagner (1987) argued that "even in an assertion, some propositions are regarded as focal or new information and others as presupposed or given information" (p. 248), and these are prone to misdirect attention, as it happens for instance in cleft sentences. In this sense, Bredart and Modolo (1988) explored the illusion creating cleft sentences that placed the inaccurate term in the focus of attention, which resulted in an increase in the rates of detection of incorrect terms. Reportedly, some other manipulations related with the focus of attention, such as capitalizing the critical term, also made the detection of inaccuracies more likely (Bredart & Docquier, 1989). In conclusion, at least for part of the literature, the focus of attention seemed to play an important role in eliciting the Moses illusion.

In parallel, a blooming line of research progressed claiming that the central cause of the Moses illusion was the semantic relation between the terms included in a statement. These studies did not neglect the relevance of the focus of attention, but argued that such description did not invalidate the main thesis of Erickson and Mattson (1981), namely that semantic relatedness directly affects the occurrence of the semantic illusion (Van Oostendorp & De Mul, 1990). Soon after the original publication, authors like Lynne Reder started to write about insufficient "matches" of memory probes to the subjects' memory representations when describing the Moses illusion (1987, p. 93). Further studies in the immediate posterior years continued to understand the illusion as a tendency to overlook inaccurate terms once they are sufficiently related to the semantic context of the sentence to assume cohesion (Reder & Cleeremans, 1990; Van Oostendorp & De Mul, 1990). All these insights led to the Partial Match Hypothesis (Kamas et al., 1996; Reder & Kusbit, 1991), stemming from the significance of semantic relatedness and inspired in contemporary models of semantic networks. Under this assumption, comprehension mechanisms perform an effortless strategy of partially matching the sentence probe to memory representations, in order to reach a vague cohesion criterion that allows further processing. As an instance, in sentences like 'Two animals of each type were taken to the ark by Moses', the term 'Moses' has semantic features which are very similar to those of 'Noah', and that adequately match the semantic context of the sentence. In consequence, the statement meets the minimal cohesion criterion for the reader or the listener, and it is therefore incorrectly assumed to be semantically accurate. Not only is this hypothesis a well-founded explanation for the Moses illusion, but it also

accentuates the adaptiveness of language comprehension mechanisms. Loosening the criterion for exhaustively recognizing pieces of information is a heuristic that enables speeded-up processing (Kamas et al., 1996). In essence, the Partial Match Hypothesis is clearly a postulate about the pragmatics of language processing.

During the last two decades, the study on semantic illusions has seen some sparse progress. While Hannon and Daneman (2001) took an individual-differences perspective in regards to the Moses illusion and found that long-term memory access and working memory capacity could be relevant, Cantor and Marsh (2016) reported that expertise in the sentences' domain may also play a role, although not preventing semantic illusions from taking place. Recently, Speckmann and Unkelbach (2020) even introduced the subjects' motivation as a variable and still reported that money incentives do not significantly change the probability of falling for the illusions. Importantly, Song and Schwarz (2008) pointed out that font readability restrained the occurrence of semantic illusions, since when the text was more difficult to read, processing fluidity was affected, making the recognition of inaccuracies more likely. However, one of the latest publications on the Moses illusion has failed to replicate the positive effects of font readability on the detection of inaccuracies (Janouskova et al., 2022). On the other hand, some other relevant models were raised, such as Shafto and MacKay's (2000) Node Structure Theory (NST), in which not only semantic but also phonetic relatedness is integrated to prompt semantic illusions. This model instigated an abandonment of pure semantic theories like the previously-described Partial Match Hypothesis, and more recent findings even highlight non-linguistic factors like visual concepts to be involved in semantic illusions (Davis & Abrams, 2016). In sum, during the last years, some other variables such as expertise, fluidness of processing, phonological relatedness and other non-linguistic features of concepts have been significantly integrated in the study of the Moses illusion.

Nevertheless, during these forty years of investigation on semantic illusions, researchers seem to have dismissed languages other than English, not to mention the nature of the well-extended multilingual population. The Moses illusion has traditionally been described as "generalizable" (Erickson & Mattson, 1981, p. 541), "robust" (Hannon & Daneman, 2001, p. 449) or "persistent" (Van Oostendorp & De Mul, 1990, p. 36). However, as reported in Table 1, the majority of the above-mentioned studies have been dedicated to test semantic illusions exclusively in English. Not only that, but these investigations almost never provided explicit notes on the sociolinguistic conditions of the participants they recruited, ignoring the fact that their subjects might have been competent in languages other

than English, or that possibly English was not even their first language. This situation reflects a significant empirical and population void in the study of the Moses illusion. Nonetheless, for such a recent line of research it is of no surprise that there is a research gap in the domain of multilingualism. Important statements like that of Grosjean (1989) manifesting the uniqueness of the bilingual condition (i.e., 'The bilingual is not two monolinguals in one!') were almost contemporary to the blooming of Moses illusion's research. In contrast, given that currently monolinguals are the exception and that socio-economic conditions will trigger an increase of multilingualism in the following years (Ansaldo & Saidi, 2014), these research gaps cannot remain unattended. Bridging these cross-linguistic and population gaps in areas as relevant as language comprehension is now of main relevance.

Table 1. *Revision of the most important studies on the Moses illusion considering the languages and subjects examined.*

Study	Language of materials	Language/s of tested subjects
Erickson & Mattson, 1981	*English*	*Native speakers of English*
Baker & Wagner, 1987	English	English speakers
Bredart & Modolo, 1988	*French*	*Native speakers of French*
Van Oostendorp & De Mul, 1990	Undetermined	Undetermined
Reder & Cleeremans, 1990	*English*	English speakers
Reder & Kusbit, 1991	*English*	*Native speakers of English*
Kamas et al., 1996	English	*Native speakers of English*
Shafto & MacKay, 2000	English	English speakers
Hannon & Daneman, 2001	English	English speakers
Song & Schwarz, 2008	English	English speakers
Cantor & Marsh, 2016	*English*	English speakers
Davis & Abrams, 2016	English	*English speakers*
Speckmann & Unkelbach, 2020	English	English speakers

Note: Information presented in *italics* means that it was explicitly stated in the study. The remaining available data, which is not presented in italics, was inferred from the language of the country where the investigations were carried out (mainly in the US).

Bilingualism and the Moses illusion

As much as most domains of language processing need to be investigated from a bilingual perspective, specifically, why should the Moses illusion manifest differently in each

language of a bilingual or a multilingual speaker? At first glance, it could seem that the language in which a question is presented to a subject should not play a role as long as the person holds the knowledge required to answer. However, to the extent that the Moses illusion has been related to variables such as the semantic relatedness between the terms in a sentence, the attentional focus during processing, or the associated costs of readability, it is not trivial to expect differences when comparing the several languages of a bilingual speaker, especially if proficiency in each language is taken into consideration. All in all, the influence of these important variables could be moderated by the language in which the statement is presented.

Precisely, one important study mentioned in the previous paragraphs described how when reading was less fluid, manipulated through font readability, the rates of detection of inaccuracies increased (Song & Schwartz, 2008). Reading in a secondly-learned language, in which readers have less proficiency, could have some positive effects analogous to such manipulation. Insofar as L2-reading has been related to a higher cost in unbalanced bilinguals (Cop et al., 2015), it might induce a more elaborate processing, and then more attentiveness to inaccurate terms. Such tentative proposal has been referred to as the 'cognitive fluidity' (Costa et al., 2014) or 'controlled-processing' (Geipel et al., 2015) hypotheses in other areas like decision making in a second language. In this domain, there is a well-supported 'Foreign Language Effect' (Cipolletti et al., 2015; Costa et al., 2014; Hayakawa et al., 2016) attributing a more rational processing style to the second language. The extension of such an effect to the bilingual Moses illusion could mean that reading distorted sentences or questions in a second less-proficient language increases the chances of detection because of a more controlled strategy induced by the costs of processing.

Conversely, such associated cost in a second language could hinder rather than facilitate the detection of inaccuracies in semantic illusions. The higher cognitive load when processing pieces of information in a foreign language could make the criteria for establishing semantic cohesion even more lenient, inducing a larger rate of semantic illusions. This other tentative hypothesis has been referred to as the 'cognitive load' (Costa et al., 2014) or 'automatic-processing' (Geipel et al., 2015) hypotheses, again in the decision-making domain. Findings in such paradigm have given more support to the former hypotheses described in the paragraph above rather than to this second premise. However, as Costa and his colleagues (2014) claim, the Foreign Language Effect could be limited to materials with an emotional component. In particular, Białek and colleagues (2020) have recently provided evidence that logic reasoning in a foreign language is deteriorated: for

these authors, processing in a second language limits conflict detection between intuitions and therefore makes further reflection less likely. Regarding the Moses illusion, second-language processing could similarly prompt a higher standard for further examining the premises, hence increasing the rates of the semantic illusion. In other words, in non-emotional sentences like those included in typical experiments testing the Moses illusion, this second hypothesis could still find support.

Very few publications have attained the bilingual population gap described above in the study of the Moses illusion. The first instance corresponds to the study developed by Geipel and her colleagues (2015), which briefly examined the illusion in native speakers of Italian (L1) that were late learners of German (L2). Importantly, subjects only performed the typical Moses illusion task in one of the two languages, Italian or German, therefore comparisons could not be made subject-by-subject. Their results revealed that, in the Italian task, around 35% of the participants recognized mistakes in incorrect sentences, while in the German task the percentage decreased to approximately 16%. In other words, conducting the experiment in German increased the rate of illusions, although the effect was only marginally significant. A second study performed some years later by Vaessen (2017) investigated native speakers of Dutch (L1) that were late learners of English (L2), additionally providing objective measures on the subjects' competence in English. In her first study, when subjects were asked to point out mistakes in incorrect sentences, a significantly larger rate of illusions was reported for the second language in comparison with the first. However, when the second study applied the Rapid Serial Visualization technique for the same sentential judgment task, no differences were observed across the two languages. This was true for the rates of semantic illusions, but also for the response times in the sentences that elicited semantic illusions. Putting these findings together, although the type of task implemented seems to have an influence in how the semantic illusion is elicited across languages, significant differences in the Moses illusion between the languages of unbalanced bilingual speakers have only been sparsely reported.

During the last year, two new studies have been developed aiming to test the same principle: whether less-proficient second languages produce the Moses illusion to the same extent the first language does. Dhaene and her colleagues (2021) have recently published an exhaustive investigation on the matter, examining bilingual subjects that were native speakers of Dutch (L1) and had achieved a considerable competence in English (L2), additionally integrating eye-tracking techniques. Their results reveal a significantly larger rate of illusions in the subjects' foreign language in comparison with their native language. Complementarily,

considering all sentences included in the experiment, English reading times were significantly larger those of Dutch, reflecting an added cost of processing for the second less-proficient language. However, reading patterns measured in number of fixations, word skipping, and regressions, were not different across languages when subjects analysed incorrect statements. In parallel, another recent investigation carried out by Fernandes and her colleagues (2022) tested Portuguese native speakers that were proficient in German as a second language. The authors reported a larger rate of semantic illusions in the subjects' second language, attributing it to an increased cost of processing in that language. Regarding the reading time measures of the incorrect sentences that produced semantic illusions, subjects spent significantly more time reading them in German than in Portuguese, indicating that there was an added processing cost which was not translated into a higher detection rate of semantic errors for this second less-proficient language. On the whole, although literature on the bilingual Moses illusion is still scarce, during the last years it has reported a higher percentage of illusions in a foreign language in comparison with the native one. Therefore, recent research apparently directs the discussion to the 'cognitive load' hypothesis, supporting that processing in a second language entails a notable cognitive effort that restrains semantic cohesion analysis.

Nevertheless, further investigation addressing different types of bilingual populations is required to establish clear conclusions from this paradigm. The studies described above have only tested bilingual speakers which were unbalanced considering their proficiency in each language. Importantly, models claiming that individuals' access to semantic information from a second language is more limited when they are less proficient in such language are not unfamiliar. For example, Kroll and Stewart (1994) could argue that studies reporting a higher percentage of semantic illusions in a less proficient language are representing an increased difficulty in accessing semantic features, hence impeding a proper analysis of the terms' adequacy to the sentence context. The conclusions coming from such well-based models should be considered side to side with any of the two tentative hypotheses described previously. In consequence, even though studies analysing unbalanced bilinguals are relevant, investigation on the whole spectrum of bilingual speakers is still necessary in order to contrast findings from different types of bilingualism and to further develop the bilingual Moses illusion field.

Finally, apart from proficiency, it should be noted that some other sociolinguistic variables have been crucial for other domains in the study of bilingual processing. As cited above, the more rational and less emotional processing for the second language suggested by

the Foreign Language Effect (Costa et al., 2014) does not stem from a difference in proficiency but from a difference in the psychological distance between the languages of a bilingual speaker. In other words, the effect is mostly due to a difference in the emotionality of each language, mainly determined by their associated uses and forms of acquisition. Additionally, research also shows that spontaneous visual simulation of concepts' features is different between languages of a bilingual speaker (Norman & Peleg, 2021), once again not because of a difference in proficiency but because of a difference in the use and acquisition of each language, leading to divergent embodiment capacities. The ability to simulate different features of concepts could play a role in the Moses illusion, as far as it has been reported that visual features of concepts also influence these illusions (Davis & Abrams, 2016). In sum, proficiency is not the only potential variable causing differences in processing across languages. Actually, research in the domains of decision-making and embodiment shows that other factors are more relevant for their paradigms, namely the use and form of acquisition of each language, and it is plausible that these could influence the Moses illusion in bilingual speakers too.

The current investigation

The present investigation specifically addressed the research gaps described in the last sections, developed in two separate experiments. Firstly, as the Moses illusion has never been tested in Spanish, there is still no empirical evidence of the effect taking place in such language. Experiment 1 was therefore conducted to validate the generalizability of the effect to Spanish, and to test the performance of the materials that were adapted for the present investigation. This study set the foundations for Experiment 2, which examined how semantic illusions were elicited in early and highly proficient Spanish-Catalan bilingual speakers.

Conducted with parallel methodologies, both Experiments 1 and 2 included the typical Moses illusion task as a sentential judgement task applying the Self-Paced Reading technique. In this sense, both groups of participants were asked to read sentences segment-by-segment, judge whether the sentences were semantically correct or incorrect and, at the end of all trials, answer to some post-test questions checking that they held the knowledge required for the main sentences. On this basis, it was accepted that a semantic illusion happened when subjects failed to notice the inaccuracy in an incorrect sentence (i.e., they answered saying that the sentence was 'correct') when they reportedly knew the right answer, as indicated by their response in the corresponding post-test question. For instance, a

semantic illusion would take place if participants answered that the sentence 'During the flood in the Old Testament, Moses took pairs of animals in an ark' is correct, and then in the corresponding post-test question 'Which biblical figure took animals in an ark during the flood?' they correctly answered that it was Noah.

The two experiments to be presented in the following pages provide important novelties to the study of the bilingual Moses illusion. By testing the degree in which semantic illusions are elicited in each language of early and highly proficient bilingual speakers, this investigation broadens the spectrum of bilingual speakers tested up to date. To the best of the author's knowledge, no other study in this line has focused on early bilingual speakers with a high competence in both of their main languages, nor extended the Moses illusion investigation to Spanish and Catalan.

Experiment 1

In the first experiment, Spanish native speakers were tested to validate that semantic illusions also take place in Spanish, and to evaluate the adequacy of the materials adapted for the present investigation in eliciting these illusions. Eventually, the results of this preliminary experiment would also serve as a basis for Experiment 2, and even allow comparisons across the two studies.

Since it was hypothesized that the Moses illusion must happen in Spanish as in the rest of the languages, semantic illusions were expected to be elicited for native speakers of Spanish. Previous studies on semantic illusions have also alleged that, when semantic illusions take place, incorrect statements are integrated and processed as if they were correct (Kamas et al., 1996). In this sense, and taking reading time measures as indicators of this integration process, it was further hypothesized that no differences should arise between the reading times of correct sentences that are adequately recognized and incorrect sentences that elicit semantic illusions.

Method

Participants

Initially, 36 native speakers of Spanish with no competence in Catalan took part in the experiment. Out of such participants, approximately 81% were university students at the time they completed the study, while the rest of the sample comprised young workers of diverse areas. All subjects decided to complete the experiment voluntarily. Additionally, selection criteria for participating in this experiment was to not have any knowledge of Catalan, not

even having tried learning it or having lived in a Catalan-speaking region, in order to eventually be able to contrast the performance of this group with that of the bilingual group tested in Experiment 2.

The process of cleaning of data (see *Pre-processing of data*) derived in the removal of three subjects, resulting in 33 participants (M_{age} = 22.91, SD_{age} = 1.26; 21 females; 31 right-handed individuals) to be finally included in the experiment. The description of this final sample in several sociolinguistic variables regarding Spanish is reported in Table 2, according to the subjects' own responses for a sociolinguistic questionnaire (see *Materials*).

Table 2. *Mean estimators of the main sociolinguistic measures regarding Spanish of the participants in Experiment 1 (standard deviations between parenthesis).*

Exposure frequency	0.79 (0.16)
Reading preference	0.73 (0.19)
Speaking preference	0.71 (0.26)
Cultural identification	0.82 (0.23)
Frequency of use	0.85 (0.11)
Proficiency (self-rated)	0.95 (0.07)

Note: All quantitative measures ranged from 0 to 1. For EXPOSURE FREQUENCY, 0 reflects absolutely no exposure to the language, and 1 reflects full exposure to the language. For READING and SPEAKING PREFERENCE, 0 means the subjects would never choose to read or speak in the language, and 1 means they would always choose the language. For CULTURAL IDENTIFICATION, 0 denotes null identification with the culture of the language, and 1 denotes complete identification with the language's culture. For FREQUENCY OF USE, 0 indicates no use of the language in any area, and 1 indicates full use of the language in all areas. For PROFICIENCY, 0 reveals null self-rated knowledge of the language and 1 reveals perfect self-reported competence.

Materials

Stimuli. A total of 74 target items were used for the present research. Some of the sentences were translated and adapted from those used in other studies (Buades-Sitjar et al., 2021; Dhaene et al., 2021; Fernandes et al., 2022; Kan et al., 2010; Reder & Kusbit, 1991; Vaessen, 2017), and some others were originally developed. Each item contained a critical term that appeared in a varying position across sentences, this is, it was not always present in the same fixed position. Such critical word was therefore replaced to construct the incorrect version of each item. This variation could include the substitution of a noun (e.g., '*vehículo'* – '*peatón'*, in English 'vehicle' – 'pedestrian'), numeral (e.g., '*doce'* – '*diez'*, in English 'twelve' – 'ten'), adjective (e.g., '*italiana'* – '*francesa'*, in English 'Italian' – 'French') or verb (e.g., '*dividir'* – '*multiplicar'*, in English 'divide' – 'multiply') with a semantically or

phonetically related word of the same grammatical category. In consequence, all 74 target items had two versions (TYPE): correct or incorrect. All the items in their two Spanish versions are available in Appendix A.

The correct and incorrect versions of each item were closely similar in sentence length as well as in their critical terms' length, measured in number of characters (ps > 0.05). Additionally, these critical words were generally gender and number congruent across their versions. The analysis of the frequency of such words, estimated using the EsPal/SUBTLEX-CAS corpus (Duchon et al., 2013), revealed no significant differences across the two versions, $t(115) = 0.180$, $p = 0.858$. Full measures of the items' features are available in Table 3.

Table 3. *Mean estimations of the properties of Spanish target sentences by VERSION (standard deviations between parenthesis).*

	Correct version	**Incorrect version**
Sentence length[1]	96.30 (10.78)	96.42 (10.91)
Critical word length[1]	7.28 (3.17)	7.42 (3.71)
Critical word frequency[2]	3.98 (0.86)	3.95 (0.88)

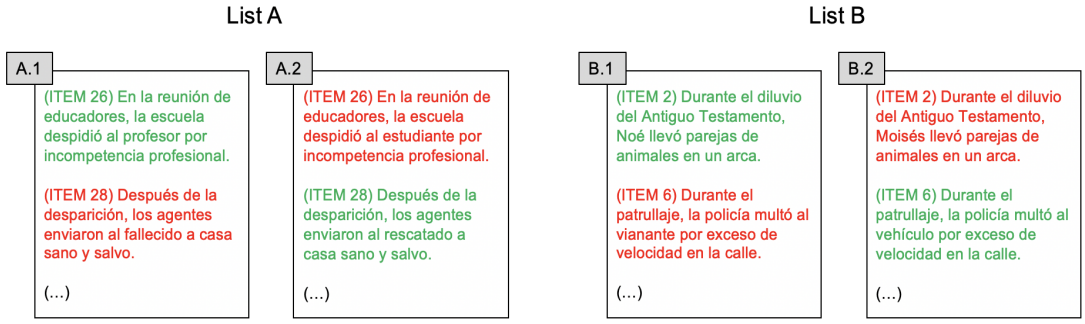
[1] Sentence and critical word length are expressed in number of characters; [2] Frequency of the critical word is expressed in the logarithm scale of frequency values.

Another 74 filler items were used in the present study, available in Appendix B. These were also in part adapted from those of previous research (Buades-Sitjar et al., 2021; Dhaene et al., 2021; Fernandes et al., 2022; Vaessen, 2017), and originally constructed. They were fixedly correct or incorrect, and intentionally shorter than target sentences in order to prevent subjects from becoming fatigued during the experiment. Accordingly, an independent-measures T test comparing the length of target and filler sentences revealed significant differences, $t(146) = 23.592$, $p < 0.001$, $d = 3.88$.

Both target and filler items were related to some theme categories, available in their corresponding appendices (*Appendix A* and *Appendix B*, respectively). Some of these sentences required basic semantic knowledge (for instance, in item 48, that lightnings in storms are *seen* and not *heard*), and the rest were related to general world knowledge themes such as history, geography or literature. All items were divided into two lists (*A* and *B*) containing the same number of items for each category. The two lists included 37 filler sentences and 37 target sentences, out of which 19 were presented in the correct version and the remaining 18 were incorrect. Therefore, each of the lists had two subsets (for list *A*, *A.1*

and *A.2*; for list *B*, *B.1* and *B.2*) according to the version of the target sentences: in one subset, half of the target sentences were correct, and in the inverse subset those target sentences were incorrect. For instance, as represented in Figure 1, item 26 in subset *A.1* was correct, but it was incorrect in subset *A.2*. The order of the items was additionally randomized for each subset.

Figure 1. *Representation of the different experimental lists implemented for the investigation.*



Note: Item sentences in green indicate that the item was presented in its correct version, while sentences presented in red indicate that the item version was incorrect. As described, lists A and B included different items. Subsets pairs *A.1*-*A.2* and *B.1*-*B.2* included the opposite sentence types for each item, meaning that a correct sentence item in *A.1* was incorrect in *A.2*, and vice versa.

Post-test questions. Some additional questions were included in the experiment in order to verify that the subjects had the knowledge required to answer the target sentences. For this purpose, 74 corresponding questions were created asking for the critical terms of the target sentences and allowing for an open answer. As an instance, the post-test question for the target sentence 'During the flood in the Old Testament, Moses took pairs of animals in an ark' was 'Which biblical figure took animals in an ark during the flood?'. All of the questions are available in Appendix C, alongside the answers that were considered valid for this post-test check.

Sociolinguistic measures. In order to obtain an exhaustive description of each participants' experience and use of Spanish, a set of questions were also developed. These were adapted from the LEAP-Q (Marian et al., 2007) and LSBQ (Anderson et al., 2018) questionnaires and are available in Appendix D. The sociolinguistic description of the participants provided in the previous section stems from the responses gathered from these questions. Importantly, no objective test was conducted, so all measures were subjectively provided by the own subjects, including proficiency in Spanish.

Procedure

The experiment was carried out online, constructed in the PcIbex platform (Zehr & Schwarz, 2018). A demonstration of the experiment is available in the link https://farm.pcibex.net/r/hUfMKQ/.

At the beginning of the experiment, participants provided consent for treating their results anonymously and completed some basic information questions. After that, they started the sentential judgement task, which included one of the four experimental lists stated before. These were the instructions provided to the subjects, translated into English:

> "In this experiment you will have to read some general knowledge questions and respond whether they are correct or incorrect. A sentence is CORRECT when what it says is true, or at least it makes sense grammatically and semantically. A sentence is INCORRECT if what it says is not true, or it does not make sense grammatically or semantically. For example: 'Rome is the capital of Italy' is a CORRECT sentence; 'Firefighters light up fires' is an INCORRECT sentence. Try to respond to the sentences rapidly. The sentences appear in a random order, therefore multiple correct or incorrect sentences can appear in a row. Respond in your best judgement, without looking up the answer or asking third-parties."

Importantly, the reading technique implemented in this experiment was Self-Paced Reading using a moving window. In other words, subjects were able to read the sentences by pressing a key that revealed each segment of them, while displaying the rest of the text as underlines. This method was used to ensure that subjects read all segments of the sentences, and to obtain reading time measures for the segment including the critical term. Once participants finished reading the last segment of each sentence, they pressed a key leading to a blank screen. By pressing the same key, they were presented with another screen showing the answer options 'Correct', 'Incorrect' or 'I don't know', which could be chosen either by clicking the buttons on the screen or by pressing the corresponding keys on the keyboard. In order to familiarize subjects with the experiment, two training trials were included before the actual experiment began. No feedback was given to the subjects, neither in training trials nor in the main task.

Once the sentential judgement task was completed for the 74 sentences contained in the experimental list presented to the participants, they proceeded to complete the corresponding post-test questions about the 37 target sentences they had read. These questions were presented in a random order, one after the other in different screens, which

appeared when the participants entered an answer and pressed a key. Again, subjects received no feedback on their answers to these questions.

After answering to all the post-test questions, participants were guided to complete the questions regarding sociolinguistic measures, as detailed in the attached file (see *Appendix D*). The response for these questions was also in an open format. Once all questions were completed, subjects indicated what they thought was the aim of the study. They were then debriefed about the Moses illusion and the real purpose of the experiment, and were finally asked whether they knew about these semantic illusions or had recognized them throughout the experiment.

Data collection

After completing the testing phase, a final dataset of responses was built including the responses each subject had provided, only for target sentences. Each data point in the dataset represented a trial, containing the sentence presented to the participant and the response he or she provided, alongside their answer to the corresponding post-test question, computed as 'valid' or 'invalid'. In addition, the Self-Paced reading task allowed obtaining the reading time measures for each segment of the sentences expressed in milliseconds, which were pondered by the number of characters present in each segment in order to control for their length. Such reading time measures were computed and introduced in the dataset in two different variables: the reading time of the whole sentence and the reading time of the critical segment only, which was the one containing the critical word.

A variety of sociolinguistic variables were also included in the dataset, stemming from the responses that the subject completing the trial had provided in the sociolinguistic questionnaire (see *Appendix D*). In this sense, the quantitative variables of Spanish EXPOSURE FREQUENCY, READING PREFERENCE, SPEAKING PREFERENCE and CULTURAL IDENTIFICATION were directly extracted from the subjects' responses to the questionnaire. Meanwhile, FREQUENCY OF USE was calculated as a mean of the subjects' answer to the questions regarding the percentage of use of Spanish in several areas: with family, with friends, when watching television or in social media, among others. The measure of PROFICIENCY was extracted as a mean of the subjects' self-rated competence in speaking, listening, reading and writing in Spanish.

Results

Pre-processing of data

The first criterion for removing subjects from the sample, considered once participants had already completed the experiment, was to discard trials from individuals who knew about the Moses illusion and recognized it while completing the experiment. This was the case for one participant. As a result, the remaining sample had either never heard about these illusions ($N = 29$) or knew about them but had not recognized them until disclosing the aims of the study ($N = 6$). The second criterion involved the subjects' rates of false detections, namely, the cases in which they knew the right answer for a correct sentence, and still categorized it as incorrect (e.g., answering that 'During the flood in the Old Testament, Noah took pairs of animals in an ark' is an incorrect sentence, and subsequently providing a correct response to the question 'Which biblical figure took animals in an ark during the flood?'). Having falsely-detected correct sentences in a large extent was considered an inadequate performance in the experiment, possibly indicating that subjects were systematically pressing the wrong keys when answering to the main sentences. Therefore, two subjects holding large overall rates of false detections (i.e., >33% of responses) were removed from the sample. These two standards reduced the initial number of subjects to a total of 33 participants, already described in previous sections (see *Participants*).

In regards to the items included in the investigation, some irregularities caused two items to have to be deleted after conducting the experiment. These were item 65, because of a semantic inaccuracy (see *Appendix A* for more details), and item 34, which was evidently confusing for the participants as approximately 56% of its responses were false detections. In consequence, all trials related to these items were deleted from the results and discarded for the analysis described in the following pages.

Trials corresponding to invalid post-test responses also had to be eliminated, for instance a subjects' response to 'During the flood in the Old Testament, Moses took pairs of animals in an ark' when his or her answer to the post-test question 'Which biblical figure took animals in an ark during the flood?' was incorrect. This cleaning process resulted in the loss of 92 trials (7.55%). Moreover, data trimming for reading times was performed independently for each group of trials stemming from the same experimental list. In total, 40 trials (3.55%) fell outside the range of acceptable reading times (i.e., +/– 3.5 SD from the mean reading time of each experimental list), and were thus removed from the dataset. As a result, the final dataset contained 1087 data points, produced by a total of 33 participants responding to 72 target items.

Analysis of response rates

On average, when subjects were presented with correct sentences, they responded that they were correct in approximately 49.25% of the times, while 'I don't know' responses happened 40.01% of the times. When considering these rates by items, correct sentences elicited correct responses approximately 50.16% of the times they were presented, while 'I don't know' responses happened in 38.87% of the occasions.

In opposition, when subjects were presented with incorrect sentences, they responded that the sentences were incorrect in approximately 69.35% of the cases, and reported that they did not know the answer 15.58% of the times they were presented. When considering these rates by items, incorrect sentences were adequately identified and categorized as 'incorrect' approximately 69.28% of the times they were presented, while 'I don't know' responses happened in 15.37% of the occasions.

As previously described, this investigation considers that a SEMANTIC ILLUSION happens when an individual reads an incorrect sentence and does not notice the inaccuracy (this is, responds that the sentence is 'correct'), even when he or she holds the required knowledge to be aware of the mistake, as indicated by a valid answer in the corresponding post-test question. Conversely, a FALSE DETECTION takes place when a subject reads a correct sentence and responds that it includes a mistake (this is, answers that the sentence is 'incorrect'), even when he or she holds the required knowledge for correctly responding to the sentence. In this sense, subjects produced semantic illusions 15.08% of the times, and in general items in their incorrect versions elicited 'correct' responses in 15.35% of the times they were presented. This type of mistake was different from correct sentences being answered as 'incorrect' (this is, FALSE DETECTIONS), which happened for the subjects 10.74% of the times, and for items 10.97% of the times they were presented. Appendix E details the amount of semantic illusions elicited by each item.

Furthermore, T-test analyses revealed that the rate of correct answers (i.e., correct sentences being answered as 'correct'), approximately 50%, was significantly larger than that of semantic illusions (i.e., incorrect sentences being answered as 'correct'), which was approximately 15%. This was true both in the analysis by participants, $t_1(64) = -5.438$, $p < 0.001$, $d = -1.39$, and by items, $t_2(138) = -13.497$, $p < 0.001$, $d = -2.28$.

Analysis of reading times

T-test analyses were performed to compare the reading times of the two types of responses, that is, responses to correct sentences that were adequately recognized to those of incorrect sentences that elicited semantic illusions. For the analysis that considered the whole

sentences' reading times, no significant differences were observed between the two types of responses, $t_1(61) = -0.924$, $p = 0.359$, $d = -0.23$; $t_2(117) = -0.973$, $p = 0.333$, $d = -0.16$. Parallelly, for the analysis that considered only the reading time measures of the critical segments, no significant differences were obtained between the two types of responses, $t_1(61) = -0.770$, $p = 0.444$, $d = -0.19$; $t_2(138) = -0.560$, $p = 0.576$, $d = -0.16$. Full descriptive measures of the comparisons by subjects are available in Table 4.

Table 4. *Mean reading times of each type of response by participants, expressed in milliseconds per character (standard deviations between parenthesis).*

	Entire sentence	Critical segment
Correct sentences; responded as 'correct'	79.00 (37.19)	116.25 (190.37)
Incorrect sentences; responded as 'correct' (SEMANTIC ILLUSIONS)	71.88 (22.98)	88.84 (71.45)

Discussion

The aim of Experiment 1 was to validate the Spanish Moses illusion in native speakers of Spanish, with the added goals of testing the performance of the materials that were elaborated for the current investigation and providing a basis for Experiment 2.

Semantic illusions reportedly happened at a considerable rate, approximately 15% of the times an incorrect sentence was presented. There was, however, a significant difference between the rates of semantic illusions and those of adequately-recognized correct sentences, indicating that participants considered sentences as 'correct' to a much larger extent when they were correct than when they were incorrect. In spite of this, the effect still took place as it is described in previous literature (Kamas et al., 1996): when comparing correct sentences that were adequately recognized with incorrect sentences that produced semantic illusions, reading times were statistically similar. This was also true for both the reading times of the entire sentences, and those of the critical segments only. Altogether, these results indicate that the Moses illusion is a phenomenon generalizable to the Spanish-speaking population, and that the processing of semantic illusions in Spanish parallels the one described for other languages: semantic illusions are truly integrated as if they were correct sentences, at least regarding reading time measures.

Since this experiment proved that the Moses illusion takes place in Spanish and that the adapted materials were able to elicit semantic illusions in this language, the same materials and procedure were implemented in Experiment 2 to examine semantic illusions in highly proficient and early Spanish-Catalan bilingual speakers.

Experiment 2

The main goal of Experiment 2 was to further analyse whether there was any difference in the semantic illusions elicited by each language of a bilingual speaker who learns the two languages early in life, and achieves a high proficiency in both of them.

To this end, early Spanish-Catalan bilinguals were recruited to participate in the present experiment, which is specifically favourable considering the peculiarities of their sociolinguistic context. Normally raised in Catalan-speaking regions, Spanish-Catalan bilingual speakers frequently reach a high proficiency in these two languages, given that schooling is mandatorily conducted in Spanish and Catalan (Intercat, n.d.). However, the use each Spanish-Catalan bilingual speaker makes of the two languages is extensively variable, as they do not normally use both languages indistinctively across different contexts. Therefore, these participants could potentially introduce some other variables, like the frequency of use of each language, which might influence the amount of semantic illusions elicited in Spanish and Catalan.

Tested on similar materials and procedures as those subjects in Experiment 1, Spanish-Catalan bilinguals were hypothesized to not show any difference in the rates of semantic illusions elicited in Spanish and Catalan, insofar as they were highly competent in both of the languages. On the other hand, and regarding reading times, again no differences were hypothesized between correct sentences that are adequately recognized and incorrect sentences that produce semantic illusions. As Experiment 1 corroborated that semantic illusions in Spanish are truly integrated as if they were correct sentences, and given that the processing of semantic illusions in proficient Spanish-Catalan bilinguals should not differ across their languages, the reading times associated to each of the response types were also assumed to not differ across languages. In sum, the Moses illusion was expected to occur as a solid effect in both languages of early and highly proficient Spanish-Catalan speakers.

Method

Participants

Initially, 44 Spanish-Catalan bilinguals took part in this experiment. Most of the sample comprised university students (73%), while the rest were young workers of diverse areas. All the subjects completed the experiment voluntarily: eight students enrolled in exchange for course credit, and the remaining subjects decided to participate by their own will. Subjects were selected for having a considerable competence in Catalan as well as in Spanish, regardless of the Catalan-speaking region in which they acquired the language.

As in Experiment 1, data-cleaning processes resulted in the removal of three bilingual subjects. In consequence, only 41 Spanish-Catalan bilingual subjects (M_{age} = 22.58, SD_{age} = 2.30; 28 females; 33 right-handed individuals) were included in further analysis. In regards to their self-reported linguistic dominance, approximately 49% of the subjects alleged having more competence in Spanish than in Catalan, 15% said to have more competence in Catalan than in Spanish, and the remaining 36% claimed to have the same competence in both languages. All subjects were early bilingual speakers, having acquired the language at home or at school before the age of 7. Regarding the order and context in which they had learned each language, approximately 54% of the participants said to have learned both languages simultaneously at home. In contrast, 29% of the participants firstly learned Spanish at home and then Catalan at school, while 10% first learned Catalan at home and then Spanish at school. The remaining 7% of the subjects said to have learnt both languages at school, while they acquired a different language at home.

The values of these participants in several sociolinguistic variables are reported in Table 5, according to their own responses for a sociolinguistic questionnaire (see *Materials*). The self-reported proficiency of this bilingual group in Spanish and in Catalan was considerably high, although a related-measures T test revealed a significantly higher proficiency in Spanish, $t(40) = 3.506$, $p = 0.001$, $d = 0.55$. Some other significant differences were found indicating a more frequent exposure to Spanish, $t(40) = 4.354$, $p < 0.001$, $d = 0.68$, and more typical use of Spanish, $t(40) = 4.606$, $p < 0.001$, $d = 0.72$. Additionally, these bilingual subjects were not significantly different from the Spanish native speakers recruited for Experiment 1 in their self-reported proficiency in Spanish, as revealed by an independent-measures T test, $t(40) = –1.631$, $p = 0.107$, $d = –0.381$. All in all, although highly proficient in both languages, the bilingual group was reportedly more competent in Spanish than in Catalan, and held a similar self-rated competence in Spanish to the subjects tested in Experiment 1.

Table 5. *Mean estimators of the main sociolinguistic measures of the participants in Experiment 2 (standard deviations between parenthesis).*

	Spanish	**Catalan**
Exposure frequency	0.57 (0.23)	0.29 (0.20)
Reading preference	0.50 (0.27)	0.36 (0.25)
Speaking preference	0.44 (0.31)	0.43 (0.31)

Cultural identification	0.76 (0.26)	0.71 (0.32)
Frequency of use	0.59 (0.24)	0.27 (0.23)
Proficiency (self-rated)	0.97 (0.05)	0.92 (0.08)

Note: For further indications on each variable, see the Note of Table 2.

Materials

Stimuli. The materials employed in Experiment 2 were the same as in Experiment 1, with the important difference that all target and filler items were additionally translated into Catalan. Therefore, all items had two additional versions (LANGUAGE), Spanish and Catalan, which are available in Appendix A for target items, and in Appendix B for filler items. An example of the resulting four possible versions of an item (LANGUAGE X TYPE) is represented in Table 6.

Table 6. *Versions of target item 2.*

SPANISH – CORRECT	Durante el diluvio del Antiguo Testamento, Noé llevó parejas de animales en un arca.
SPANISH – INCORRECT	Durante el diluvio del Antiguo Testamento, Moisés llevó parejas de animales en un arca.
CATALAN – CORRECT	Durant el diluvi de l'Antic Testament, Noè va portar parelles d'animals en una arca.
CATALAN – INCORRECT	Durant el diluvi de l'Antic Testament, Moisès va portar parelles d'animals en una arca.

(In English, "During the flood in the Old Testament, *Noah/Moses* took pairs of animals in an ark").

The new target and filler sentences in Catalan had a similar length to the ones in Spanish, also in the critical terms of target items, measured in number of characters (*p*s > 0.05). These critical terms were also generally gender and number congruent across their versions in Catalan. Regarding the frequency of such terms, estimated using the SUBTLEX-CAT corpus (Guasch et al., 2013), no differences were found across their correct and incorrect versions, nor when comparing them with their Spanish translations (*p*s > 0.05). The critical words' cognate status, considered as the orthographic similarity between their Spanish and Catalan translations, was analysed using the Normalized Levensthein Distance (Guasch et al., 2013) and also reported no significant differences across the languages (*p*s > 0.05). Full measures of these features are available in Table 7.

Table 7. *Mean estimations of the properties of target sentences by LANGUAGE and VERSION (standard deviations between parenthesis).*

	Correct version		Incorrect version	
	Spanish	**Catalan**	**Spanish**	**Catalan**
Sentence length	96.30 (10.78)	93.80 (11.16)	96.42 (10.91)	93.62 (11.51)
Critical word length	7.28 (3.17)	7.08 (3.08)	7.42 (3.71)	6.96 (3.03)
Critical word frequency	3.98 (0.86)	4.07 (0.78)	3.95 (0.88)	3.94 (0.96)
Critical word cognate status[1]	0.76 (0.21)		0.73 (0.30)	

[1]Cognate status of the critical word is estimated from 0 to 1, indicating respectively 'no orthographic overlap at all' and 'complete orthographical overlap'. For further indications on the rest of the variables, see the notes of Table 3.

Post-test questions. The additional questions at the end of the experiment were included just as in Experiment 1. In this study, however, the questions had two versions, one in Spanish and one in Catalan, to be able to match the language in which the main target sentences were presented. The two versions of these questions are included in Appendix C, alongside the valid answers in each language.

Sociolinguistic measures. The questionnaire on the different sociolinguistic measures was also parallel to that included in Experiment 1, although for these bilingual subjects, additional questions concerning the same sociolinguistic measures in Catalan were included. Appendix D details the questions that were specifically presented to the subjects in this experiment.

Procedure

The testing procedure used in this study was the same as in Experiment 2, with the exception that subjects completed two blocks of the sentential judgement task: one in Spanish, and one in Catalan. The experimental lists presented in each block were different, as each one corresponded to one of the two possible lists (*A* and *B*) previously described. In other words, different items were presented in each language. The order of the language blocks was counterbalanced across participants, including an interlude screen indicating that the first language block was completed and that the task would now switch to the other language.

Additionally, post-test questions were presented in the language of the main sentence they referred to. In other words, the post-test question for a sentence that had been presented in Catalan was included in that same language. For this phase of the experiment, the questions appeared in two language blocks with a fixed order: first, Spanish questions about the target sentences they read in Spanish, and then Catalan questions for the sentences

presented in such language. The answer for these questions was also open and subjects were not instructed to respond in any specific language, therefore a correct answer in any language was considered a 'valid' response.

Data collection

Just as in Experiment 1, a dataset gathering all responses to target sentences was created. In this file, each data point not only included the target sentence, the participants' response and the corresponding reading time measures, but also the language in which the sentence was presented and the testing block in which it appeared. Additionally, for these bilingual subjects, the several sociolinguistic variables were included for both Spanish and Catalan.

Results

Pre-processing of data

Parallel to the data-cleaning criteria for Experiment 1, in this second study one participant that recognized the Moses illusion had to be excluded from the dataset. Consequently, the remaining subjects had either never heard about these illusions ($N = 26$) or knew about them but had not recognized them until disclosing the aims of the study ($N = 18$). Two subjects were additionally removed from the sample for holding large overall rates of false detections (i.e., >33% of responses). These processes reduced the testing sample to 41 participants.

In addition to items 65 and 34 being deleted from the materials of the experiment, some further orthographic mistakes were alerted in the Catalan translations of items 10 and 50 (see *Appendix A* for more details). All trials related to these items were deleted from the results and discarded for the analysis described in the following pages.

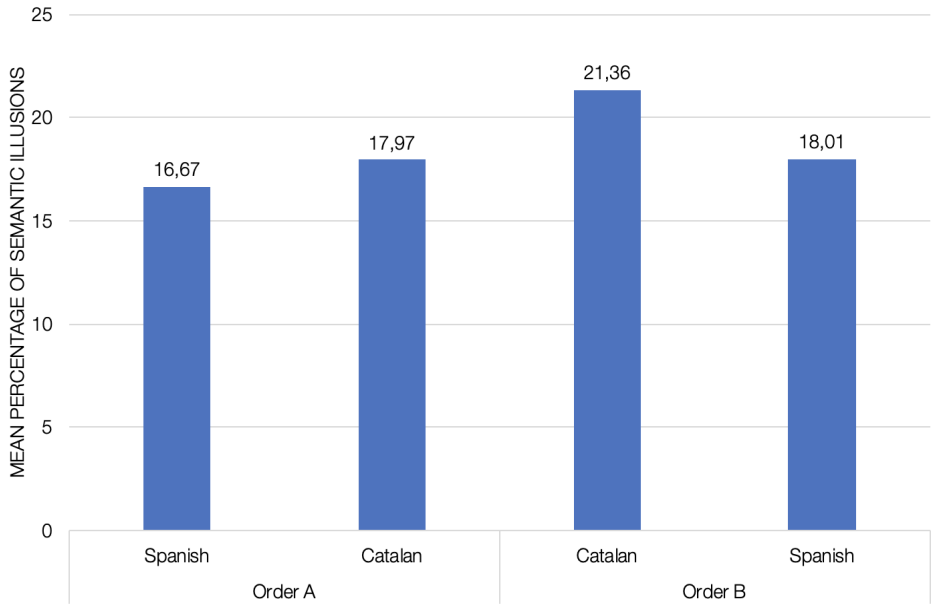
Moreover, 445 target trials corresponding to invalid post-test answers (14.84%) were also removed from the dataset. Data trimming was performed independently for each combination of the experimental lists, leading to the elimination of 119 trials (4.66%) that fell outside the range of acceptable reading times (i.e., +/– 3.5 SD from the mean reading time of each combination). In consequence, the final dataset for this experiment contained 2434 data points, produced by a total of 41 participants responding to 70 target items.

Analysis of semantic-illusion rates

A two-way analysis of variance (ANOVA) was carried out including the independent variables of LANGUAGE and BLOCK, which were respectively within-subjects and between-

subject factors in the analysis by participants, and both within-subjects variables in the analysis by items. The factor LANGUAGE did not have a significant main effect, $F_1(1,39) = 0.940$, $p = 0.338$, $\eta_2 = 0.02$; $F_2(1,69) = 1.795$, $p = 0.185$, $\eta_2 = 0.03$. The same happened for the BLOCK factor, as no significant main effects was observed, $F_1(1,39) = 0.591$, $p = 0.591$, $\eta_2 = 0.01$; $F_2(1,69) = 0.012$, $p = 0.913$, $\eta_2 = 0.00$. The interaction between the two variables was also non-significant, $F_1(1,39) = 0.187$, p = 0.668, $\eta_2 = 0.01$; $F_2(1,69) = 0.114$, $p = 0.737$, $\eta_2 = 0.00$. The mean percentages of semantic illusions rates by participants are represented in Figure 2.

Figure 2. *Mean percentages of semantic illusions by LANGUAGE and BLOCK.*



Note: 'Order A' refers to the condition in which the first block is performed in Spanish, and the second one in Catalan. 'Order B' means that the first block is performed in Catalan, and the second one in Spanish.

In addition, the rate of semantic illusions elicited in Spanish by Spanish-Catalan bilinguals, which was approximately 17%, was compared to that produced by native speakers of Spanish (Experiment 1), which was approximately 15%. T-test analyses showed no significant differences, $t_1(72) = -0.704$, $p = 0.484$, $d = -0.17$; $t_2(69) = -0.308$, $p = 0.759$, $d = -0.04$.

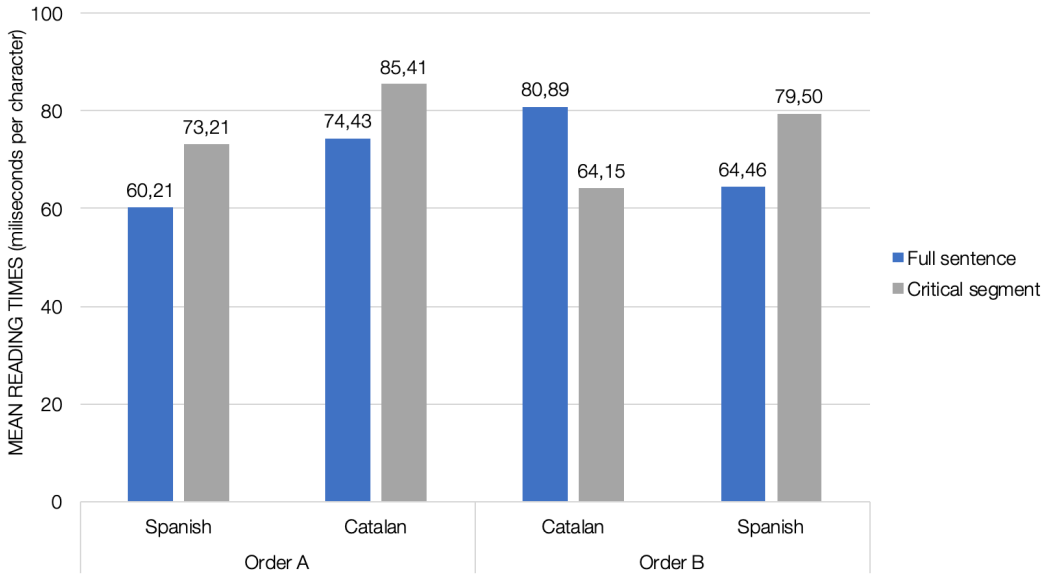
Analysis of reading times

The analysis of reading times was firstly performed just including the trials referring to sentences that produced semantic illusions, and then comparing semantic illusions to adequately-recognized correct sentences in the two languages. In both cases, the analyses were performed considering the reading times of the whole sentence as well as those of the critical segment.

Regarding sentences that produced semantic illusions, a two-way analysis of variance (ANOVA) was carried out including LANGUAGE and BLOCK as independent variables, which were again respectively within-subjects and between-subjects variables in the analysis by participants, and both within-subjects variables in the analysis by items. The analysis of reading times of the whole sentences did not reveal any significant effect of LANGUAGE, $F_1(1,27) = 2.423$, $p = 0.131$, $\eta_2 = 0.08$; $F_2(1,8) = 1.352$, $p = 0.278$, $\eta_2 = 0.15$, or BLOCK, $F_1(1,27) = 0.032$, $p = 0.859$, $\eta_2 = 0.01$; $F_2(1,8) = 0.008$, $p = 0.932$, $\eta_2 = 0.01$. Furthermore, no significant interaction effect between the two variables was observed, $F_1(1,27) = 1.647$, $p = 0.210$, $\eta_2 = 0.06$; $F_2(1,8) = 2.220$, $p = 0.175$, $\eta_2 = 0.22$.

In regards to the critical segment reading times, as in the previous analysis, no significant effects were observed for LANGUAGE, $F_1(1,27) = 0.014$, $p = 0.906$, $\eta_2 = 0.01$; $F_2(1,8) = 0.362$, $p = 0.564$, $\eta_2 = 0.04$, or BLOCK, $F_1(1,27) = 1.060$, $p = 0.312$, $\eta_2 = 0.04$; $F_2(1,8) = 0.529$, $p = 0.488$, $\eta_2 = 0.06$. No significant interaction effect between the two variables was found, $F_1(1,27) = 0.322$, $p = 0.575$, $\eta_2 = 0.01$; $F_2(1,8) = 0.109$, $p = 0.750$, $\eta_2 = 0.01$. These results suggest that neither the language or the block in which the semantic illusions were elicited had an effect on the time spent reading the whole sentences or the critical segment including the incorrect term. Figure 3 represents the subjects' reading times for semantic illusions in each condition.

Figure 3. *Mean reading times in sentences eliciting semantic illusions by LANGUAGE and BLOCK, expressed in milliseconds per character.*



Note: 'Order A' refers to the condition in which the first block is performed in Spanish, and the second one in Catalan. 'Order B' means that the first block is performed in Catalan, and the second one in Spanish.

Reading time measures of semantic illusions elicited in Spanish by Spanish-Catalan bilinguals were also compared to those produced by native speakers of Spanish (Experiment 1). T-test analysis showed no significant differences in the reading times of either the whole sentence (in Experiment 1, 71.88 milliseconds per character on average; in Experiment 2, 62.34 milliseconds per character on average), $t_1(64) = –0.513$, $p = 0.610$, $d = –0.13$; $t_2(44) = 0.737$, $p = 0.465$, $d = 0.11$, or the critical segment (in Experiment 1, approximately 88.84 milliseconds per character; in Experiment 2, approximately 76.36 milliseconds per character), $t_1(64) = –0.483$, $p = 0.631$, $d = –0.12$; $t_2(44) = –0.973$, $p = 0.336$, $d = –0.15$, indicating that semantic illusions took similar reading times in both groups.

With respect to the comparison of reading times between correct sentences that were adequately recognized and incorrect sentences that elicited semantic illusions, no ANOVA could be performed since the number of trials available for each type of response was not uniform. Therefore, several T-tests were performed separately for each language, where the type of response (i.e., correct identifications vs. semantic illusions) was analysed as a repeated measure in the analysis by participants and as an independent measure in the analysis by items. Considering the whole-sentence reading times in Spanish, there was not any significant difference between the two types of responses, $t_1(37) = 1.437$, $p = 0.159$, $d = 0.23$; $t_2(122) = -1.789$, $p = 0.076$, $d = -0.32$. The same pattern was observed in the analysis of reading times for the critical segments, $t_1(33) = 0.187$, $p = 0.853$, $d = 0.03$, $t_2(122) = -1.500$, $p = 0.136$, $d = -2.70$. The results were very similar for Catalan, since no differences were found either in the whole-sentence reading times, $t_1(37) = 0.892$, $p = 0.378$, $d = 0.14$; $t_2(123) = 0.649$, $p = 0.518$, $d = 0.12$, or in reading times of the critical segments, $t_1(34) = 0.478$, $p = 0.636$, $d = 0.08$; $t_2(122) = 0.894$, $p = 0.373$, $d = 0.16$. The average reading times by participants for the two types of responses in each language are represented in Table 8.

Table 8. *Average reading times by participants for each response type in each language, expressed in milliseconds per character (standard deviations between parenthesis).*

	Spanish		**Catalan**	
	Entire sentence	Critical segment	Entire sentence	Critical segment
Correct sentences; responded as 'correct'	59.61 (26.11)	76.77 (28.88)	69.52 (37.72)	72.59 (14.16)
Incorrect sentences; responded as 'correct' (SEMANTIC ILLUSIONS)	68.90 (33.99)	79.40 (61.92)	77.72 (43.78)	75.22 (30.21)

Discussion

Experiment 2 was carried out with the goal of investigating how semantic illusions are elicited in early highly proficient Spanish-Catalan bilinguals. In essence, it was hypothesized that the Moses illusion would consistently take place in both Spanish and Catalan. This was explored considering the rates of semantic illusions in each language, in addition to the reading time measures of semantic illusions against adequately-recognized correct sentences.

Regarding the rates of semantic illusions, no significant differences were found across the two languages and the two experimental blocks in which the task was completed. When the amount of semantic illusions elicited in Spanish were compared to those of the Spanish native speakers of Experiment 1, no significant differences were found. Taking into consideration these results, it cannot be held that semantic illusions happen differently in each language of the highly proficient Spanish-Catalan subjects tested, at least when the percentages of semantic illusions are considered.

On the other hand, regarding reading time measures, semantic illusions took roughly the same time to be read in both languages and in both experimental blocks. When comparing the reading time measures of correct sentences that were adequately recognized to those that produced semantic illusions, no significant differences were found, neither in Spanish or in Catalan. These results were furtherly replicated with the reading time measures of the whole sentence and those of the critical segment only. Altogether, when considering these measures, semantic illusions seem to happen canonically in both languages: they appear to be processed as if they were correct sentences (Kamas et al., 1996). Besides, when the reading time measures of semantic illusions elicited in Spanish were compared across experiments (this is, participants from Experiment 1 vs. those from Experiment 2), no significant differences were observed.

In conclusion, Experiment 2 revealed that the Moses illusion is consistent across both languages of early and highly proficient Spanish-Catalan bilingual speakers, reported both in the rates of semantic illusions and in reading time measures. Likewise, processing semantic illusions in Spanish did not differ as a function of the sample, this is, from native speakers of Spanish to Spanish-Catalan bilinguals.

General discussion

The investigation presented in these pages had the main goal of filling in the empirical and population gaps observed in the Moses-illusion research line. In this sense,

Experiment 1 explored semantic illusions in Spanish for native speakers of this language, and Experiment 2 further examined these illusions in early and highly proficient Spanish-Catalan bilingual speakers.

The first experiment obtained clear results, validating that the Moses illusion extends to Spanish language and that the materials adapted for the present investigation were able to produce semantic illusions. Admittedly, the overall percentage of semantic illusions elicited with these materials (15%) was surprisingly low compared to that of past studies. For instance, Vaessen (2017) reported approximately 30% of semantic illusion rates using a very similar design to the one in the present research. In particular, previous investigations including the materials in the form of questions have especially achieved high rates of semantic illusions. As an instance, Erickson and Mattson (1981) reported finding 43% of semantic illusions in their results, or more recently, Dhaene and her colleagues (2021) even achieved a 60% rate of semantic illusions. Although theoretically producing the illusion is independent of the way in which materials are presented to the subjects (Van Oostendorp & De Mul, 1990), and previous studies using the materials in the form of sentences have still been able to elicit the Moses illusions (Vaessen, 2017), it seems that semantic mistakes remain unnoticed more frequently when they are included in questions. Therefore, even though the materials for the present research were able to elicit the Moses illusion, it is likely that using questions instead could have produced larger rates of semantic illusions.

In Experiment 2, early and highly proficient Spanish-Catalan bilingual speakers were tested. Bearing in mind that this type of bilingual speakers achieves a high competence in both Spanish and Catalan, no differences were expected across the languages. Indeed, the rates of semantic illusions elicited in Spanish and in Catalan were not significantly different (all ps > 0.05), even when subjects had subjectively reported to have more competence in Spanish than in Catalan. This is in line with previous studies which have failed to find a significant difference in the amount of semantic illusions across languages in spite of the differences in the competence of each language (Geipel et al., 2015; Vaessen, 2017; but see Fernandes et al., 2022). The parallelisms in the processing of the Moses illusion were also observed in reading time measures. In this regard, the time participants spent reading semantic illusions was not different across their two languages (not even when considering the critical segment reading times to correct sentences, all ps > 0.45), indicating a fairly similar competence in both languages regardless of the participants' subjective estimations. Furthermore, when analysing each language separately, reading time measures of sentences producing semantic illusions did not differ from those associated to adequately-recognized

correct sentences. The Moses illusion therefore seems to take place canonically for both languages of early and highly proficient bilingual speakers, as incorrect sentences are truly processed as if they were correct (Kamas et al., 1996). Altogether, the results of the current investigation suggest no difference between the languages in the way semantic illusions are elicited. By being just in between the 'cognitive load' and 'cognitive fluidity' hypotheses for second language processing (Costa et al., 2014), the conclusions of the present study do not point at an advantage or a disadvantage in the second language of Spanish-Catalan bilingual speakers: semantic processing in Catalan was just as (in)accurate and fast as in Spanish.

Nevertheless, a follow-up study including several methodological improvements is still necessary to consolidate the findings of the present investigation. Further research presenting the materials in the form of questions instead of sentences could eventually increase the likelihood of semantic illusions, allowing for more variation in the results, and therefore providing some more nuanced comparisons between the languages. Moreover, larger sample sizes according to the suggestions of some methodological review articles (Brysbaert, 2019) could increase the power of future investigations, supporting the search for more significant effects. Finally, and most importantly, implementing more sophisticated statistical models could take into consideration the influence of several confounding variables into the analysis. In particular, by examining such future results with a Linear Mixed Effect Model some of the statistical limitations of the present investigation would be avoided, allowing for more detailed results. Any further research performed under these methodological advancements would be of extraordinary relevance for the present study and for the bilingual Moses illusion field.

Besides the important conclusions described in the previous paragraphs, the current experiment provides some other insights that are relevant for the whole Moses illusion paradigm. First, the results of this study support the idea that semantic illusions are not related with a cooperative principle of communication (Grice, 1975), since in this case they have been reported when subjects were explicitly instructed to point out incorrect sentences. Secondly, the Moses illusion in this experiment has taken place in incorrect sentences which were built substituting terms for semantically related ones, but also for phonetically related ones. This further proves the points claimed by Shafto and Mackay's model (2000), including both semantic and phonetic features. Also, the Moses illusion in this experiment was not produced because of an encoding failure (Park & Reder, 2004), since it still occurred when subjects had to read all segments of the sentences, in line with other studies applying controlled reading methods (Vaessen, 2017). Lastly, and most importantly, this experiment

has demonstrated that the Moses illusion happens both in Spanish and Catalan languages, which is a positive finding considering that this line of study has scarcely received cross-linguistic validation. The present study is relevant in much more terms other than the main comparison regarding bilingual subjects.

In conclusion, the results extracted from the present investigation indicate that the Moses illusion takes place in Spanish, as reported by native Spanish speakers, and that it also seems consistent for both languages of highly proficient Spanish-Catalan bilingual speakers. In light of previous hypothesis, for these bilinguals, semantic processing in Catalan is just as controlled and intuitive as it is in Spanish. In helping to understand the bilingual Moses illusion, this study opens some questions of theoretical relevance to the study of bilingualism. Ultimately, examining semantic illusions encompasses an investigation on the mistakes subjects make in service of allowing language processing to flow. In that sense, the Moses illusion is a sign of how language comprehension mechanisms have adapted to a complex, variable and sometimes inaccurate environment. Comparing this measure across the languages of a bilingual speaker and finding that highly proficient bilingual speakers have achieved a high level of adaptation and pragmatism in both of their languages is therefore a marvellous finding for the research on bilingualism. The potential of the investigation on the bilingual Moses illusion cannot be dismissed. Research needs to continue developing this line of study to build a more solid conceptual framework from where to provide new-wave descriptions of how second languages are processed.

Conclusion

The study of the Moses illusion has received scarce cross-linguistic validation and extension to the bilingual population, which is of main relevance since second languages are hypothesized to modulate the extent to which the Moses illusion is produced. The present investigation proved that the Moses illusion takes place in Spanish, and that early and highly proficient Spanish-Catalan bilingual speakers are able to elicit the illusion parallelly in both of their languages. These findings point at a similar semantic processing of Spanish and Catalan, which is just as ‘controlled’ or ‘automatic’ in both languages, considering previous theoretical considerations in the field. However, further research on the bilingual Moses illusion is required to build on these findings and, more generally, the field of second language processing.

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Appendix A

Target stimuli

1: Correct version in Spanish

2: Incorrect version in Spanish

3: Correct version in Catalan

4: Incorrect version in Catalan

Experiment 1 only included the Spanish versions (*1* and *2*). Experiment 2 involved the four versions of all items (*1* to *4*).

The words marked in italics are the critical words. The underlined section of the sentences indicates in which segment did the subjects read the critical terms during the Self-Paced reading task.

The items presented in this appendix are presented as they were originally included in Experiment 1. Mistakes are indicated for the items that were subsequently removed (items 10, 34, 50 and 65). English translations to all items are available upon request from the author.

1. Theme category: 'science'
1: El Premio Nobel de Medicina, otorgado en 1906 al español *Santiago Ramón y Cajal*, le dio fama internacional.
2: El Premio Nobel de Medicina, otorgado en 1906 al español *Camilo José Cela*, le dio fama internacional.
3: El Premi Nobel de Medicina, atorgat el 1906 a l'espanyol *Santiago Ramón i Cajal*, li va donar fama internacional.
4: El Premi Nobel de Medicina, atorgat el 1906 a l'espanyol *Camilo José Cela*, li va donar fama internacional.

2. Theme category: 'religion'
1: Durante el diluvio del Antiguo Testamento, *Noé* llevó parejas de animales en un arca.
2: Durante el diluvio del Antiguo Testamento, *Moisés* llevó parejas de animales en un arca.
3: Durant el diluvi de l'Antic Testament, *Noè* va portar parelles d'animales en una arca.
4: Durant el diluvi de l'Antic Testament, *Moisès* va portar parelles d'animales en una arca.

3. Theme category: 'basic semantic knowledge'
1: Después del derrumbe, los bomberos recuperaron los cadáveres de los *muertos* entre los escombros del edificio.
2: Después del derrumbe, los bomberos recuperaron los cadáveres de los *vivos* entre los escombros del edificio.
3: Després de l'esfondrament, els bombers van recuperar els cadàvers dels *morts* entre les runes de l'edifici.

4: Després de l'esfondrament, els bombers van recuperar els cadàvers dels *vius* entre les runes de l'edifici.

4. Theme category: 'geography'
1: La Mezquita Çamlica, situada en Estambul, la ciudad más grande de *Turquía*, se inauguró en 2019.
2: La Mezquita Çamlica, situada en Estambul, la ciudad más grande de *Egipto*, se inauguró en 2019.
3: La Mesquita Çamlica, situada a Istanbul, la ciutat més gran de *Turquia*, es va inaugurar el 2019.
4: La Mesquita Çamlica, situada a Istanbul, la ciutat més gran d'*Egipte*, es va inaugurar el 2019.

5. Theme category: 'literature'
1: Después de encontrar el zapato de cristal, el príncipe buscó a *Cenicienta* sin descanso por todo el reino.
2: Después de encontrar el zapato de cristal, el príncipe buscó a *Blancanieves* sin descanso por todo el reino.
3: Després de trobar la sabata de vidre, el príncep va buscar la *Ventafocs* sense descans per tot el regne.
4: Després de trobar la sabata de vidre, el príncep va buscar la *Blancaneus* sense descans per tot el regne.

6. Theme category: 'basic semantic knowledge'
1: Durante el patrullaje, la policía multó al *vehículo* por exceso de velocidad en la calle.
2: Durante el patrullaje, la policía multó al *vianante* por exceso de velocidad en la calle.
3: Durant el patrullatge, la policia va multar el *vehicle* per excés de velocitat al carrer.
4: Durant el patrullatge, la policia va multar el *vianant* per excés de velocitat al carrer.

7. Theme category: 'basic semantic knowledge'
1: El alfabeto táctil 'braille', desarrollado por el francés Braille, permite a los *ciegos* leer con facilidad.
2: El alfabeto táctil 'braille', desarrollado por el francés Braille, permite a los *sordos* leer con facilidad.
3: L'alfabet tàctil braille, desenvolupat pel francès Braille, permet als *cecs* llegir amb facilitat.
4: L'alfabet tàctil braille, desenvolupat pel francès Braille, permet als *sords* llegir amb facilitat.

8. Theme category: 'geography'
1: Con solo 77.000 habitantes, el principado de Andorra está situado en los *Pirineos* y es un destino popular para esquiar.
2: Con solo 77.000 habitantes, el principado de Andorra está situado en los *Alpes* y es un destino popular para esquiar.
3: Amb només 77.000 habitants, el principat d'Andorra està situat als *Pirineus* i és una destinació popular per esquiar.
4: Amb només 77.000 habitants, el principat d'Andorra està situat als *Alps* i és una destinació popular per esquiar.

9. Theme category: 'religion'
1: Según el Nuevo Testamento, Jesús comió con los *doce* apóstoles durante la Última Cena antes de la crucifixión.

2: Según el Nuevo Testamento, Jesús comió con los *diez* apóstoles durante la Última Cena antes de la crucifixión.
3: Segons el Nou Testament, Jesús va menjar amb els *dotze* apòstols durant l'Últim Sopar abans de la crucifixió.
4: Segons el Nou Testament, Jesús va menjar amb els *deu* apòstols durant l'Últim Sopar abans de la crucifixió.

10. Theme category: 'literature'
1: La famosa autora inglesa J. K. Rowling escribió *'Harry Potter'*, los libros que la hicieron millonaria.
2: La famosa autora inglesa J. K. Rowling escribió *'El señor de los anillos'*, los libros que la hicieron millonaria.
3: La famosa autora anglesa J. K. Rowling va escriure *'Harry Potter'*, el llibres que la van fer milionària.
4: La famosa autora anglesa J. K. Rowling va escriure *'El senyor dels anells'*, el llibres que la van fer milionària.

Note: This item was removed in Experiment 2 due to orthographic mistakes in the Catalan versions ('*el llibres*'; article was singular and noun was plural).

11. Theme category: 'literature'
1: Antes de que la princesa lo besara, el príncipe era una *rana*, según el cuento de los hermanos Grimm.
2: Antes de que la princesa lo besara, el príncipe era una *calabaza*, según el cuento de los hermanos Grimm.
3: Abans de que la princesa el besés, el príncep era una *granota*, segons el conte dels germans Grimm.
4: Abans de que la princesa el besés, el príncep era una *carbassa*, segons el conte dels germans Grimm.

12. Theme category: 'basic semantic knowledge'
1: En las pruebas de acceso al ejército, el evaluador no permitió que los *inaptos* pasaran a la prueba final.
2: En las pruebas de acceso al ejército, el evaluador no permitió que los *aptos* pasaran a la prueba final.
3: A les proves d'accés a l'exèrcit, l'avaluador no va permetre que els *inaptes* passessin a la prova final.
4: A les proves d'accés a l'exèrcit, l'avaluador no va permetre que els *aptes* passessin a la prova final.

13. Theme category: 'geography'
1: Podemos encontrar en el puerto marítimo de la capital danesa *Copenhague* una estatua muy famosa.
2: Podemos encontrar en el puerto marítimo de la capital danesa *Estocolmo* una estatua muy famosa.
3: Podem trobar al port marítim de la capital danesa *Copenhague* una estàtua molt famosa.
4: Podem trobar al port marítim de la capital danesa *Estocolm* una estàtua molt famosa.

14. Theme category: 'literature'
1: En el cuento del lobo y los siete cabritos, el *cabrito* menor se escondió en un reloj.
2: En el cuento del lobo y los siete cabritos, el *cerdito* menor se escondió en un reloj.

3: Al conte del llop i les set cabretes, la *cabreta* menor es va amagar en un rellotge.
4: Al conte del llop i les set cabretes, la *porqueta* menor es va amagar en un rellotge.

15. Theme category: 'literature'
1: Antes de ser descubierta por los nazis, Anna Frank escribió un *diario* entre los años 1942 y 1944.
2: Antes de ser descubierta por los nazis, Anna Frank escribió un *cuento* entre los años 1942 y 1944.
3: Abans de ser descoberta pels nazis, Anna Frank va escriure un *diari* entre els anys 1942 i 1944.
4: Abans de ser descoberta pels nazis, Anna Frank va escriure un *conte* entre els anys 1942 i 1944.

16. Theme category: 'science'
1: Después de observar la caída de una manzana, la ley de la gravedad fue enunciada por *Newton* en el siglo XVII.
2: Después de observar la caída de una manzana, la ley de la gravedad fue enunciada por *Einstein* en el siglo XVII.
3: Després d'observar la caiguda d'una poma, la llei de la gravetat va ser enunciada per *Newton* al segle XVII.
4: Després d'observar la caiguda d'una poma, la llei de la gravetat va ser enunciada per *Einstein* al segle XVII.

17. Theme category: 'basic semantic knowledge'
1: En un cuadrado, un ángulo tiene 90 grados de *apertura* en cada una de las cuatro esquinas.
2: En un cuadrado, un ángulo tiene 90 grados *centígrados* en cada una de las cuatro esquinas.
3: En un quadrat, un angle té 90 graus d'*obertura* en cada una de les quatre cantonades.
4: En un quadrat, un angle té 90 graus *centígrads* en cadascuna de les quatre cantonades.

18. Theme category: 'history'
1: Al convertirse en el primer hombre en pisar la luna, *Neil Armstrong* dijo una frase recordada para siempre.
2: Al convertirse en el primer hombre en pisar la luna, *Louis Armstrong* dijo una frase recordada para siempre.
3: En convertir-se en el primer home en trepitjar la lluna, *Neil Armstrong* va dir una frase recordada per sempre.
4: En convertir-se en el primer home en trepitjar la lluna, *Louis Armstrong* va dir una frase recordada per sempre.

19. Theme category: 'history'
1: Una bomba atómica golpeó la ciudad *japonesa* de Hiroshima al final de la Segunda Guerra Mundial.
2: Una bomba atómica golpeó la ciudad *china* de Hiroshima al final de la Segunda Guerra Mundial.
3: Una bomba atòmica va colpejar la ciutat *japonesa* d'Hiroshima al final de la Segona Guerra Mundial.
4: Una bomba atòmica va colpejar la ciutat *xinesa* d'Hiroshima al final de la Segona Guerra Mundial.

20. Theme category: 'basic semantic knowledge'
1: En la fiesta literaria, los críticos elogiaron al *autor* por su nueva novela policíaca.
2: En la fiesta literaria, los críticos elogiaron al *lector* por su nueva novela policíaca.
3: A la festa literària, els crítics van elogiar l'*autor* per la seva nova novel·la policíaca.
4: A la festa literària, els crítics van elogiar el *lector* per la seva nova novel·la policíaca.

21. Theme category: 'science'
1: La teoría de la relatividad fue desarrollada por el físico *Albert Einstein* el siglo pasado.
2: La teoría de la relatividad fue desarrollada por el físico *Max Planck* el siglo pasado.
3: La teoria de la relativitat va ser desenvolupada pel físic *Albert Einstein* el segle passat.
4: La teoria de la relativitat va ser desenvolupada pel físic *Max Planck* el segle passat.

22. Theme category: 'geography'
1: En la Rioja, los amantes del vino visitan las bodegas a la orilla del *Ebro* para disfrutar de las catas de vino.
2: En la Rioja, los amantes del vino visitan las bodegas a la orilla del *Tajo* para disfrutar de las catas de vino.
3: A la Rioja, els amants del vi visiten els cellers a la riba de l'*Ebre* per gaudir dels tasts de vi.
4: A la Rioja, els amants del vi visiten els cellers a la riba del *Tajo* per gaudir dels tasts de vi.

23. Theme category: 'history'
1: Tras la conquista del poder, Hitler preparó la *Segunda* Guerra Mundial con un plan pensado al detalle.
2: Tras la conquista del poder, Hitler preparó la *Primera* Guerra Mundial con un plan pensado al detalle.
3: Després de la conquesta del poder, Hitler va preparar la *Segona* Guerra Mundial amb un pla pensat al detall.
4: Després de la conquesta del poder, Hitler va preparar la *Primera* Guerra Mundial amb un pla pensat al detall.

24. Theme category: 'basic semantic knowledge'
1: Durante la persecución, el policía arrestó al *sospechoso* del robo al banco.
2: Durante la persecución, el policía arrestó a la *víctima* del robo al banco.
3: Durant la persecució, el policia va arrestar el *sospitós* del robatori al banc.
4: Durant la persecució, el policia va arrestar la *víctima* del robatori al banc.

25. Theme category: 'history'
1: Fue en el año 1917 que el Zar de Rusia fue derrocado por *Lenin* durante la revolución rusa.
2: Fue en el año 1917 que el Zar de Rusia fue derrocado por *Stalin* durante la revolución rusa.
3: Va ser l'any 1917 que el Zar de Rússia va ser enderrocat per *Lenin* durant la revolució comunista.
4: Va ser l'any 1917 que el Zar de Rússia va ser enderrocat per *Stalin* durant la revolució comunista.

26. Theme category: 'basic semantic knowledge'
1: En la reunión de educadores, la escuela despidió al *profesor* por incompetencia profesional.
2: En la reunión de educadores, la escuela despidió al *estudiante* por incompetencia profesional.
3: A la reunió d'educadors, l'escola va acomiadar el *professor* per incompetència professional.
4: A la reunió d'educadors, l'escola va acomiadar *l'estudiant* per incompetència professional.

27. Theme category: 'geography'

1: Ubicada en el centro del país, la capital *húngara* Budapest ha sido sede de varios partidos de fútbol europeos.
2: Ubicada en el centro del país, la capital *húngara* Bucarest ha sido sede de varios partidos de fútbol europeos.
3: Ubicada en el centre del país, la capital *hongaresa* Budapest ha estat seu de diveross partits de futbol europeus.
4: Ubicada en el centre del país, la capital *hongaresa* Bucarest ha estat seu de diveross partits de futbol europeus.

28. Theme category: 'basic semantic knowledge'

1: Después de la desparición, los agentes enviaron al *rescatado* a casa sano y salvo.
2: Después de la desparición, los agentes enviaron al *fallecido* a casa sano y salvo.
3: Després de la desaparició, els agents van enviar el *rescatat* a casa sa i estalvi.
4: Després de la desaparició, els agents van enviar el *mort* a casa sa i estalvi.

29. Theme category: 'literature'

1: En la película Drácula de Bram Stoker, el protagonista se transformaba en *vampiro* cuando se ponía nervioso.
2: En la película Drácula de Bram Stoker, el protagonista se transformaba en *monstruo* cuando se ponía nervioso.
3: A la pel·lícula Dràcula de Bram Stoker, el protagonista es transformava en *vampir* quan es posava nerviós.
4: A la pel·lícula Dràcula de Bram Stoker, el protagonista es transformava en *monstre* quan es posava nerviós.

30. Theme category: 'others'

1: Durante un memorable concierto de Mozart, el público disfrutó de la *música* del compositor durante horas.
2: Durante un memorable concierto de Mozart, el público disfrutó de las *pinturas* del compositor durante horas.
3: Durant un memorable concert de Mozart, el públic va gaudir de la *música* del compositor durant hores.
4: Durant un memorable concert de Mozart, el públic va gaudir de les *pintures* del compositor durant hores.

31. Theme category: 'religion'

1: La Biblia nos dice que Jesús previó la traición de *Judas* durante la Última Cena antes de su crucifixión.
2: La Biblia nos dice que Jesús previó la traición de *Jonás* durante la Última Cena antes de su crucifixión.
3: La Bíblia ens diu que Jesús va preveure la traició de *Judas* durant l'Últim Sopar abans de la seva crucifixió.
4: La Bíblia ens diu que Jesús va preveure la traició de *Jonàs* durant l'Últim Sopar abans de la seva crucifixió.

32. Theme category: 'others'

1: En las escuelas se enseña el alfabeto romano, que tiene 26 *letras* en muchos idiomas.

2: En las escuelas se enseña el alfabeto romano, que tiene 26 *números* en muchos idiomas.
3: A les escoles s'ensenya l'alfabet romà, que té 26 *lletres* a molts idiomes.
4: A les escoles s'ensenya l'alfabet romà, que té 26 *nombres* a molts idiomes.

33. Theme category: 'literature'
1: En el famoso cuento infantil, Rapunzel lanza las *trenzas* para ayudar al príncipe a subir a la torre.
2: En el famoso cuento infantil, Rapunzel lanza las *cuerdas* para ayudar al príncipe a subir a la torre.
3: Al famós conte infantil, Rapunzel llança les *trenes* per ajudar el príncep a pujar a la torre.
4: Al famós conte infantil, Rapunzel llança les *cordes* per ajudar el príncep a pujar a la torre.

34. Theme category: 'basic semantic knowledge'
1: Al final del conflicto, los vencedores declararon su *victoria* en una larga cumbre de crisis.
2: Al final del conflicto, los vencedores declararon su *derrota* en una larga cumbre de crisis.
3: Al final del conflicte, els vencedors van declarar la seva *victòria* en una llarga cimera de crisi.
4: Al final del conflicte, els vencedors van declarar la seva *derrota* en una llarga cimera de crisi.

Note: This item was removed from in Experiments 1 and 2 since it produced false detections in more than 50% of the cases.

35. Theme category: 'literature'
1: Antes de casarse con el príncipe, los siete enanitos protegieron a *Blancanieves* de la malvada reina.
2: Antes de casarse con el príncipe, los siete enanitos protegieron a *Cenicienta* de la malvada reina.
3: Abans de casar-se amb el príncep, els set nans van protegir la *Blancaneus* de la malvada reina.
4: Abans de casar-se amb el príncep, els set nans van protegir la *Ventafocs* de la malvada reina.

36. Theme category: 'others'
1: En una noche de locura, el pintor Vincent van Gogh perdió una *oreja* por automutilación.
2: En una noche de locura, el pintor Vincent van Gogh perdió un *ojo* por automutilación.
3: En una nit de bogeria, el pintor Vincent van Gogh va perdre una *orella* per automutilació.
4: En una nit de bogeria, el pintor Vincent van Gogh va perdre un *ull* per automutilació.

37. Theme category: 'basic semantic knowledge'
1: Para hacer una naranjada, la cocinera exprimió muchas *naranjas* maduras durante toda la mañana.
2: Para hacer una naranjada, la cocinera exprimió muchas *manzanas* maduras durante toda la mañana.
3: Per fer una taronjada, la cuinera va esprémer moltes *taronges* madures durant tot el matí.
4: Per fer una taronjada, la cuinera va esprémer moltes *pomes* madures durant tot el matí.

38. Theme category: 'religion'
1: En el día de Navidad, los cristianos recuerdan el *nacimiento* de Jesucristo en la aldea de Belén.
2: En el día de Navidad, los cristianos recuerdan la *muerte* de Jesucristo en la aldea de Belén.
3: El dia de Nadal, els cristians recorden el *naixement* de Jesucrist en el llogaret de Betlem.
4: El dia de Nadal, els cristians recorden la *mort* de Jesucrist en el llogaret de Betlem.

39. Theme category: 'others'

1: Los juegos olímpicos se celebran cada *cuatro* años para conmemorar los juegos originales de la Antigua Grecia.
2: Los juegos olímpicos se celebran cada *dos* años para conmemorar los juegos originales de la Antigua Grecia.
3: Els jocs olímpics se celebren cada *quatre* anys per conmemorar els jocs originals de l'Antiga Grècia.
4: Els jocs olímpics se celebren cada *dos* anys per conmemorar els jocs originals de l'Antiga Grècia.

40. Theme category: 'astronomy'

1: En un eclipse solar, el sol es tapado por la *luna* y deja de verse por unas horas.
2: En un eclipse solar, el sol es tapado por la *tierra* y deja de verse por unas horas.
3: En un eclipse solar, el sol és tapat per la *lluna* i deixa de veure's per unes hores.
4: En un eclipse solar, el sol és tapat per la *terra* i deixa de veure's per unes hores.

41. Theme category: 'history'

1: Cristóbal Colón llegó a América después de un largo viaje en el siglo *XV* pensando que era la India.
2: Cristóbal Colón llegó a América después de un largo viaje en el siglo *XIV* pensando que era la India.
3: Cristòfor Colom va arribar a Amèrica després d'un llarg viatge al segle *XV* pensant que era l'Índia.
4: Cristòfor Colom va arribar a Amèrica després d'un llarg viatge al segle *XIV* pensant que era l'Índia.

42. Theme category: 'literature'

1: En la historia de la Caperucita Roja, el *lobo* se vistió de abuelita con la intención de comerse a la protagonista.
2: En la historia de la Caperucita Roja, el *zorro* se vistió de abuelita con la intención de comerse a la protagonista.
3: A la història de la Caputxeta Vermella, el *llop* es va vestir d'àvia amb la intenció de menjar-se la protagonista.
4: A la història de la Caputxeta Vermella, la *guineu* es va vestir d'àvia amb la intenció de menjar-se la protagonista.

43. Theme category: 'geography'

1: Moscú, Nápoles y Atenas son tres *ciudades* que se pueden encontrar en Europa.
2: Moscú, Nápoles y Atenas son tres *capitales* que se pueden encontrar en Europa.
3: Moscou, Nàpols i Atenes són tres *ciutats* que es poden trobar a Europa.
4: Moscou, Nàpols i Atenes són tres *capitals* que es poden trobar a Europa.

44. Theme category: 'others'

1: Cruella de Vil es la villana principal de los *101* Dálmatas, una famosa película de Disney.
2: Cruella de Vil es la villana principal de los *100* Dálmatas, una famosa película de Disney.
3: Cruella de Vil és la vilana principal dels *101* Dàlmates, una famosa pel·licula de Disney.
4: Cruella de Vil és la vilana principal dels *100* Dàlmates, una famosa pel·licula de Disney.

45. Theme category: 'music'
1: Michael Jackson se convirtió en una estrella del *pop* con canciones como 'Thriller'.
2: Michael Jackson se convirtió en una estrella del *rock* con canciones como 'Thriller'.
3: Michael Jackson es va convertir en una estrella del *pop* amb cançons com 'Thriller'.
4: Michael Jackson es va convertir en una estrella del *rock* amb cançons com 'Thriller'.

46. Theme category: 'geography'
1: Una famosa torre inclinada se puede encontrar en la ciudad *italiana* de Pisa.
2: Una famosa torre inclinada se puede encontrar en la ciudad *francesa* de Pisa.
3: Una famosa torre inclinada es pot trobar a la ciutat *italiana* de Pisa.
4: Una famosa torre inclinada es pot trobar a la ciutat *francesa* de Pisa.

47. Theme category: 'history'
1: Barack Obama hizo historia como el primer presidente *demócrata* negro en los Estados Unidos.
2: Barack Obama hizo historia como el primer presidente *republicano* negro en los Estados Unidos.
3: Barack Obama va fer història com el primer president *demòcrata* negre als Estats Units.
4: Barack Obama va fer història com el primer president *republicà* negre als Estats Units.

48. Theme category: 'semantics'
1: Durante una tormenta, al *ver* un relámpago, no es seguro encontrar refugio bajo un árbol.
2: Durante una tormenta, al *oir* un relámpago, no es seguro encontrar refugio bajo un árbol.
3: Durant una tempesta, en *veure* un llampec, no és segur trobar refugi sota un arbre.
4: Durant una tempesta, en *escoltar* un llampec, no és segur trobar refugi sota un arbre.

49. Theme category: 'others'
1: En un 'Home Run' de béisbol, un jugador golpea la pelota con el *bate* tan lejos que puede correr alrededor del campo.
2: En un 'Home Run' de béisbol, un jugador golpea la pelota con la *raqueta* tan lejos que puede correr alrededor del campo.
3: En un 'Home Run' de beisbol, un jugador colpeja la pilota amb el *bat* tan lluny que pot córrer al voltant del camp.
4: En un 'Home Run' de beisbol, un jugador colpeja la pilota amb la *raqueta* tan lluny que pot córrer al voltant del camp.

50. Theme category: 'dates'
1: El último día del año se celebra en Nochevieja, el 31 de *diciembre*, con fuegos artificiales.
2: El último día del año se celebra en Nochevieja, el 31 de *enero*, con fuegos artificiales.
3: L'últim día de l'any se celebra la nit de Cap d'Any, el 31 de *desembre*, amb focs artificials.
4: L'últim día de l'any se celebra la nit de Cap d'Any, el 31 de *gener*, amb focs artificials.

Note: This item was removed in Experiment 2 due to orthographic mistakes in the Catalan versions (the word '*día*' has no accent in Catalan).

51. Theme category: 'history'
1: El famoso barco transantlántico del Titanic chocó en el océano *Atlántico* con un iceberg y se hundió.
2: El famoso barco transantlántico del Titanic chocó en el océano *Pacífico* con un iceberg y se hundió.

3: El famós vaixell transantlàntic del Titanic va xocar a l'oceà *Atlàntic* amb un iceberg i es va esfonsar.
4: El famós vaixell transantlàntic del Titanic va xocar a l'oceà *Pacífic* amb un iceberg i es va esfonsar.

52. Theme category: 'dates'
1: Hay años especiales cada cuatro años en los que febrero *gana* un día en el calendario.
2: Hay años especiales cada cuatro años en los que febrero *pierde* un día en el calendario.
3: Hi ha anys especials cada cuatre anys en els que febrer *guanya* un dia al calendari.
4: Hi ha anys especials cada cuatre anys en els que febrer *perd* un dia al calendari.

53. Theme category: 'others'
1: Los Reyes Magos de Oriente son conocidos por repartir regalos de *navidad* montados en sus camellos.
2: Los Reyes Magos de Oriente son conocidos por repartir regalos de *cumpleaños* montados en sus camellos.
3: Els Reis Mags d'Orient són coneguts per repartir regals de *nadal* muntats en els seus camells.
4: Els Reis Mags d'Orient són coneguts per repartir regals d'*aniversari* muntats en els seus camells.

54. Theme category: 'others'
1: En Halloween los niños se disfrazan y van *recogiendo* caramelos de casa en casa.
2: En Halloween los niños se disfrazan y van *repartiendo* caramelos de casa en casa.
3: A Halloween els nens es disfressen i van *recollint* caramels de casa a casa.
4: A Halloween els nens es disfressen i van *repartint* caramels de casa a casa.

55. Theme category: 'mathematics'
1: Los números primos, como el 3 o el 5, son números que sólo se pueden *dividir* entre 1 y sí mismos.
2: Los números primos, como el 3 o el 5, son números que sólo se pueden *multiplicar* entre 1 y sí mismos.
3: Els nombres primers, com el 3 o el 5, són nombres que només es poden *dividir* entre 1 i ells mateixos.
4: Els nombres primers, com el 3 o el 5, són nombres que només es poden *multiplicar* entre 1 i ells mateixos.

56. Theme category: 'others'
1: La lengua romance más hablada en el mundo es el *español*, que es la lengua oficial de muchos países.
2: La lengua romance más hablada en el mundo es el *inglés*, que es la lengua oficial de muchos países.
3: La llengua romanç més parlada al món és l'*espanyol*, que és llengua oficial de molts països.
4: La llengua romanç més parlada al món és l'*anglès*, que és llengua oficial de molts països.

57. Theme category: 'animals'
1: El ornitorrinco es conocido por ser actualmente uuno de los únicos *mamíferos* que pone huevos.
2: El ornitorrinco es conocido por ser actualmente uuno de los únicos *ovíparos* que pone huevos.
3: L'ornitorinc és conegut per ser actualment un dels únics *mamífers* que posa ous.

4: L’ornitorinc és conegut per ser actualment un dels únics *ovípars* que posa ous.

58. Theme category: ‘animals’
1: Existen organismos como los caracoles que son ***hermafroditas*** por tener órganos reproductivos femeninos y masculinos.
2: Existen organismos como los caracoles que son ***afroditas*** por tener órganos reproductivos femeninos y masculinos.
3: Hi ha organismes com els caracols que són ***hermafrodites*** per tenir òrgans reproductius femenins i masculins.
4: Hi ha organismes com els caracols que són ***afrodites*** per tenir òrgans reproductius femenins i masculins.

59. Theme category: ‘others’
1: El fémur conecta la pelvis con la rodilla y es el hueso más fuerte y más *largo* en los seres humanos.
2: El fémur conecta la pelvis con la rodilla y es el hueso más fuerte y más *corto* en los seres humanos.
3: El fèmur connecta la pelvis amb el genoll i és l’os més fort i més *llarg* en els éssers humans.
4: El fèmur connecta la pelvis amb el genoll i és l’os més fort i més *curt* en els éssers humans.

60. Theme category: ‘history’
1: La misión espacial que llevó el primer hombre a la luna fue Apollo *11* en el año 1969.
2: La misión espacial que llevó el primer hombre a la luna fue Apollo *12* en el año 1969.
3: La missió espacial que va portar el primer home a la lluna va ser Apollo *11* l’any 1969.
4: La missió espacial que va portar el primer home a la lluna va ser Apollo *12* l’any 1969.

61. Theme category: ‘psychology’
1: La agorafobia es el pánico a los espacios *abiertos* y suele ir acompañada de ansiedad.
2: La agorafobia es el pánico a los espacios *cerrados* y suele ir acompañada de ansiedad.
3: L’agorafòbia és el pànic als espais *oberts* i sol anar acompanyada d’ansietat.
4: L’agorafòbia és el pànic als espais *tancats* i sol anar acompanyada d’ansietat.

62. Theme category: ‘psychology’
1: La extraversión es un rasgo de la personalidad que se suele manifestar en ser abierto, ***hablador*** y enérgico.
2: La extraversión es un rasgo de la personalidad que se suele manifestar en ser abierto, ***reservado*** y enérgico.
3: L’extraversió és un tret de la personalitat que se sol manifestar en ser obert, ***xerraire*** i enèrgic.
4: L’extraversió és un tret de la personalitat que se sol manifestar en ser obert, ***reservat*** i enèrgic.

63. Theme category: ‘mathematics’
1: ‘Un cuarto’ en forma de fracción tiene un 4 como *denominador*, tal y como aprenden los niños en la escuela.
2: ‘Un cuarto’ en forma de fracción tiene un 4 como *numerador*, tal y como aprenden los niños en la escuela.
3: ‘Un quart’ en forma de fracció té un 4 com a *denominador*, tal com aprenen els nens a l’escola.
4: ‘Un quart’ en forma de fracció té un 4 com a *numerador*, tal com aprenen els nens a l’escola.

64. Theme category: 'geography'
1: Las auroras boreales son un fenómeno natural de luz que se da principalmente en la región *Ártica* por la noche.
2: Las auroras boreales son un fenómeno natural de luz que se da principalmente en la región *Antártica* por la noche.
3: Les aurores boreals són un fenomen naturual de llum que es dóna principalment a la regió *Àrtica* a la nit.
4: Les aurores boreals són un fenomen naturual de llum que es dóna principalment a la regió *Antàrtica* a la nit.

65. Theme category: 'science'
1: Cuando una célula se divide se dice que se da la *mitosis* durante la reproducción celular.
2: Cuando una célula se divide se dice que se da la *meiosis* durante la reproducción celular.
3: Quan una cèl·lula es divideix es diu que es produeix la *mitosi* durant la reproducció cel·lular.
4: Quan una cèl·lula es divideix es diu que es produeix la *meiosi* durant la reproducció cel·lular.

Note: This item was removed in Experiments 1 and 2 since the incorrect sentences actually contained no semantic inaccuracy. These said 'When a cell divides, it is said that meiosis occurs during cell reproduction' intending to be semantically incorrect, but both mitosis and meiosis refer to processes of cell division during cell reproduction.

66. Theme category: 'music'
1: El K-pop, popular en regiones asiáticas, es un género de música *pop* originario de Corea.
2: El K-pop, popular en regiones asiáticas, es un género de música *rap* originario de Corea.
3: El K-pop, popular a regions asiàtiques, és un gènere de música *pop* originari de Corea.
4: El K-pop, popular a regions asiàtiques, és un gènere de música *rap* originari de Corea.

67. Theme category: 'others'
1: Normalmente cocinado con salmón y arroz, el sushi originario de *Japón* se come con palillos.
2: Normalmente cocinado con salmón y arroz, el sushi originario de *China* se come con palillos.
3: Normalment cuinat amb salmó i arròs, el sushi originari del *Japó* es menja amb bastonets.
4: Normalment cuinat amb salmó i arròs, el sushi originari de la *Xina* es menja amb bastonets.

68. Theme category: 'astronomy'
1: Cuando una estrella ha explotado se la llama estrella *supernova* en astrofísica.
2: Cuando una estrella ha explotado se la llama estrella *nebulosa* en astrofísica.
3: Quan una estrella ha explotat s'anomena estrella *supernova* en astrofísica.
4: Quan una estrella ha explotat s'anomena estrella *nebulosa* en astrofísica.

69. Theme category: 'mathematics'
1: En la naturaleza se puede encontrar la forma hexagonal de *seis* lados en las colmenas de las abejas.
2: En la naturaleza se puede encontrar la forma hexagonal de *siete* lados en las colmenas de las abejas.
3: A la naturalesa es pot trobar la forma hexagonal de *sis* costats als ruscs de les abelles.
4: A la naturalesa es pot trobar la forma hexagonal de *set* costats als ruscs de les abelles.

70. Theme category: 'geography'
1: Al viajar a Londres se debería visitar el famoso edificio *Big Ben*, que ha sido remodelado recientemente.

2: Al viajar a Londres se debería visitar el famoso edificio *Big Bang*, que ha sido remodelado recientemente.
3: En viatjar a Londres s'hauria de visitar el famós edifici *Big Ben*, que ha estat remodelat recentment.
4: En viatjar a Londres s'hauria de visitar el famós edifici *Big Bang*, que ha estat remodelat recentment.

71. Theme category: 'mathematics'
1: En un triángulo equilátero, cada uno de los *tres* lados tiene la misma longitud.
2: En un triángulo equilátero, cada uno de los *cuatro* lados tiene la misma longitud.
3: En un triangle equilàter, cadascun dels *tres* costats té la mateixa longitud.
4: En un triangle equilàter, cadascun dels *quatre* costats té la mateixa longitud.

72. Theme category: 'literature'
1: Julio Verne escribió una novela donde Phileas Fogg da la vuelta al mundo en *ochenta* días.
2: Julio Verne escribió una novela donde Phileas Fogg da la vuelta al mundo en *noventa* días.
3: Julio Verne va escriure una novel·la on Phileas Fogg fa la volta al món en *viutanta* dies.
4: Julio Verne va escriure una novel·la on Phileas Fogg fa la volta al món en *noranta* dies.

73. Theme category: 'geography'
1: Las islas paradisíacas de Hawaii, situadas en el océano *Pacífico*, pertenecen a los Estados Unidos de América.
2: Las islas paradisíacas de Hawaii, situadas en el océano *Atlántico*, pertenecen a los Estados Unidos de América.
3: Les illes paradisíaques de Hawaii, situades a l'oceà *Pacífic*, pertanyen als Estats Units d'Amèrica.
4: Les illes paradisíaques de Hawaii, situades a l'oceà *Atlàntic*, pertanyen als Estats Units d'Amèrica.

74. Theme category: 'others'
1: Mark Zuckerberg, un famoso magnate de las redes sociales, creó *Facebook* cuando tenía solo 20 años.
2: Mark Zuckerberg, un famoso magnate de las redes sociales, creó *Twitter* cuando tenía solo 20 años.
3: Mark Zuckerberg, un famós magnat de les xarxes socials, va crear *Facebook* quan només tenia 20 anys.
4: Mark Zuckerberg, un famós magnat de les xarxes socials, va crear *Twitter* quan només tenia 20 anys.

Appendix B

Filler stimuli

1: Spanish version

2: Catalan version

Experiment 1 only included the Spanish version of these filler sentences (version *1*).

Experiment 2 included both versions (*1* and *2*).

English translations to all items are available upon request from the author.

1. Theme category: 'animals'; type: incorrect
   1: El pelaje de los osos del Polo Sur es blanco.
   2: El pelatge dels óssos del Pol Sud és blanc.

2. Theme category: 'animals'; type: correct
   1: XY es la combinación de cromosomas para un animal macho.
   2: XY és la combinació de cromosomes per a un animal mascle.

3. Theme category: 'astronomy'; type: correct
   1: El sol sale por el este.
   2: El sol surt per l'est.

4. Theme category: 'astronomy'; type: incorrect
   1: El planeta Marte tiene diez anillos.
   2: El planeta Mart té deu anells.

5. Theme category: 'science'; type: incorrect
   1: Los monos son comparables a los humanos de acuerdo a la teoría de Charles David.
   2: Els micos són comparables als humans d'acord amb la teoria de Charles David.

6. Theme category: 'science'; type: correct
   1: La composición del agua es H2O.
   2: La composició de l'aigua és H2O.

7. Theme category: 'history'; type: correct
   1: Marie Curie es conocida por sus estudios sobre radiactividad.
   2: Marie Curie és coneguda pels seus estudis sobre radioactivitat.

8. Theme category: 'science'; type: incorrect
   1: Los protones son las partículas que tienen carga negativa.
   2: Els protons són les partícules que tenen càrrega negativa.

9. Theme category: 'food'; type: correct
   1: La salsa mexicana guacamole se prepara principalmente con aguacates.
   2: La salsa mexicana guacamole es prepara principalment amb alvocats.

10. Theme category: 'food'; type: incorrect
   1: La cadena de comida rápida Burguer King normalmente sirve platos de pollo.
   2: La cadena de menjar ràpid Burguer King normalment serveix plats de pollastre.

11. Theme category: 'science'; type: correct
   1: En el ADN se encuentran los rasgos hereditarios de un organismo.
   2: A l'ADN hi ha els trets hereditaris d'un organisme.

12. Theme category: 'others'; type: incorrect
   1: Lionel Messi juega en el Real Madrid.
   2: Lionel Messi juga al Real Madrid.

13. Theme category: 'dates'; type: incorrect
   1: El Día de Todos los Santos se celebra el 1 de septiembre.
   2: El Dia de Tots Sants se celebra l'1 de setembre.

14. Theme category: ‘others’; type: correct
1: Invierno, primavera, verano y otoño son las cuatro estaciones del año.
2: Hivern, primavera, estiu i tardor són les quatre estacions de l'any.

15. Theme category: ‘dates’; type: incorrect
1: El mes de marzo tiene menos días que el mes de febrero.
2: El mes de març té menys dies que el mes de febrer.

16. Theme category: ‘geography’; type: correct
1: Suiza es famosa por los relojes de cuco y el chocolate.
2: Suïssa és famosa pels rellotges de cucut i la xocolata.

17. Theme category: ‘geography’; type: correct
1: La capital de Alemania es Berlín.
2: La capital d'Alemanya és Berlín.

18. Theme category: ‘others’; type: correct
1: El rojo y el amarillo forman la bandera de España.
2: El vermell i el groc formen la bandera d'Espanya.

19. Theme category: ‘geography’; type: correct
1: El 'London Eye' es una famosa noria situada en Londres.
2: El 'London Eye' és una famosa noria situada a Londres.

20. Theme category: ‘geography’; type: incorrect
1: La Torre Eiffel se puede encontrar en Marsella.
2: La Torre Eiffel es pot trobar a Marsella.

21. Theme category: ‘geography’; type: incorrect
1: Madrid es la capital de Argentina.
2: Madrid és la capital d'Argentina.

22. Theme category: ‘geography’; type: incorrect
1: Los Pirineos se encuentran entre España y Portugal.
2: Els Pirineus es troben entre Espanya i Portugal.

23. Theme category: ‘geography’; type: incorrect
1: La sede de la Unión Europea está en Londres.
2: La seu de la Unió Europea és a Londres.

24. Theme category: ‘geography’; type: correct
1: El río más largo de África es el río Nilo.
2: El riu més llarg d'Àfrica és el riu Nil.

25. Theme category: ‘geography’; type: incorrect
1: Estados Unidos se encuentra al sur de México.
2: Estats Units es troba al sud de Mèxic.

26. Theme category: ‘geography’; type: incorrect
1: La Alhambra es un conjunto de palacios antiguos de Málaga.
2: L'Alhambra és un conjunt de palaus antics de Màlaga.

27. Theme category: ‘others’; type: incorrect
1: Leonardo DaVinci pintó el Guernica.
2: Leonardo DaVinci va pintar el Guernica.

28. Theme category: ‘history’; type: correct
1: Thomas Edison, inventor del teléfono, era americano.
2: Thomas Edison, inventor del telèfon, era americà.

29. Theme category: ‘history’; type: correct
1: El muro de Berlín cayó en el año 1999.
2: El mur de Berlín va caure l'any 1999.

30. Theme category: ‘history’; type: incorrect
1: El presidente Trump quería construir un muro en la frontera con Canadá.
2: El president Trump volia construir un mur a la frontera amb Canadà.

31. Theme category: ‘history’; type: incorrect
1: La moneda que se usaba en España antes del euro era la peseta.

2: La moneda que es feia servir a Espanya abans de l'euro era la pesseta.

32. Theme category: ‘history’; type: correct
1: Sócrates, Platón y Aristóteles fueron filósofos romanos.
2: Sòcrates, Plató i Aristòtil van ser filòsofs romans.

33. Theme category: ‘history’; type: incorrect
1: El muro de Berlín cayó en el año 1999.
2: El mur de Berlín va caure l'any 1999.

34. Theme category: ‘history’; type: correct
1: Martin Luther King fue un famoso activista de los derechos afroamericanos.
2: Martin Luther King va ser un famós activista dels drets afroamericans.

35. Theme category: ‘literature’; type: correct
1: Hermione es la amiga de Harry Potter.
2: Hermione és l'amiga de Harry Potter.

36. Theme category: ‘literature’; type: correct
1: El socio de Sherlock Holmes se llama Dr. Watson.
2: El soci de Sherlock Holmes es diu Dr. Watson.

37. Theme category: ‘literature’; type: incorrect
1: Ariel se transforma de humana a sirena.
2: Ariel es transforma d'humana a sirena.

38. Theme category: ‘literature’; type: correct
1: Dulcinea es un personaje del Quijote.
2: Dulcinea és un personatge del Quixot.

39. Theme category: ‘literature’; type: incorrect
1: A Pinocho le crece la nariz cuando dice la verdad.
2: A Pinotxo li creix el nas quan diu la veritat.

40. Theme category: ‘literature’; type: incorrect
1: Hansel y Gretel eran primos.
2: Hansel i Gretel eren cosins.

41. Theme category: ‘literature’; type: incorrect
1: En el cuento de Aladín, Aladín sale de una lámpara.
2: Al conte d’Aladín, Aladín surt d’una llàntia.

42. Theme category: ‘literature’; type: correct
1: El sombrerero es un personaje de Alicia en el país de las maravillas.
2: El barreter és un personatge d'Alícia al país de les meravelles.

43. Theme category: ‘literature’; type: incorrect
1: Peter Pan es un adulto que nunca crece.
2: Peter Pan és un adult que no creix mai.

44. Theme category: ‘mathematics’; type: incorrect
1: Once huevos son necesarios para hacer una docena.
2: Onze ous són necessaris per fer una dotzena.

45. Theme category: ‘mathematics’; type: incorrect
1: El número romano V representa el número 10.
2: El nombre romà V representa el nombre 10.

46. Theme category: ‘mathematics’; type: correct
1: El 50% de 200 euros es 100 euros.
2: El 50% de 200€ és 100€.

47. Theme category: ‘mathematics’; type: correct
1: Un trienio es un periodo equivalente a tres años.
2: Un trienni és un període equivalent a tres anys.

48. Theme category: ‘music’; type: correct
1: Amy Winehouse murió a causa del alcohol.
2: Amy Winehouse va morir a causa de l'alcohol.

49. Theme category: ‘music’; type: correct
1: A Elvis Presley se le conoce a menudo como el rey del Rock and Roll.
2: A Elvis Presley se'l coneix sovint com el rei del Rock and Roll.

50. Theme category: ‘others’; type: correct
1: El violín y la guitarra son instrumentos de cuerda.
2: El violí i la guitarra són instruments de corda.

51. Theme category: ‘others’; type: correct
1: El sentido de las agujas del reloj es hacia la derecha.
2: El sentit de les agulles del rellotge és cap a la dreta.

52. Theme category: ‘others’; type: incorrect
1: Para hacer el color verde hay que mezclar azul y rojo.
2: Per fer el color verd cal barrejar blau i vermell.

53. Theme category: ‘others’; type: correct
1: El logo de los juegos olímpicos tiene seis anillos.
2: El logotip dels jocs olímpics té sis anells.

54. Theme category: ‘others’; type: incorrect
1: Seis dígitos se usan como pin de una tarjeta de crédito.
2: Sis dígits es fan servir com a pin d'una targeta de crèdit.

55. Theme category: ‘psychology’; type: correct
1: Una persona que padece insomnio es incapaz de dormir.
2: Una persona que pateix insomni és incapaç de dormir.

56. Theme category: ‘psychology’; type: incorrect
1: La gente con aracnofobia le tiene miedo a todos los insectos.
2: La gent amb aracnofòbia té por de tots els insectes.

57. Theme category: ‘religion’; type: correct
1: Eva comió una manzana en el Paraíso.
2: Eva va menjar una poma al Paradís.

58. Theme category: ‘religion’; type: correct
1: Alá es el dios de la religión islámica.
2: Al·là és el déu de la religió islàmica.

59. Theme category: ‘religion’; type: incorrect
1: El Ramadán se celebra en la religión hindú.
2: El Ramadà se celebra a la religió hindú.

60. Theme category: ‘religion’; type: incorrect
1: En la Biblia, Jesús transforma el vino en agua.
2: A la Bíblia, Jesús transforma el vi en aigua.

61. Theme category: ‘basic semantic knowledge’; type: incorrect
1: En el periodo de incubación los animales duermen durante todo el invierno.
2: En el període d'incubació els animals dormen durant tot l'hivern.

62. Theme category: ‘basic semantic knowledge’; type: incorrect
1: El soldado sin arma disparará.
2: El soldat sense arma dispararà.

63. Theme category: ‘basic semantic knowledge’; type: correct
1: Los cajeros en un supermercado cobran a los clientes.
2: Els caixers en un supermercat cobren als clients.

64. Theme category: ‘basic semantic knowledge’; type: correct
1: Las ballenas son animales marinos.
2: Les balenes són animals marins.

65. Theme category: ‘basic semantic knowledge’; type: incorrect
1: En las elecciones, los ciudadanos botan en las urnas.
2: A les eleccions, els ciutadans boten a les urnes.

66. Theme category: ‘basic semantic knowledge’; type: incorrect
1: El limón tiene un sabor dulce.
2: La llimona té un sabor dolç.

67. Theme category: ‘basic semantic knowledge’; type: correct
1: El café es una bebida que normalmente genera activación.
2: El cafè és una beguda que normalment genera activació.

68. Theme category: ‘basic semantic knowledge’; type: incorrect

1: Un artículo en rebajas cuesta más que su precio habitual.
2: Un article en rebaixes costa més que el preu habitual.

69. Theme category: 'basic semantic knowledge'; type: correct
1: El Caribe tiene un clima cálido.
2: El Carib té un clima càlid.

70. Theme category: 'basic semantic knowledge'; type: correct
1: Las montañas se miden en metros sobre el nivel del mar.
2: Les muntanyes es mesuren en metres sobre el nivell del mar.

71. Theme category: 'basic semantic knowledge'; type: correct
1: Un quilo de plumas pesa menos que un quilo de piedras.
2: Un quilo de plomes pesa menys que un quilo de pedres.

72. Theme category: 'others'; type: correct
1: Bill Gates es famoso por su programa de software Microsoft.
2: Bill Gates és famós pel seu programa de programari Microsoft.

73. Theme category: 'television'; type: correct
1: Darth Vader es el nombre del villano principal de Star Wars.
2: Darth Vader és el nom del dolent principal de Star Wars.

74. Theme category: 'television'; type: incorrect
1: Una famosa esponja amarilla vive en un coco en el fondo del mar.
2: Una famosa esponja groga viu en un coco al fons del mar.

Appendix C

Post-test check questions

1: Spanish version

2: Catalan version

Experiment 1 only included the Spanish version of these filler sentences (version *1*).

Experiment 2 included both versions (*1* and *2*).

English translations to all questions are available upon request from the author.

Item number	Question	Valid answers (Spanish / Catalan)
1	1: ¿Quién está relacionado con la medicina, Santiago Ramón y Cajal o Camilo José Cela? 2: Qui està relacionat amb la medicina, Santiago Ramón i Cajal o Camilo José Cela?	'Santiago Ramón y Cajal' / 'Santiago Ramón i Cajal'
2	1: ¿Qué figura bíblica llevó animales en un arca durante el diluvio? 2: Quina figura bíblica va portar animals en una arca durant el diluvi?	'Noé' / 'Noè'
3	1: ¿Un cadáver es un cuerpo con o sin vida? 2: Un cadàver és un cos amb o sense vida?	'Sin vida' / 'Sense vida'
4	1: ¿Cuál es la capital de Turquía? 2: Quina és la capital de Turquia?	'Ankara' / 'Ankara' [1] 'Estambul' / 'Istanbul'
5	1: ¿Qué princesa Disney está relacionada con un zapato de cristal? 2: Quina princesa Disney està relacionada amb una sabata de vidre?	'Cenicienta' / 'Ventafocs'
6	1: ¿Quiénes suelen ser multados por exceso de velocidad, los vehículos o los peatones? 2: Qui sol ser multat per excés de velocitat, els vehicles o els vianants?	'Vehículos' / 'Vehicles'
7	1: ¿Para quienes es útil el braille? 2: Per a qui és útil el braille?	'Para los ciegos' / 'Per als cecs'
8	1: ¿En qué cadena montañosa se encuentra Andorra? 2: A quina cadena muntanyenca es troba Andorra?	'Pirineos' / 'Pirineus'
9	1: ¿Cuántos apóstoles se asocian normalmente a Jesús?	'Doce' / 'Dotze'

	2:	Quants apòstols normalment s'associen a Jesús?	
10	1:	¿Por qué saga de libros es conocida J.K. Rowling?	‘Harry Potter’ / ‘Harry Potter’
	2:	Per quina saga de llibres és coneguda J.K. Rowling?	
11	1:	¿Qué era el príncipe antes de que la princesa lo besara en el famoso cuento infantil?	‘Sapo’ / ‘Gripau’
	2:	Què era el príncep abans que la princesa el besés en el famós conte infantil?	[2] ‘Rana’ / ‘Granota’
12	1:	¿Quiénes son descartados de las pruebas de acceso militar, los inaptos o los aptos?	‘Inaptos’ / ‘Inaptes’
	2:	Quins són descartats de les proves d’accés militar, els inaptes o els aptes?	
13	1:	¿Cuál es la capital de Dinamarca donde hay una famosa estatua de una sirena?	‘Copenhague’ / ‘Copenhague’
	2:	Quina és la capital de Dinamarca on hi ha una estàtua famosa d'una sirena?	
14	1:	¿Qué animal se esconde en un reloj en el cuento del lobo y los siete cabritos?	‘Un cabrito’ / ‘Una cabreta’
	2:	Quin animal s'amaga en un rellotge al conte del llop i les set cabretes?	
15	1:	¿Qué tipo de libro escribió Anna Frank durante la Segunda Guerra Mundial?	‘Un diario’ / ‘Un diari’
	2:	Quin tipus de llibre va escriure Anna Frank durant la Segona Guerra Mundial?	
16	1:	¿Quién formuló la ley de la gravedad, asociada a la caída de una manzana?	‘Isaac Newton’ / ‘Isaac Newton’
	2:	Qui va formular la llei de la gravetat, associada amb la caiguda d'una poma?	‘Newton’ / ‘Newton’
17	1:	¿Los ángulos se miden con grados centígrados o con grados de abertura?	‘De abertura’ / ‘D’obertura’
	2:	Els angles es mesuren amb graus centígrads o amb graus d’obertura?	
18	1:	¿Quién fue la primera persona en llegar a la Luna?	‘Neil Armstrong’ / ‘Neil Armstrong’
	2:	Qui va ser la primera persona a arribar a la Lluna?	
19	1:	¿En qué país estalló la bomba de Hiroshima?	‘Japón’ / ‘Japó’
	2:	A quin país va esclatar la bomba d'Hiroshima?	
20	1:	¿Los críticos en las fiestas literarias hablan de los lectores o de los autores?	‘Autores’ / ‘Autors’
	2:	Els crítics a les festes literàries parlen dels lectors o dels autors?	

21	1: ¿Quién desarrolló la teoría de la relatividad? 2: Qui va desenvolupar la teoria de la relativitat?	‘Albert Einstein’ / ‘Albert Einstein’ ‘Einstein’ / ‘Einstein’
22	1: ¿Qué río, de los principales de España, pasa por la Rioja? 2: Quin riu dels principals d'Espanya passa per la Rioja?	‘Ebro’ / ‘Ebre’
23	1: ¿Con qué guerra se asocia normalmente a Hitler? 2: Amb quina guerra normalment s'associa a Hitler?	‘Segunda’ / ‘Segona’ ‘Segunda Guerra Mundial’ / ‘Segona Guerra Mundial’
24	1: ¿A quién suele perseguir y arrestar la policía en un robo, a los sospechosos o a las víctimas? 2: A qui sol perseguir i arrestar la policia en un robatori, els sospitosos o les víctimes?	‘Sospechosos’ / ‘Sospitosos’
25	1: ¿A qué figura se asocia la revolución comunista rusa? 2: A quina figura s'associa la revolució comunista russa?	‘Vladimir Lenin’ / ‘Vladimir Lenin’ ‘Lenin’ / ‘Lenin’
26	1: ¿Quienes pueden ser despedidos de una escuela por incompetencia profesional, los estudiantes o los profesores? 2: Qui pot ser acomiadat d'una escola per imcompetència professional, els estudiants o els professors?	‘Profesores’ / ‘Professors’
27	1: ¿Cuál es la capital de Hungría? 2: Quina és la capital d'Hongria?	‘Budapest’ / ‘Budapest’
28	1: ¿Un fallecido puede ser 'devuelto a casa sano y salvo'? 2: Un mort pot ser ‘tornat a casa sa i estalvi’?	‘No’ / ‘No’
29	1: ¿En qué se transforma Drácula? 2: En què es transforma Dràcula?	‘En vampiro’ / ‘En vampir’
30	1: ¿Mozart era músico o pintor? 2: Mozart era músic o pintor?	‘Músico’ / ‘Músic’
31	1: ¿Qué apóstol traicionó a Jesús? 2: Quin apòstol va trair Jesús?	‘Judas’ / ‘Judes’
32	1: ¿Qué hay en el alfabeto, letras o números? 2: Què hi ha a l'alfabet, lletres o números?	‘Letras’ / ‘Lletres’
33	1: ¿Con qué ayuda Rapunzel al príncipe a subir a la torre? 2: Amb què ajuda Rapunzel al príncep a pujar a la torre?	‘Trenzas’ / ‘Trenes’ ‘Cabello’ / ‘Cabell’

34	1: ¿A los vencedores se les asocia con la victoria o la derrota? 2: Als vencedors se'ls associa amb la victòria o la derrota?	‘Victoria’ / ‘Victòria’
35	1: ¿A qué princesa se asocian los siete enanitos? 2: Amb quina princesa s'associen els set nans?	‘Blancanieves’ / ‘Blancanieves’
36	1: ¿Qué parte del cuerpo perdió Vincent van Gogh? 2: Quina part del cos va perdre Vincent van Gogh?	‘Oreja’ / ‘Orella’
37	1: ¿Con qué fruta se hace una naranjada? 2: Amb quina fruita es fa una taronjada?	‘Naranja’ / ‘Taronges’
38	1: ¿Qué se celebra el día de Navidad, relacionado con Jesús? 2: Què se celebra el dia de Nadal, relacionat amb Jesús?	‘Su nacimiento’ / ‘El seu naixement’
39	1: ¿Cada cuántos años se celebran los juegos olímpicos? 2: Cada quants anys se celebren els jocs olímpics?	‘Cuatro’ / ‘Quatre’
40	1: ¿Qué astro tapa al sol en un eclipse solar? 2: Quin astre tapa el sol en un eclipsi solar?	‘Luna’ / ‘Lluna’
41	1: ¿En qué siglo llegó Cristóbal Colón a América? 2: En quin segle va arribar Cristòfor Colom a Amèrica?	‘XV’ / ‘XV’ ‘Quince’ / ‘Quinze’
42	1: ¿Qué animal se quiere comer a Caperucita Roja? 2: Quin animal es vol menjar a la Caputxeta Vermella?	‘Lobo’ / ‘Llop’
43	1: ¿Son Moscú, Nápoles y Atenas capitales de países? 2: Són Moscou, Nàpols i Atenes capitals de països?	‘No’ / ‘No’
44	1: ¿Cuántos dálmatas hay en la famosa película de Disney? 2: Quants dàlmates hi ha a la famosa pel·lícula de Disney?	‘101’ / ‘101’
45	1: ¿Con qué género de música se asocia a Michael Jackson, con el pop o con el rock? 2: Amb quin gènere de música s'associa Michael Jackson, amb el pop o amb el rock?	‘Pop’ / ‘Pop’
46	1: ¿En qué país se encuentra la torre inclinada de Pisa? 2: A quin país es troba la torre inclinada de Pisa?	‘Italia’ / ‘Itàlia’
47	1: ¿Barack Obama era un presidente demócrata o republicano? 2: Barack Obama era un president demòcrata o republicà?	‘Demócrata’ / ‘Demòcrata’
48	1: ¿Un relámpago se ve o se oye? 2: Un llampec es veu o s’escolta?	‘Se ve’ / ‘Es veu’

49	1:	¿Con qué golpea el jugador principal la pelota en el béisbol?	‘Con un bate’ / ‘Amb un bat’
	2:	Amb què colpeja el jugador principal la pilota al beisbol?	
50	1:	¿En qué mes se celebra el último día del año?	‘Diciembre’ / ‘Desembre’
	2:	A quin mes se celebra l'últim dia de l'any?	
51	1:	¿Por qué océano viajaba el Titanic?	‘Atlántico’ / ‘Atlàntic’
	2:	Per quin oceà viatjava el Titanic?	
52	1:	¿En los años bisiestos, febrero tiene un día más o un día menos?	‘Más’ / ‘Més’
	2:	Als anys de traspàs o bisextils, el febrer té un dia més o un dia menys?	
53	1:	¿Los Reyes Magos reparten regalos de cumpleaños?	‘No’ / ‘No’
	2:	Els Reis Mags reparteixen regals d’aniversari?	
54	1:	¿En Halloween los niños recogen caramelos?	‘Sí’ / ‘Si’
	2:	A Halloween els nens recullen caramels?	
55	1:	¿Un número primo solo se puede multiplicar entre 1 y sí mismo, o dividir entre 1 y sí mismo?	‘Dividir’ / ‘Dividir’
	2:	Un nombre primer només es pot multiplicar entre 1 i ell mateix, o dividir entre 1 i ell mateix?	
56	1:	¿De las lenguas romances, cuál es la más hablada en el mundo?	‘Español’ / ‘Espanyol’
	2:	De les llengües romàniques, quina és la més parlada al món?	
57	1:	¿Qué tipo de animal es el ornitorrinco, mamífero u ovíparo?	‘Mamífero’ / ‘Mamífer’
	2:	Quin tipus d'animal és l'ornitorinc, mamífer o ovípar?	‘Mamífero ovíparo’ / ‘Mamífer ovípar’
58	1:	¿Cómo se llama a un organismo que tiene órganos reproductivos tanto femeninos como masculinos?	‘Hermafrodita’ / ‘Hermafrodita’
	2:	Com s'anomena un organisme amb òrgans reproductius tant femenins com masculins?	
59	1:	¿Es el fémur un hueso largo o corto?	‘Largo’ / ‘Llarg’
	2:	És el fèmur un os llarg o curt?	
60	1:	¿Qué misión llevó al primer hombre a la luna, Apollo 11 o Apollo 12?	‘Apollo 11’ / ‘Apollo 11’
	2:	Quina missió va portar el primer home a la lluna, Apollo 11 o Apollo 12?	‘11’ / ‘11’
61	1:	¿A qué le tiene pánico la gente con agorafobia, espacios abiertos o cerrados?	‘Espacios abiertos’ / ‘Espais oberts’
	2:	A què té pànic la gent amb agorafòbia, espais oberts o tancats?	

62	1:	¿Son las personas extrovertidas normalmente habladoras o reservadas?	‘Habladoras’ / ‘Xerraires’
	2:	Són les persones extravertides normalment xerraires o reservades?	
63	1:	¿Cómo se llama la parte de la fracción donde se escribe el 4 en ‘un cuarto’?	‘Denominador’ / ‘Denominador’
	2:	Com s'anomena la part de la fracció on s'escriu el 4 a 'un quart'?	
64	1:	¿En qué región del mundo aparecen las auroras boreales, en regiones del Ártico o del Antártico?	‘Ártico’ / ‘Àrtic’
	2:	A quina regió del món apareixen les aurores boreals, en regions de l’Àrtic o de l’Antàrtic?	
65	1:	¿Cómo se llama el proceso por el que una célula se divide en la reproducción celular?	[3] ‘Mitosis’ / ‘Mitosi’
	2:	Com s'anomena el procés pel qual una cèl·lula es divideix en la reproducció cel·lular?	
66	1:	¿Qué género de música es el K-pop, pop o rap?	‘Pop’ / ‘Pop’
	2:	Quin gènere de música és el K-pop, pop o rap?	
67	1:	¿De qué país es originario el sushi?	‘Japón’ / ‘Japó’
	2:	De quin país és originari el sushi?	
68	1:	¿Cómo se llama a una estrella que ha explotado?	‘Supernova’ / ‘Supernova’
	2:	Com es diu una estrella que ha explotat?	
69	1:	¿Cuántos lados tiene un hexágono?	‘Seis’ / ‘Sis’
	2:	Quants costats té un hexàgon?	‘6’ / ‘6’
70	1:	¿Qué famoso edificio en Londres tiene un reloj?	‘Big Ben’ / ‘Big Ben’
	2:	Quin famós edifici a Londres té un rellotge?	
71	1:	¿Cuántos lados tiene un triángulo?	‘Tres’ / ‘Tres’
	2:	Quants costats té un triangle?	‘3’ / ‘3’
72	1:	¿Cuántos días tardó el protagonista de la novela de Julio Verne en ‘dar la vuelta al mundo’?	‘Ochenta’ / ‘Vuitanta’
	2:	Quants dies va trigar el protagonista de la novel·la de Julio Verne a ‘donar la volta al món’?	‘80’ / ‘80’
73	1:	¿En qué océano están las islas de Hawaii?	‘Pacífico’ / ‘Pacífic’
	2:	A quin oceà estan les illes de Hawaii?	
74	1:	¿Qué red social creó Mark Zuckerberg?	‘Facebook’ / ‘Facebook’
	2:	Quina xarxa social va crear Mark Zuckerberg?	

[1] '*Estambul'* or '*Istambul'* (in English, 'Istanbul') were also considered valid answers although they were not the correct answers to the main question. It was assumed that answering Istanbul is the capital of Turkey indicated that the subject held the geography knowledge required to answer to the main sentence.

[2] '*Rana'* or '*granota'* (in English, 'frog') were also considered valid answers although they were technically not the correct answers to the main question. Both frogs and toads have been included in the tale to which the original sentence refers to.

[3] '*Mitosis'* or '*mitosi'* (in English, 'mitosis') were technically not the only valid answers to the question included in this table, since meiosis also matches the description. This item was further removed from the analysis (for more details see Appendix A).

Appendix D

Sociolinguistic questionnaire

This appendix includes all the questions participants had to complete related to some sociolinguistic measures.

Questions presented only in Experiment 1 are represented in **green**. Questions presented only to the Spanish-Catalan bilingual participants in Experiment 2 are represented in **blue**. The rest of the questions in **black** were presented in both experiments.

The English translation of the questionnaire is available upon request from the author.

Escribe en el recuadro otras lenguas que conozcas, a parte del castellano:

…

Escribe todas las lenguas que conoces en orden de dominancia, de mayor a menor. Si más de una tiene la misma posición, indícalo (por ejemplo: 'castellano, inglés/francés').

…

Indica el nombre de cada lengua que conoces y, al lado, escribe el porcentaje de tiempo que estás expuesto/a de media actualmente a cada lengua (por ejemplo: 'castellano 80%, catalán 10%, inglés 10%').

…

¿Has aprendido alguna vez catalán?

…

¿Has vivido alguna vez en ciudades donde se hablase catalán?

…

Si tuvieses que **leer un texto** disponible en todas las lenguas que conoces, escribe en qué porcentaje elegirías leerlo en cada lengua (por ejemplo: '90% castellano, 10% catalán').

…

Si tuvieses que **hablar** con una persona que conoce a la perfección todas las lenguas que tú conoces, escribe en qué porcentaje elegirías comunicarte con ella en cada lengua (por ejemplo: '60% castellano, 20% catalán, 20% inglés').

…

Para cada lengua que conoces, escribe del 0 al 10 cuánto te identificas con su cultura (por ejemplo: '9 castellano, 9 catalán, 3 inglés').

…

Escribe en qué porcentaje usas cada lengua para hablar con tu **familia** (por ejemplo: '100% castellano').

…

Escribe en qué porcentaje usas cada lengua para hablar con tu **pareja** (por ejemplo: '90% catalán, 10% castellano').

…

Escribe en qué porcentaje usas cada lengua para hablar con tus **amigos/as** (por ejemplo: '60% castellano, 20% catalán, 20% inglés').

…

Escribe el porcentaje en que **ves la televisión, series o películas** en cada lengua (por ejemplo: '90% inglés, 10% castellano').

…

Escribe en qué porcentaje usas cada lengua cuando **vas de compras o a restaurantes** (por ejemplo: '100% castellano').

…

Escribe en qué porcentaje usas cada lengua cuando **vas al ayuntamiento, banco u otras oficinas** (por ejemplo: '90% castellano, 10% francés').

…

Escribe en qué porcentaje usas cada lengua para **hacer búsquedas en internet** (por ejemplo: ‘50% castellano, 50% inglés’).

…

Escribe en qué porcentaje usas cada lengua en **redes sociales**, sin contar mensajería (por ejemplo: ‘80% inglés, 20% castellano’).

…

Las preguntas de a continuación se refieren solo al **CASTELLANO**

Escribe a qué edad adquiriste el castellano (si eres hablante nativo/a, escribe ‘nativo’).

…

Escribe dónde aprendiste el castellano (por ejemplo: ‘en casa’).

…

Indica brevemente cuánto tiempo has estado viviendo en ciudades de habla castellana, aunque en esos lugares se hablase además otra lengua (por ejemplo, ‘Segovia – 18 años, Madrid – 5 años’).

…

Indica brevemente cuánto tiempo has estado estudiando o trabajando en instituciones de habla castellana, aunque en esos lugares se hablase además otra lengua (por ejemplo, ‘Universidad de Sevilla – 4 años’).

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **HABLANDO CASTELLANO**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **ENTENDIENDO CASTELLANO ORALMENTE**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **LEYENDO CASTELLANO**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **ESCRIBIENDO CASTELLANO**.

…

Las preguntas de a continuación se refieren solo al **CATALÁN**

Escribe a qué edad adquiriste el catalán (si eres hablante nativo/a, escribe ‘nativo’).

…

Escribe dónde aprendiste el catalán (por ejemplo: ‘en casa’).

…

Indica brevemente cuánto tiempo has estado viviendo en ciudades de habla catalana, aunque en esos lugares se hablase además otra lengua (por ejemplo, ‘Mallorca – 18 años, Barcelona – 4 años’).

…

Indica brevemente cuánto tiempo has estado estudiando o trabajando en instituciones de habla catalana, aunque en esos lugares se hablase además otra lengua (por ejemplo, ‘Universidad de Barcelona – 4 años’).

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **HABLANDO CATALÁN**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **ENTENDIENDO CATALÁN ORALMENTE**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **LEYENDO CATALÁN**.

…

Indica del 0 al 10, siendo ‘10’ la competencia perfecta, cómo de competente eres **ESCRIBIENDO CATALÁN**.

…

Appendix E

Summary of the performance of target items in Experiment 1

Item	Item extract	Proportion of semantic illusions
1	*El Premio Nobel de Medicina...*	0.100
2	*Durante el diluvio…*	0.167
3	*Después del derrumbe…*	0.143
4	*La Mezquita Çamlica…*	0.000
5	*Después de encontrar el zapato…*	0.286
6	*Durante el patrullaje…*	0.333
7	*El alfabeto táctil 'braille'…*	0.143
8	*Con solo 77.000 habitantes…*	0.333
9	*Según el Nuevo Testamento…*	0.000
10	*La famosa autora J.K. Rowling…*	0.037
11	*Antes de que la princesa…*	0.000
12	*En las pruebas de acceso al ejército…*	0.000
13	*Podemos encontrar en el puerto…*	0.000
14	*En el cuento del lobo…*	0.000
15	*Antes de ser descubierta por los nazis…*	0.333
16	*Después de observar la caída…*	0.000
17	*En un cuadrado, un ángulo…*	0.286
18	*Al convertirse en el primer hombre…*	0.500
19	*Una bomba atómica…*	0.222
20	*En la fiesta literaria…*	0.429
21	*La teoría de la relatividad…*	0.000
22	*En La Rioja, los amantes del vino…*	0.000
23	*Tras la conquista del poder…*	0.000
24	*Durante la persecución…*	0.222
25	*Fue en el año 1917 que el Zar…*	0.400
26	*En la reunión de educadores…*	0.000
27	*Ubicada en el centro del país…*	0.125
28	*Después de la desaparición…*	0.111
29	*En la película Drácula …*	0.250
30	*Durante un memorable concierto…*	0.143
31	*La Biblia nos dice que Jesús…*	0.125
32	*En las escuelas se enseña…*	0.429
33	*En el famoso cuento infantil, …*	0.000
34	*Al final del conflicto, los vencedores…*	0.200
35	*Antes de casarse con el príncipe, …*	0.000
36	*En una noche de locura, el pintor…*	0.100

37	*Para hacer una naranjada, …*	0.000
38	*En el día de Navidad, los cristianos…*	0.000
39	*Los juegos olímpicos se celebran…*	0.125
40	*En un eclipse solar, el sol es tapado…*	0.250
41	*Cristóbal Colón llegó a América…*	0.111
42	*En la historia de la Caperucita Roja, …*	0.300
43	*Moscú, Nápoles y Atenas son…*	0.200
44	*Cruella de Vil es la villana…*	0.222
45	*Michael Jackson se convirtió…*	0.429
46	*Una famosa torre inclinada…*	0.000
47	*Barack Obama hizo historia…*	0.333
48	*Durante una tormenta, al ver…*	0.625
49	*En un 'Home Run' de béisbol, …*	0.143
50	*El ultimo día del año se celebra…*	0.067
51	*El famoso barco transantlántico…*	0.143
52	*Hay años especiales cada cuatro años…*	0.111
53	*Los Reyes Magos de Oriente…*	0.111
54	*En Halloween los niños…*	0.167
55	*Los números primos, …*	0.111
56	*La lengua romance más hablada…*	0.250
57	*El ornitorrinco es conocido…*	0.125
58	*Existen organismos como…*	0.500
59	*El fémur conecta la pelvis…*	0.333
60	*La misión espacial que llevó…*	0.000
61	*La agorafobia es el pánico…*	0.333
62	*La extraversión es un rasgo…*	0.200
63	*"Un cuarto" en forma de fracción…*	0.250
64	*Las auroras boreales son…*	0.333
65	*Cuando una célula se divide…*	0.267
66	*El K-pop, popular en regiones…*	0.143
67	*Normalmente cocinado con salmón…*	0.286
68	*Cuando una estrella ha explotado…*	0.000
69	*En la naturaleza se puede encontrar…*	0.286
70	*Al viajar a Londres se debería…*	0.143
71	*En un triángulo equilátero, …*	0.000
72	*Julio Verne escribió una novela…*	0.000
73	*Las islas paradisíacas de Hawaii, …*	0.125
74	*Mark Zuckerberg, un famoso…*	0.200