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Adult Bilingualism: the Partial Effects of Feature Similarity in the L2 Processing of Relative Clauses

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Abstract

Recent studies suggest that there is an asymmetry between the processing of object relative clauses (ORs) and subject relative clauses (SRs), with the former showing greater parsing costs. In syntactic theory, this is accounted for by an expanded version of a locality principle coined featural Relativized Minimality (fRM). According to it, this phenomenon results from the effects of an intervener between the moved relative head and its trace. It also predicts that the disruption can be modulated through the similarity in syntactic features between the two elements. Thus, the more similar, or identical, the two phrases are, the more intervention effects are observed. However, although this phenomenon is consistently seen in L1 processing, there is an ongoing debate on whether this is also found in L2 parsing. By means of a self-paced reading task, the performance of adult Spanish-English bilinguals is assessed, and reaction time data is collected. The results show that ORs take longer to process than SRs, but only one matching number condition, singular-singular, is parsed significantly slower. This is accounted for as a result of the L2 speakers relying more heavily on non-syntactic cues such as the plural marking found in plural-plural items.

Keywords: relative clauses, featural relativized minimality, performance, number, English, Spanish

1. Introduction

In recent years, the difference in processing among two kinds of relative clauses (RCs) has seen a re-emergence of interest as a topic of linguistic research. More specifically, "a large body of literature shows a robust asymmetry in the comprehension of subject relatives (SRs) compared to object relatives (ORs)" (Cilibrasi, Adani, Pérez, Schmidt, Wigdorowitz & Tsimpli 2022, p. 663). Indeed, previous research has successfully demonstrated that ORs pose greater parsing difficulties than SRs, which are mostly well understood (see Belletti, Friedman, Brunato & Rizzi, 2012; Contemori & Marinis, 2014; Cilibrasi et al., 2022 among others). Moreover, comparative studies among age groups have shown that this difficulty is especially evident among young children, as adults in general do not seem to encounter such significant issues during off-line parsing of ORs (see Contemori & Belletti, 2013; Contemori & Marinis, 2014; Solaimani, 2024). At the same time, it has also been found that altering the similarity between the relative head and the relative subject of an OR appears to result in an ameliorating effect that facilitates comprehension (Biondo, Belletti, Rizzi, Pagliarini & Moscati, 2022; Morton & Schuele, 2024; Solaimani, 2024).

This phenomenon has been largely accounted for with an extension of a locality principle, which has been named featural Relativized Minimality (fRM) (Xia, White & Guzzo, 2024). It predicts that only a specific set of features, those that are syntactically active, will modulate processing costs. One feature that seems to fall into this category in English is number (Morton & Schuele, 2024). Thus, a structure such as (2) is expected to result in faster reaction times (RTs) and greater accuracy compared to (1) due to the difference in number specification.

(1) *The cat*$_{[sg]}$ *that the dog*$_{[sg]}$ *chases runs.*

(2) *The cats*$_{[pl]}$ *that the dog*$_{[sg]}$ *chases run.*

However, it seems that, while findings in L1 parsing have been mostly consistent, studies examining L2 processing show differing results. For instance, research performed on Mandarin-English and Spanish-English bilinguals (Xia, White & Guzzo, 2022; Xia et al., 2024) presented results that are arguably inconclusive. Contrarily to what is predicted, number mismatch does not produce the facilitatory effect that is expected taking into account the prior literature. Given that there appears to be an ongoing debate on whether L2 on-line processing is comparable to that of the L1 (Papadopoulou, Douka & Paspali, 2025), the present project aims to contribute to the understanding of RC comprehension in the domain of adult bilingualism. Due to its apparent ambiguity in L2 processing, number is the feature under examination in this study. With this objective in mind, an experiment is designed to test the performance of Spanish-English adult bilinguals and provide data that could answer the following research questions:

RQ1: Do Spanish-English adult bilinguals process SRs significantly faster than ORs?

RQ2: Do Spanish-English adult bilinguals process ORs significantly faster under number mismatch conditions?

2. Theoretical Framework

2.1 Movement and Traces

The Copy Theory of Movement, which is defined as "a significant discovery (…) and insufficiently appreciated" by Chomsky (2015, p. x), is a central notion to the current analysis of RC processing as much as it seems to be a core property of natural languages. According to it, the theta-role of a phrase may be interpreted in a different place from where it is physically articulated. The way this is conceptualized is in terms of movement, by which some elements are merged in the position where they are understood, typically known as the merge position, and then displaced to the one where they are pronounced, known as the target position. In undergoing such movement operation, phrases leave behind a silent copy called trace, which are conventionally represented by *t* (Rizzi, 2001). It is essential to note that traces inherit the featural specifications of the element they represent. A clear connection must be made between the displaced constituent and its trace for its thematic-role to be properly parsed. These connections between a moved element and its original position are known as chains, or dependencies. It seems that longer chains cause parsing issues by themselves, as they tax memory resources (Yadav, Frank, Futrell & Husain, 2025). Additionally, it is to be expected that if a chain were to be disrupted, the moved element would not be properly interpreted, resulting in parsing issues.

Indeed, these dependencies are subject to intervention from other elements (Biondo et al., 2022). These potential intervention effects are accounted for under the umbrella of Relativized Minimality (RM) (Rizzi, 2001). According to this principle, whenever an element (Z) is similar in features ($_{[F]}$ or $_{[f]}$) to a displaced element (X) and intervenes between X and its trace (Y), the chain is disrupted and the proper interpretation

of the theta-role (Θ) is impeded. In such a case, the parser will require re-analysis of the sentence, which translates into longer RTs and higher rates of inaccuracy (Friedman, Rizzi & Belletti, 2009; Contemori & Marinis, 2014). As can be seen in Figure 1 and Figure 2, X is taken to represent the relative head DP which is the displaced element. It constitutes the relative subject in SRs and the relative object in ORs. In both structures, Y reflects the position of the trace and Z, of the second DP. The theta-role that might be wrongly interpreted in the case of SRs is that of Agent, whereas in ORs, it is that of Theme. As mentioned previously, number is the feature under study.

SR: *The dog*$_{[sg]}$ *that* t$_{[sg]}$ *chases the cat*$_{[sg]}$.

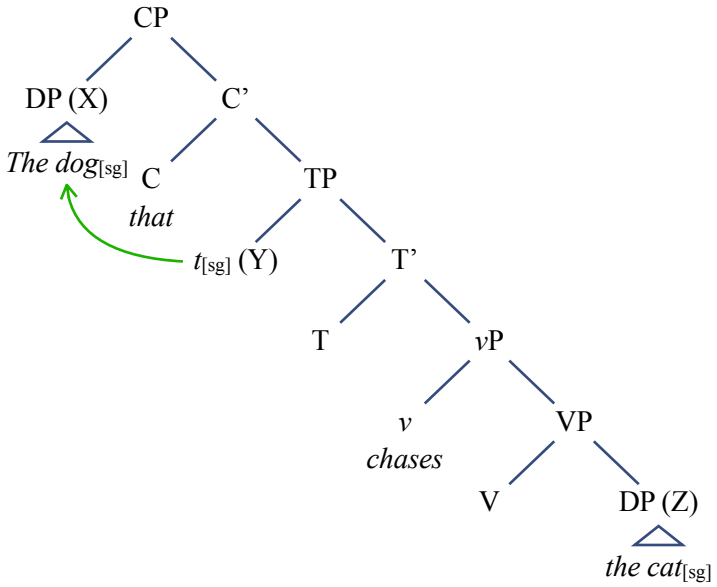

Figure 1. Hierarchical representation of an SR structure.

OR: *The dog*[sg] *that the cat*[sg] *chases* t[sg].

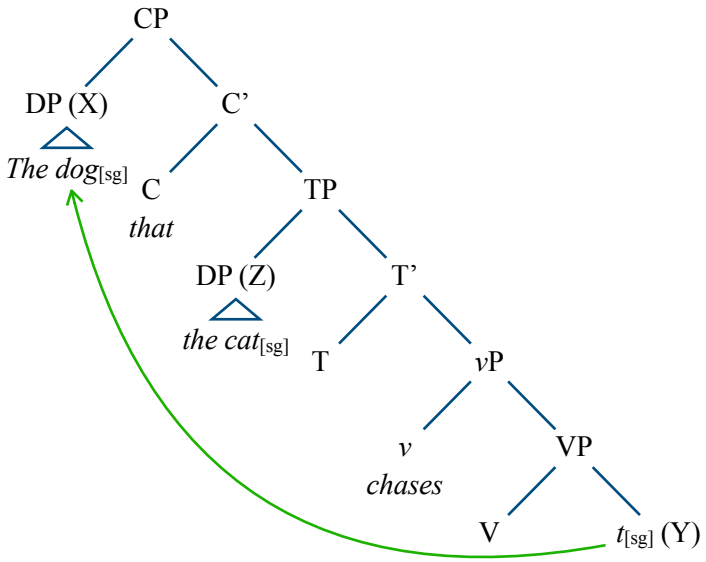

Figure 2. Hierarchical representation of an OR structure.

Syntactic operations such as movement are locally bound. Consequently, RM is considered to be a sub-class of locality effects (Rizzi, 2001). This means that whenever the parser needs to establish a dependency between two elements, in this case from Y to X, it will look for the closest, or most local and most similar element in the structure in order to close the dependency as soon as possible (Friedman et al., 2009; Yadav et al., 2025). As a consequence, a premature closing of the chain is observed in ORs, but not in SRs. Additionally, the assumption that RM is the governing principle at play behind this phenomenon has been suggested by previous studies. For instance, Contemori and Belletti (2013) performed an elicitation task in which they found that both Italian adults and children tend to produce passive ORs over active ones. This tendency is taken as evidence for an RM approach. Similarly to SRs, in passive OR constructions the disturbance of an intervener is avoided through an operation known as smuggling. Additionally, Friedman et al. (2009) found that ORs with *pro* subjects, i.e., without lexically restricted interveners, are favored in terms of processing load. This, in turn, is also a strategy that seeks to avoid

overt intervening constituents. Nevertheless, given that the two elements are sufficiently dissimilar, as illustrated in Figure 3 by $_{[F]}$ and $_{[f]}$, the parser will encounter less impediment in properly establishing the chain due to the mismatching features between the two DPs. This results in the facilitatory effect of feature mismatch reported in multiple studies (see Biondo et al., 2022; Morton & Schuele, 2024; Solaimani, 2024 among others).

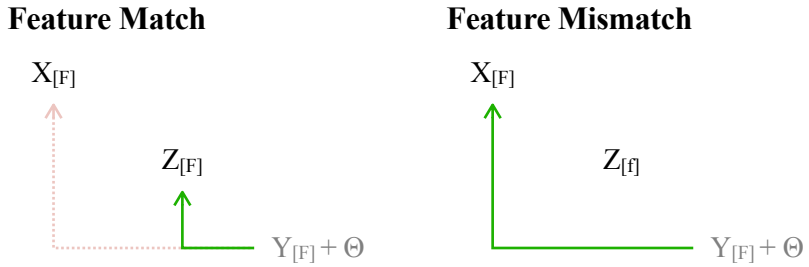

Figure 3. Representation of OR analysis under match and mismatch conditions.

2.2 Featural Relativized Minimality

These findings raise the question of whether any kind of similarity is relevant for the computation of intervention effects. There have been attempts at explaining this phenomenon from purely psychological or cue-based approaches that do not take into account syntactic structures or features. According to these, any kind of similarity between the two DPs should cause intervention effects to slow down or impede comprehension of ORs (Belletti et al., 2012; Biondo et al., 2022; Papadopoulou et al., 2025). Nevertheless, there appears to be sufficient evidence to claim that RM is, in fact, selective in the similarities to which it is sensitive. That is, not any kind of feature is relevant in the computation of dependencies. Belletti et al. (2012) tested this hypothesis comparing the performance of Hebrew- and Italian-speaking children, manipulating the feature of gender. The reason behind the study of this featural specification is its nature as an attractor that triggers movement in Hebrew but not in Italian. The aim was to compare

whether this characteristic of syntactic features was relevant or if, indeed, RM reacted equally regardless of their nature. They found that, as predicted by a selective account, only Hebrew speakers benefitted significantly from gender mismatch when parsing ORs. Research coming from non-syntactic accounts might argue that the facilitatory effect comes as a result of the overt morphological subject-verb agreement, which aids in keeping both DPs as clearly different entities in the working memory (Biondo et al., 2022). This claim seems to be supported by the findings in Xia et al. (2024), where they found no difference in processing between present-tense and past-tense RCs, despite the latter showing no overt agreement morphology in English. They accounted for this finding as a result of the stimuli being too easy to parse for the adult participants. Similarly, Contemori and Marinis (2014) found that both adults and children showed greater sensitivity to forms with overt number morphology. On the other hand, other studies have found that the presence or absence of morphological cues at the surface level in French verbs did not make a difference. Mismatch was beneficial regardless, which is a consistent finding expected by a selective RM approach (Bentea & Durrleman, 2017, cited in Cilibrasi et al., 2022).

Notwithstanding the inconsistency regarding the role of morphology, these new insights contributed to creating what Xia et al. (2024) define as "an expanded version of the relativized minimality framework" (p. 1), which has been coined featural Relativized Minimality (fRM). By this account, only those features that are syntactically active, i.e., those that trigger movement, are relevant for the computation of intervention. The principle of fRM is formulated as seen in (3).

(3) In a configuration X . . . Z . . . Y . . ., a local relation between X and Y is disrupted when:

a. Z structurally intervenes between X and Y (i.e., Z c-commands Y and Z does not c-command X).

b. Z matches the specification in morphosyntactic features of X.

Therefore, it has to be noted that gender is not the only syntactic feature that is relevant for fRM processing. In fact, there is a multiplicity of them that are related to movement operations. The ones at the core are known as *phi*-features, which constitute the collection of those that participate in subject-verb agreement and are responsible for the movement to the subject position (Belletti et al., 2012; Xia et al., 2022). Some members of this family are case, number, or gender, although the list may vary depending on the target language. Additionally, there are other features that have been found to be relevant in the computation of dependencies, which are animacy, lexical category, and lexical restriction (Contemori & Marinis, 2014; Choe & Deen, 2020; Morton & Schuele, 2024). Nevertheless, as established above, the study at hand will exclusively examine the role of number in English sentence comprehension.

Expanding on the theory of fRM, the unequal computation performance among adults and children is accounted for in related yet slightly more complex terms. Friedman et al. (2009) advance a schematic conceptualization of how featural specification is computed when intervention is present, where the relation between X, Z, and Y might be of identity, inclusion, or disjunction. See Table 1 below for a representation of these relations. Whenever the DPs and the trace share the exact same set of relevant features, they enter into a relation of identity. On the other hand, if only some but not all of the

features are shared, they are found in a relation of inclusion. Lastly, if none of the relevant features are shared among the phrases, their relation becomes one of disjunction.

	X	Z	Y	Adult G.	Child G.
Identity:	+A…	+A…	<+A>	*	*
Inclusion:	+A, +B…	+A…	<+A, +B>	ok	*
Disjunction:	+A…	+B…	<+A>	ok	ok

Table 1. Featural relations taken from Friedman et al. (2009).

With this model of relations between constituents, Friedman et al. (2009) claim that the general constraint that the intervener poses on processing is caused by an identity relation, which is neither contemplated by the adult or the child grammar. On the contrary, a disjunction relation seems to be part of both grammars. Nevertheless, the difference resides in the inclusion relation, which appears to exist within the adult grammar but not in the child one. Friedman et al. (2009) argue that this phenomenon "may relate to a limitation in the operative syntactic memory" (p. 84). Due to this constraint, children are claimed to apply a stronger version of fRM, by which only disjunction is allowed. Consequently, the three relation levels serve as a gradient for the degree of intervention encountered (Villata, Rizzi & Franck, 2016). In turn, identity shows the greatest level of disruption; disjunction, the lowest, and inclusion falls somewhere in between. In the case of this study, there is a relevant feature for fRM that is always present, which is $_{[N]}$ and then the specification of number may be identical or included as seen below in (4) and (5), respectively.

(4) Identity: *The cat*$_{[N, +sg]}$ *that the dog*$_{[N, +sg]}$ *chases* t$_{[N, +sg]}$.
X Z Y

(5) Inclusion: *The cats*$_{[N, +pl]}$ *that the dog*$_{[N, +sg]}$ *chases* t$_{[N, +pl]}$.
X Z Y

2.3 Previous Research on Number

There have been a wide variety of studies that have analyzed the effects of number mismatch from an fRM approach. Morton and Schuele (2024) examined its role among English-speaking children through a sentence-picture matching task (SPMT). It was reported that SRs showed greater overall accuracy than ORs, and the latter displayed greater accuracy when they presented a mismatch in number. Nevertheless, only when the dissimilarity was overtly expressed in the verbal morphology did the results show the expected pattern, which opposed their hypothesis that explicit surface-level manifestations were not essential. Adani, Forgiarni, Guasti and Van Der Lely (2014) also observed this facilitatory effect of number mismatch in monolingual English-speaking children that suffer from a specific language impairment (SLI). Other studies have taken interest in the comparison between the processing patterns of different age groups. Contemori and Marinis (2014) contrasted the effects of number mismatch in the parsing of RCs in monolingual English-speaking children and adults. Aside from the predicted facilitatory effects of feature and clause type, their combination of both RT and accuracy data demonstrated that, while children are significantly less accurate than adults overall, they show the same on-line processing patterns. This is affirmed to serve as evidence of a child-adult continuum of grammar.

Turning towards bilingualism, Cilibrasi et al. (2022) examined the role of feature mismatch in RC processing by Czech-English bilingual children, with a special focus on exposure. A distinction is made between structures that appear as early phenomena in the

acquisition process and those that appear later. Less demanding structures such as SRs are argued to appear earlier, and more syntactically complex ones such as ORs, later. The former are claimed to be less dependent on exposure to the L2, whereas the latter are argued to be more dependent. Unexpectedly, while the results showed an overall benefit of number mismatch, more exposure seemed to hinder its facilitatory effect. Similarly, Xia et al. (2022) tested the performance of Mandarin-English bilingual adults, focusing on the effects of number in RC comprehension. Both a cloze test and a self-paced reading task were performed. The experiments yielded comparable results, with SRs being processed faster and more accurately by L2 speakers. Nonetheless, when it comes to ORs, an unforeseen facilitatory effect of match was found. The authors interpreted this data as a result of the usual lack of number morphology in the participants' L1. This, as is claimed, might have made them more sensitive to the morphology, taking them longer to analyze. Guided by this hypothesis, Xia et al. (2024) conducted similar tests with Spanish-English and Mandarin-English adult bilinguals. The aim this time was to test the effects of the L1 in the parsing of these structures. Mandarin was chosen due to the optional nature of its overt number marking, while Spanish requires it to be explicit in all cases. Thus, while speakers of the former are hypothesized to take longer times of analysis when overt morphology is found, those of the latter are expected to react faster. The outcome was arguably inconclusive. On the one hand, ORs were, once again, processed slower. However, despite Mandarin-English speakers being expected to perform better with past tense items due to the lack of overt morphology, they did so with present tense conditions. Additionally, taking into account both groups, number matching or mismatching conditions had no significant effect on processing whatsoever. This was claimed to be due

to the stimuli presented being too easy to parse, making intrinsic syntactic features not necessary for disambiguation.

In summary, there is, as it seems, a discrepancy between the processing patterns of monolinguals when compared to those of bilinguals in their L2 (Fujimori, Nakayama & Yoshimura, 2024). Whereas, as predicted by an fRM account, a facilitatory effect of number mismatch is attested in various L1 contexts (see Adani et al., 2014; Biondo et al., 2022; Morton and Schuele, 2024; Papadopoulou et al., 2025 among others), bilingual speakers do not appear to consistently display such an effect when processing their L2 (see Contemori & Marinis, 2014; Xia et al., 2022; Xia et al., 2024 among others). As Papadopoulou et al. (2025) claim, "there has been a debate on whether similarity effects are observed in L2 RC processing with findings not being conclusive yet" (p. 4). The aim of this study is to contribute to this debate with data on Spanish-English adult bilinguals, assuming that the expanded principle of fRM is held during the processing of an L2.

2.4 Hypotheses

Referring back to the research questions and the prior literature work discussed in previous sections, this project's hypotheses will now be exposed. With that purpose, the RQs are presented here once again:

> RQ1: Do Spanish-English adult bilinguals process SRs significantly faster than ORs?
>
> RQ2: Do Spanish-English adult bilinguals process ORs significantly faster under number mismatch conditions?

It has to be noted that participants are expected to be highly proficient users of English. As a consequence, they should have acquired native-like processing patterns, as did the participants in Solaimani (2024). Taking this into account and regarding RQ1, it is hypothesized that Spanish-English adult bilinguals will find lower processing costs with SRs than with ORs. This is consistent with an fRM account since the former RCs lack the presence of an intervener (see Belletti et al., 2012; Contemori & Marinis, 2024; Cilibrasi et al., 2022 among others). In respect of RQ2, Spanish-English adult bilinguals are expected to process ORs with number mismatch faster than with number match. At the same time, feature dissimilarity is not expected to have an effect in SRs. This is also consistent with an fRM approach (see Biondo et al., 2022; Morton & Schuele, 2024; Solaimani, 2024 among others), since number matching ORs are affirmed to involve a more challenging identity relation while mismatch defines one of inclusion, i.e., a relation that is easier to comprehend (Friedman et al., 2009; Villata et al., 2016).

3. Methodology

3.1 Participants

This study is based on data from 5 adult participants (age = 18-30). They were L1 speakers of Spanish and Catalan as well as L2 speakers of English. The learners were all recruited from the Autonomous University of Barcelona (UAB) and they were completely naive of the purpose of the experiment. None of the participants suffered from a reading-related impairment. Additionally, 4 of them claimed to have achieved at least a C1 level of English proficiency. When it comes to the L2, the answers varied but they claimed to be exposed to English between 1 and 5 hours a day and produce it between less than 1 hour and a maximum of 5 daily hours. The mean onset age of acquisition is 9 years and as a product of schooling in a majority of the cases.

3.2 Pre-Test Questionnaire

Prior to partaking in the task per se, the participants completed an online pre-test questionnaire made and distributed with *Notion*'s form builder. Indications from Dörney and Taguchi (2009) were followed. The aim was to gather data on the participants' exposure, production, and overall proficiency of English, since these are variables that could potentially influence the results. Before being administered, it was piloted with another 4 volunteers. The questions focused on the level of English attained, with special attention being paid to their daily exposure to and production of both the L1s and the L2. They were also asked if they suffered from any reading impairment, such as dyslexia, which could significantly alter the results. See Table 2 for examples of the questions they were presented with. The questionnaire also provided them with a participant ID number in order to preserve anonymity during data processing.

Questions	Answers
Do you suffer from any reading impairment?	*Yes* | *No*
How many of these languages have you learned from birth?	*Catalan* | *Spanish* | *English*
How many daily hours do you speak Catalan/...Spanish/ ...English?	*< 1h* | *1h - 3h* | *3h - 5h* | *>5h*
How many daily hours do you read in or listen to Catalan/...Spanish/...English?	*< 1h* | *1h - 3h* | *3h - 5h* | *>5h*

Table 2. Sample of questions asked to the participants.

3.3 Self-Paced Reading Task

Two approaches to testing language processing have been explored throughout the Theoretical Framework section, which vary according to Chomsky's (2015) competence and performance distinction. This means that experiments either test for accuracy and off-line processing, or for RTs and on-line processing, respectively. However, given that adults do not seem to struggle with off-line processing (Contemori & Marinis, 2014; Xia et al., 2022), only their on-line comprehension will be tested. Therefore, the experiment consisted of a self-paced reading task[1] (SPRT), which was coded employing *jsPsych*, a *JavaScript* package for programming behavioral experiments. As can be seen in Table 3, all items were divided into 5 segments and all of them were initially hidden behind dashes. Following a moving-window paradigm, pressing the space bar would reveal the following segment and hide the previous one. As a safety measure to ensure that the participants were indeed comprehending the stimuli, accuracy questions were added to some of the items, a strategy adapted from the SPRT in Pladevall-Ballester, Puig-Mayenco and Capdevila (2024). The order of the items was randomized. Once

[1] This task is publicly stored and accessible in this GitHub repository. It is highly recommended to carefully read the documentation. This aims to comply with the CoARA principles of responsibility, openness, trust and dialogue, willing to promote a more transparent and democratic way of doing research.

programmed, the task was piloted with another 5 volunteers and the pertinent adjustments were applied.

Subject Relative Clauses

	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
SS	*The horse*	*that*	*chases*	*the zebra*	*falls*
PP	*The zebras*	*that*	*follow*	*the horses*	*run*
PS	*The dogs*	*that*	*push*	*the cat*	*cry*
SP	*The cat*	*that*	*hugs*	*the dogs*	*smiles*
Question			*Who smiles?*	*The cat / The dogs*	

Object Relative Clauses

	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
SS	*The horse*	*that*	*the zebra*	*chases*	*falls*
PP	*The zebras*	*that*	*the horses*	*follow*	*run*
PS	*The dogs*	*that*	*the cat*	*push*	*cry*
SP	*The cat*	*that*	*the dogs*	*hug*	*smiles*
Question			*Who runs?*	*The zebras / The horses*	

Table 3. Sample of the stimuli presented during the SPRT.

Regarding the items, the task contained a total of 47 stimuli, 32 of which were experimental items and 15 were fillers. Additionally, another 2 practice items were presented at the beginning of the task for the participants to get acquainted with it. 8 of the experimental items had a follow-up question regarding the subject of the main verb, as the ones in Table 3. 5 of the fillers involved a follow-up *yes/no* question. The DPs in the experimental sentences were all animal entities, thus avoiding a facilitatory animacy contrast (Mak & Vonk, 2002), whereas those in the filler sentences were humans in

combination with inanimate objects. Regarding the syntax, all structures contained center-embedded relative clauses, which are known to be harder to process (Contemori & Marinis, 2014). This, as well as avoiding any other kind of feature mismatch and employing animal entities, were measures taken following Xia et al. (2024) and their conclusion that adult bilinguals might have found their stimuli too easy to parse. Thus, the items were designed to overload the adult's cognitive system, at least enough to make slowdowns in syntactic operations salient. Main clause predicates were all intransitive, whereas those of the embedded clause were transitive and their thematic roles were reversible. All verbs were of high frequency, avoiding, therefore, slowdowns caused by low-frequency words (Keating & Jegerski, 2015).

3.4 Procedure

As mentioned previously, a week prior to partaking in the task, the participants were asked to fill in the pre-test questionnaire. After a date was established for testing, they were invited to the laboratory where the experiment was to take place. This controlled setting ensured that the participants encountered the same experimental conditions during the process. Before beginning the task, they were informed on how it would proceed, and they were given the chance to ask questions. Afterwards, they were asked to sign a consent form, giving the experimenter permission to anonymously process and analyze their data. After that, the task began and, once completed, they were thanked for their participation. See Figure 4 for a visualization of the SPRT sequence.

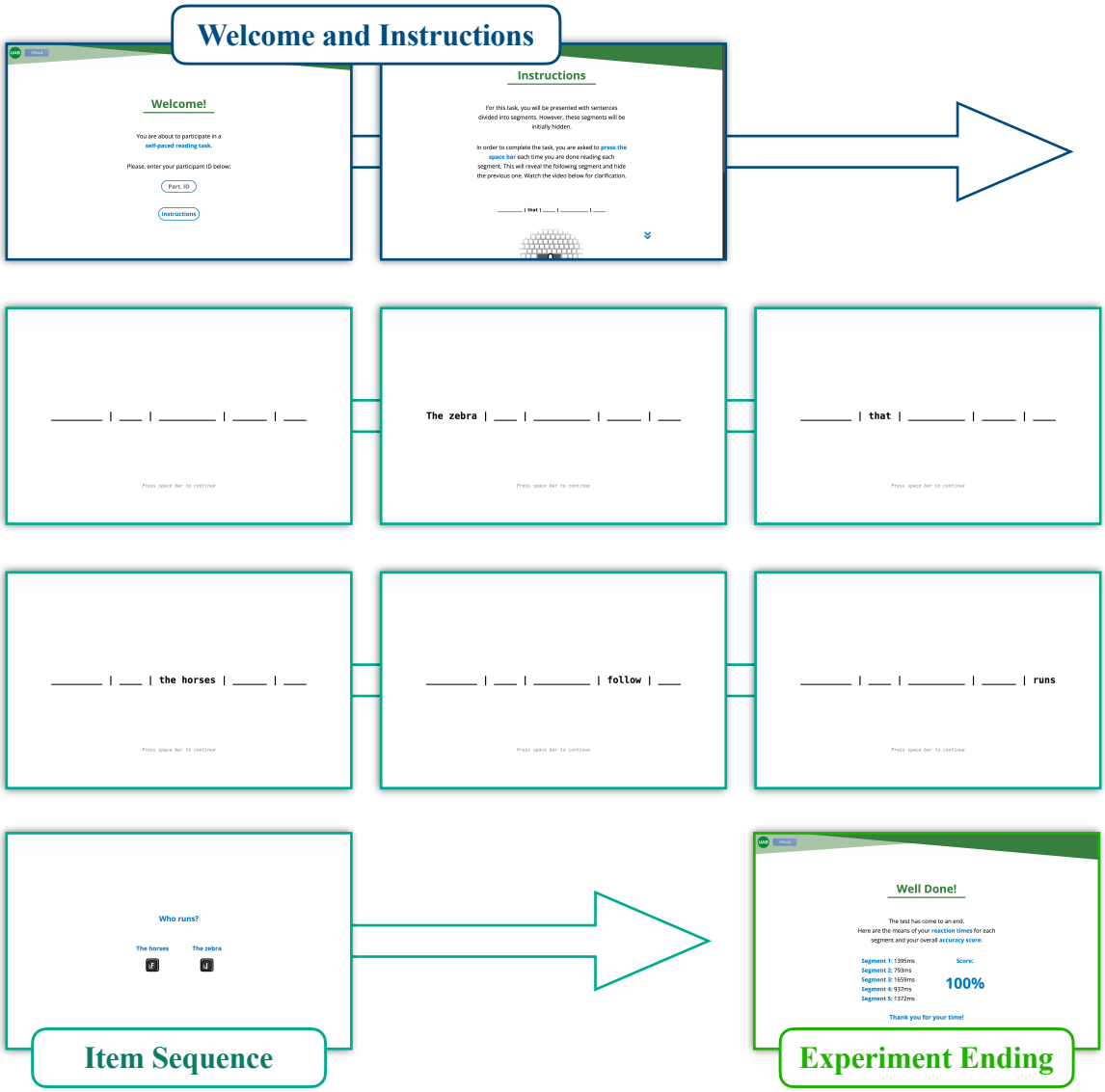

Figure 4. Visualization of the SPRT procedure.

3.5 Predictions

The items in the SPRT varied in two main conditions: *clause type* and *number*. The values were either *SR* or *OR* for the first variable, and *singular-singular* (SS), *plural-plural* (PP), *singular-plural* (SP), or *plural-singular* (PS) for the second one. Information on a per-segment basis was also collected for further detail. Taking that into account, two predictions were formulated in accordance with the two RQs and hypotheses:

P1: Aligning with the first hypothesis, significantly longer RTs are expected to be found in the OR *clause type* condition compared to SR.

P2: An interaction between *clause type* and *number* is expected, with ORs involving number mismatch showing faster RTs than ORs with number match. No effect of *number* is expected in SRs.

4. Results

The data obtained through both the questionnaire and the SPRT were analyzed employing mixed effects (LME) models created using the function *lmer()* from the package *lme4* in *R*. *P*-values were obtained with the package *lmerTest*. In order to approximate a normal distribution, RTs were log-transformed to reduce skew. Moreover, observations that were 1.5 times higher or lower than the interquartile range (< 177ms and > 3997ms) were treated as outliers and ignored. Following Keating and Jegerski (2015)'s indications, items with wrong answers were also ignored since they might have emerged as a consequence of lack of attention. This resulted in a loss of 50 observations, or 6% of the total data. The resulting data roughly approximated a symmetrical distribution with a mean of 1009ms (*SD* = 668ms) and a median of 744ms. See Figure 5 for a visualization of the distribution.

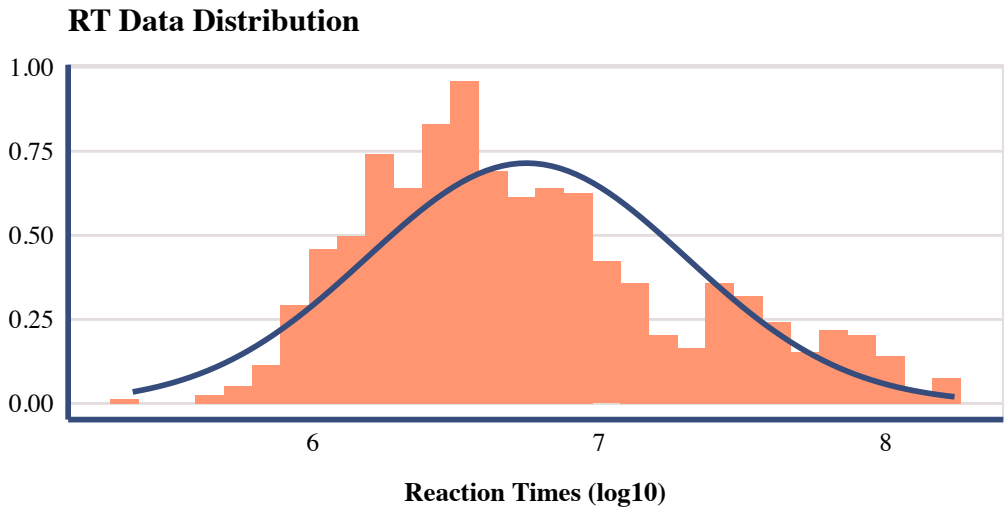

Figure 5. Histogram of RT data distribution.

Two LME models were employed. Only RTs from segments 3 and 4 were taken into account since these constitute the RC region. RTs were treated as the dependent variable, while *clause type* and *number* were defined as the independent variables, or

predictors. Information on exposure and production of English was added as random effects that could potentially alter the output (Cilibrasi et al., 2022).

The first LME model aimed at providing data for the first RQ, and, thus, only included *clause type* as the predictor for RTs. The resulting model was formulated as indicated in (6). The second LME model aimed at answering the second RQ, and, therefore, it involved an interaction between *clause type* and *number*. The resulting model was formulated as indicated in (7).

(6) lmer(data, RTs ~ clause type + (1 | L2 exposure) + (1 | L2 production))

(7) lmer(data, RTs ~ clause type * number + (1 | L2 exposure) + (1 | L2 production))

The results of the first linear model can be seen in Table 4. As observed, there is a positive and significant effect of *clause type*, with ORs being predicted to display a mean RT of 1047.4 ms compared to the 806.8 ms of SRs ($p < 0.001$). See Figure 6 for a visualization of this effect. A wider dispersion can also be observed for ORs, indicating greater variability towards longer RTs.

1st LME Model Output

Effects of *Clause Type* on RTs

Condition	Predicted Mean RTs (ms)	Std. Error	*t*-value	*p*-value	Signif. Code
SR	806.756	0.169	39.693	< 0.001	***
OR	1,047.405	0.053	4.927	< 0.001	***

Table 4. Output of the first LME model.

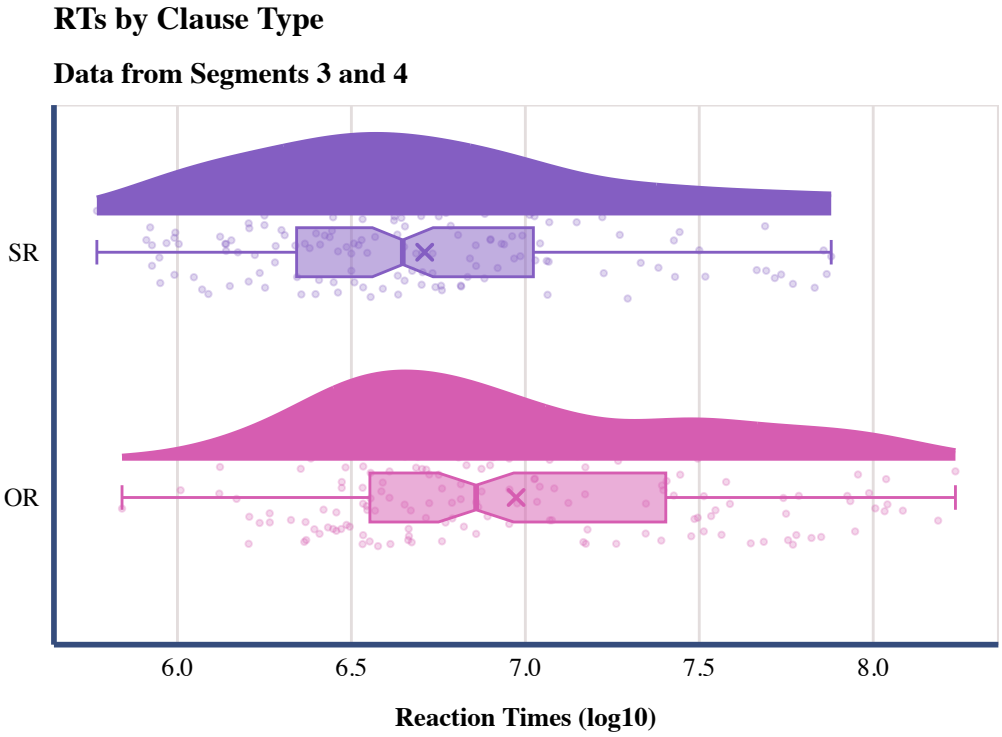

Figure 6. Visualization of *clause type* effects on RTs.

The results of the second linear model can be seen in Table 5. The output shows only one significant interaction between *clause type* and *number*, with ORs in the SS condition being processed significantly slower than the rest ($p < 0.01$). These are predicted to show a mean RT of 1043.4 ms compared to the 778.1 ms of SRs. No other significant interaction between the two predictors was found. Neither ORs nor SRs were read significantly faster or slower under the PP condition ($p = 0.93$ and $p = 0.88$, respectively). Similarly, this was the case with both RCs under the SP condition ($p = 0.51$ for SRs and $p = 0.64$ for ORs). Finally, a similar lack of significant effects was detected in SRs and ORs under the PS condition ($p = 0.38$ and $p = 0.78$, respectively). See Figure 7 below for a visualization of these data.

2nd LME Model Output

Effects of Interaction *Number* * *Clause Type* on RTs

Condition	Predicted Mean RTs (ms)	Std. Error	*t*-value	*p*-value	Signif. Code
SR * SS	778.104	0.180	36.991	< 0.001	***
SR * PP	765.208	0.107	–0.156	0.88	
SR * SP	834.432	0.107	0.653	0.51	
SR * PS	855.318	0.107	0.884	0.38	
OR * SS	1,043.414	0.106	2.760	< 0.01	**
OR * PP	767.593	0.150	–0.090	0.93	
OR * SP	725.051	0.150	–0.470	0.64	
OR * PS	745.410	0.151	–0.284	0.78	

Table 5. Output of the second LME model.

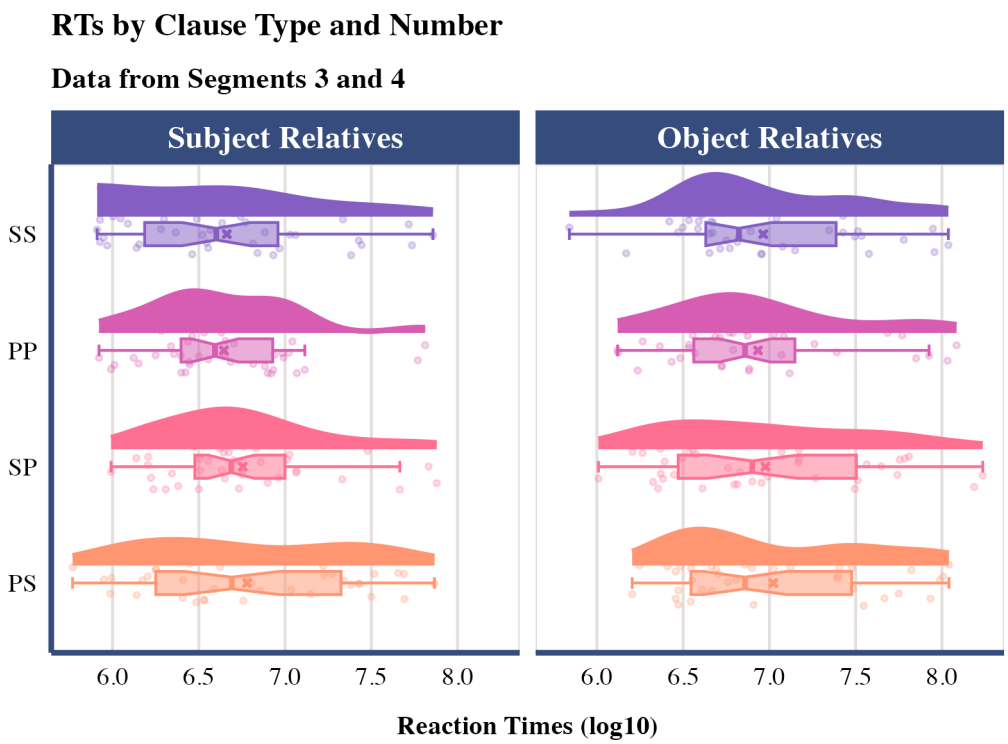

Figure 7. Visualization of *clause type* and *number* effects on RTs.

5. Discussion

The aim of this section is to revisit the predictions formulated previously and contrast them with the data. This will be done throughout the following subsections, targeting both predictions individually. With this objective in mind, they are presented below once again:

> P1: Significantly longer RTs are expected to be found in the OR *clause type* condition compared to SR.
>
> P2: An interaction between *clause type* and *number* is expected, with ORs involving number mismatch showing faster RTs than ORs with number match. No effect of *number* is expected in SRs.

5.1 Effects of Clause Type

As described in the analysis of the data, Spanish-English bilinguals did show significantly slower RTs with ORs than with SRs, which can be observed in Figure 6. This aligns with P1 as well as multiple other studies that have found a significant increase in processing cost in the former type of RC (see Biondo et al., 2022; Contemori & Belletti, 2013 among others). This is predicted by and consistent with an fRM account, this project's approach to sentence processing. Taking into account the related hypothesis formulated previously, this is considered to be a sign of both the longer dependency than can be observed in Figure 2 (Yadav et al., 2025) together with the effects of an intervening element that causes a premature closing of the chain and, consequently, the need for a re-analysis (Friedman et al., 2009). Revisit Figure 3 above for a visualization of said re-analysis. In summary, it shows that highly proficient bilinguals have properly acquired native-like RC representation as they display comparable processing patterns.

5.2 Effects of Number

The data obtained from the second model, however, presents a more complex message to decipher. On the one hand, P2 predicted that no effect of number match or mismatch should have been observed in SRs, as they lack the presence of an intervener and, thus, do not involve fRM in their computation (Biondo et al., 2022). As can be seen in Table 5, the experiment yielded results that are consistent with this claim, since featural variation showed no significant effects in the processing of SRs. On the other hand, ORs with number dissimilarity were expected to show shorter RTs since they involve a relation of inclusion compared to the one of identity found in matching conditions. When placed in a gradient, these are claimed to be easier and harder to parse, respectively (Villata et al., 2016). Contrarily, the data showed only one significant effect of number, with SS conditions being parsed slower than the other conditions.

At a first glance, these findings might appear incoherent with the fRM approach adopted in this paper. However, examining it from a different perspective might provide an interpretation that aligns with the predictions presented. As Xia et al. (2024) defend, "RM does not claim that there MUST be differences (…). Rather, the claim is that, if there are differences, mismatched items will be easier to process" (pp. 11-12). In fact, this is consistent with the results of the present study, as the only condition that was significantly slower to parse was a matching one, SS. The others, although not significant, showed a clear tendency towards lower processing costs, in line with those observed in SRs. Therefore, it is reasonable to suggest that inclusion relations, SP and PS, were, in fact, faster to process than, at least, one of the identity sets, SS.

The question remains as to why, then, this was not the case with the other identity relation, PP, as was predicted. A plausible explanation to account for this finding may come from memory-based accounts. Studies propose that items marked with surface-level information, such as plurals in English, are generally easier to parse (Contemori & Marinis, 2014; Pratt & Fernández, 2016). Additionally, it is also claimed that the differences observed between L1 and L2 processing might be caused by an over-reliance on non-syntactic cues such as semantics or surface information by bilingual speakers (Clahsen and Felser, 2006; 2018). With this information in mind, it could be concluded that this special sensitivity to morphological cues by L2 speakers in combination with marked items being easier to parse overall might have somehow modulated the identity relation found in the PP condition. This would explain why it was favored whereas the identity relation in the SS condition was not, as it does not involve this processing aid due to the lack of surface-level information in English singular nouns. This would also align with L1 processing studies that find a consistent effect of mismatch in all inclusion relations (e.g., Belletti et al., 2012; Contemori & Marinis, 2014), since the greater sensitivity to extra-syntactic cues seems to be a special trait of bilinguals when processing their L2 and not so much of monolinguals.

In summary, the interpretation given to the results of this study suggests that, when it comes to syntax, the L1 and L2 processing of RCs are, indeed, comparable. However, bilingual speakers seem to incorporate some peculiarities when parsing their L2 as they appear to rely more heavily on extra-syntactic information such as surface-level information (Clahsen and Felser, 2006; 2018). Therefore, this assumes that the participants of this study would have shown parallel patterns of processing to monolinguals, i.e., significantly higher costs for both matching conditions, had they not had this special

sensitivity to morphological cues that is assumed to have aided in the comprehension of the PP condition, in particular. This assumption aligns with Cilibrasi et al., (2022), as they affirm that late phenomena, such as ORs, involve syntax-external resources to a greater extent. Additionally, this is also somewhat consistent with the findings in Xia et al., (2024), since they found that Mandarin-English bilinguals were only significantly slower with SS conditions, just like the participants in this study. Nonetheless, this claim definitely calls for further research to support it properly.

6. Conclusion

In conclusion, the present study has aimed to contribute to the debate on whether L1 and L2 processing of RCs are comparable. Whereas a harder parsing of ORs compared to SRs has been consistently found across speaker groups (e.g. Friedman et al., 2009 for child L1; Cilibrasi et al., 2022 for child L2; Xia et al., 2022 for adult L2) by previous literature, the effects of featural manipulation in L2 speakers are not so clear (Papadopoulou et al., 2025; Xia et al., 2024). The project's research questions aimed at answering whether Spanish-English adult bilinguals would find more difficulties parsing ORs than SRs and whether they would find a facilitatory effect of number mismatch only with the former RCs.

These queries have been approached through the lenses of an fRM approach, an expanded version of the syntactic locality principle of relativized minimality put forward by Rizzi (2001) (Xia et al., 2024). The increase in processing costs of ORs is accounted for as a consequence of the disruption of a dependency caused by an intervening element, which is not present in SRs. Additionally, this framework also expected a facilitatory effect of feature mismatch between the two DPs in OR processing (Xia et al., 2022). This has been conceptualized in a set of theoretical relations between the intervener and the disrupted element (Belletti et al., 2012). These relations assumed by fRM serve as a gradient to determine the degree of disruption present depending on the similarity in the relevant features (Villata et al., 2016). More specifically, this paper aimed to examine the role of number in mediating intervention effects, since it seems to be quite inconsistent in this regard (Xia et al., 2022). In summary, given the previous research, L2 speakers were hypothesized to parse SRs faster than ORs due to the complete lack of an intervener in the former. At the same time, they were also hypothesized to find inclusion relations, i.e.,

mismatch conditions, easier to process in ORs, whereas no featural effect was expected in SRs, again, due to the lack of disruption in the first place.

By means of an SPRT, RT data was collected from 5 Spanish-English adult bilinguals. In accordance with the hypotheses, significantly longer RTs were predicted to be found in ORs when compared to SRs, suggesting a disruption caused by an intervener. Additionally, shorter RTs were expected to be found with inclusion relations in ORs while no variation across number conditions was expected in SRs. Upon examination of the data, although longer RTs were found in ORs, number mismatch conditions did not show faster RTs in either RC type. The only significant effect found was the longer response times found in an identity relation, SS.

The results have been considered as being initially unexpected, but not incompatible with the principle of fRM, which does not claim that mismatch must have an effect but that, if it does, it should be beneficial (Xia et al., 2024). At the same time, the finding that only one of the identity conditions, SS, showed the expected longer RTs was accounted for as a result of the special sensitivity of L2 speakers to surface-level information (Clahsen and Felser, 2006; 2018). Thus, it is possible that these cues are computed differently during L2 processing and that they have had some role in facilitating the parsing of the other match condition, PP, exclusively (Contemori & Marinis, 2014; Pratt & Fernández, 2016).

6.1 Shortcomings and Future Course of Action

Having summarized the study as a whole, there are a few caveats that must be addressed. Beginning with the design of the SPRT, although experiment design was performed to the best of the available knowledge, there are certain technical considerations that were

learned too late into the development of the project. For instance, the randomization of the items as well as the small number of them might have caused repetition effects. Furthermore, time limitations impeded performing a norming study to ensure the quality of the items. These relevant aspects to be considered in future experiments were taken from Keating and Jegerski (2015).

Regarding the sample and the data itself, it has to be noted that the most plausible reason behind the results that have been found is the limited number of participants. Crucially, it was certainly not representative, which resulted in a data distribution that was not normal ($p < 0.05$ on a Shapiro-Wilk test), as can be seen in Figure 5. Therefore, the outputs of the LME models should be treated more as tendencies rather than as significant correlations. In order to test these hypotheses properly, Keating and Jegerski (2015) recommend a minimum of 12 participants per condition. Given that this study examined 2 independent variables, one with 2 possible values and the other with 4, a total of 8 conditions were tested, which would have required a minimum of 96 participants in total. Replicating the experiment in a large-scale format with the appropriate modifications and such a considerable sample size would be a potential future course of action.

Additionally, given the bilingual nature of Catalonia, it could have also been interesting to analyze the interaction between the two L1s, Catalan and Spanish, and the L2, English. The role of morphology could have also been added as an additional predictor variable, employing tenses with varying levels of surface-level information as proposed in Xia et al. (2024). Despite these shortcomings being somewhat discouraging at a first glance, their recognition is essential as it paves the way for multiple ways in which

this line of research can be expanded moving forward as well as improved with the lessons learned here together with the proper resources.

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