

eman ta zabal zazu



Universidad del País Vasco Euskal Herriko Unibertsitatea

**SUBJECT-VERB AGREEMENT IN REAL TIME:  
ACTIVE FEATURE MAINTENANCE AS  
SYNTACTIC PREDICTION**

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# Resumen

La comprensión de oraciones en tiempo real requiere realizar varias operaciones de forma simultánea: la morfología y el significado de las palabras se procesan según se van encontrando y, más importante todavía, deben establecerse relaciones entre las palabras que se van procesando y los diferentes puntos temporales. Estas relaciones se extienden a elementos muy variados y de diferentes categorías, que transmiten informaciones diferentes, como la concordancia sujeto-verbo. ¿Cómo se asegura el sistema de que la información se mantiene durante el procesamiento de todos los elementos que se encuentran entre el sujeto y el verbo? El objetivo general de esta tesis es responder a esta pregunta.

Específicamente, nuestro objetivo ha sido investigar si el sistema mantiene activa la información necesaria para asegurarse de que la concordancia entre sujeto y verbo se da durante el procesamiento de la oración. Intentamos demostrar que el mantenimiento activo de las representaciones en una oración ejemplifica una predicción sintáctica. Este mantenimiento activo implica que los elementos entre un sujeto y un verbo que muestren una dependencia sintáctica a distancia serán procesados con un mayor coste. Por ello, hemos medido tanto el coste global de procesamiento de los elementos situados entre el sujeto y el verbo, como los efectos que pudieran revelar los rasgos morfosintácticos de las representaciones mantenidas. Prestando atención al mantenimiento de los rasgos morfosintácticos, fuimos capaces de comprobar si la concordancia entre el sujeto y el verbo es *psicológicamente real*. Es decir, las teorías lingüísticas definen la concordancia sujeto-verbo como una covarianza de las características morfosintácticas entre el sujeto y el verbo (Steele, 1978). Aquí comprobamos si esta covarianza en la comprensión en tiempo real se consigue mediante un mantenimiento activo de dichos rasgos. Creemos que el modelo más adecuado para tratar nuestros descubrimientos es el Modelo Minimalista de la Gramática Generativa, el cual propone que la concordancia es una operación necesaria en la derivación de las oraciones y que los elementos que llevan los *rasgos no interpretables* (i.e. los rasgos morfosintácticos que no tienen una interpretación semántica hasta que no son cotejados por los rasgos de otro elemento) están de alguna manera *activos* hasta que encuentran algún elemento cotejador (Acuña-Fariña, 2009). Los estudios conductuales,

electrofisiológicos y de neuroimagen proveen evidencia de que el cerebro responde a violaciones de concordancia, estudiando el coste de la integración de la concordancia en el verbo (véase Mancini, 2018). Nosotros nos propusimos comprobar a la concordancia sujeto-verbo *mientras* se está estableciendo, es decir, antes del verbo. Esto sigue la tendencia actual en la predicción del lenguaje, donde la predicción como preactivación debe ser medida antes de la integración (Ilkin & Sturt, 2011; Kuperberg & Jaeger, 2016).

Otros estudios han investigado el coste de mantenimiento en los elementos que interrumpen la concordancia sujeto-verbo y el coste de mantenimiento relacionado con su establecimiento. Aunque los estudios con cláusulas subordinadas de relativo encontraron un crecimiento en el coste del procesamiento que pudiera ser adscrito a la relación sujeto-verbo (Hakes et al., 1976; Van Dyke & Lewis, 2003), Chen et al. (2005) usaron cláusulas subordinadas diferentes y encontraron resultados distintos: que el coste de procesamiento en la misma cláusula subordinada aumenta con el número de verbos predichos. Nosotros pusimos esto a prueba usando un paradigma de lectura más natural (seguimiento de los movimientos oculares), y cláusulas subordinadas adverbiales incrustadas entre el verbo y el sujeto principal, en dos lenguas morfológicamente distintas: el español (Experimento 1) y el inglés (Experimento 2). En el Experimento 1, comparamos el tiempo de lectura en la cláusula subordinada adverbial que podía estar incrustada entre el sujeto principal y el verbo (i.e. condición experimental: *Esa chica, [cada vez que un chico viene a casa], se pone nerviosa*) o no estarlo (i.e. condición control: *Para esa chica, [cada vez que un chico viene a casa], todo lo demás es aburrido*). Encontramos que el tiempo de lectura antes de avanzar a la región siguiente (en inglés *go-past*, termino que usaremos en el resto del resumen) y las regresiones (en inglés *regressions out*) incrementaban en la condición experimental, lo cual sugiere que el establecimiento de la concordancia entre el sujeto y el verbo causa un coste en el procesamiento de los elementos entre ellos. En el Experimento 2, creamos oraciones similares en inglés, aunque con un cambio mínimo en la condición control (condición experimental: *That student, [as soon as a professor finishes the class], leaves the classroom*, “Ese estudiante, [tan pronto como el profesor termina la clase], se va del aula”, condición control: *I watched that student, and [as soon as a professor finishes the class ], she leaves the*



*classroom*, “Observé al estudiante y, [tan pronto como el profesor termina la clase], se va del aula”). De forma parecida al experimento en español, encontramos que los tiempos de lectura durante el primer pase en la región (en inglés *first pass*; termino que usaremos en el resto del resumen) y los tiempos de lectura *go-past* de la cláusula incrustada eran mayores en los ítems experimentales, lo cual sugiere que el mantenimiento de la relación entre el sujeto y el verbo aumenta el coste de procesamiento.

Tras establecer que la concordancia sujeto-verbo implica el mantenimiento de la información relevante, lo cual aumenta el coste de procesamiento de los elementos interpolados, nos centramos en la segunda pregunta de investigación, la cual se refiere a la naturaleza de dicha representación mantenida. Nos preguntamos si contiene rasgos morfosintácticos y, más específicamente, rasgos de número y categoría gramatical. Para comprobar el estado potencialmente activo de dichos rasgos, nos centramos en los efectos que pudieran causar en los elementos interpolados, como la interferencia debida a la similitud (en inglés *similarity-based interference*). La literatura en el procesamiento de oraciones ha probado que la concordancia entre sujeto y verbo puede ser afectada durante el procesamiento, lo cual ocurre cuando un sustantivo que no es el sujeto comparte algunos rasgos con el sujeto. De igual manera, comprobamos si la interferencia ocurre entre la representación mantenida de la concordancia del sujeto-verbo principal, y el sujeto y el verbo de la cláusula incrustada, interrumpiendo dicha concordancia.

Para investigar la interferencia debida a la similitud con el rasgo de número, manipulamos si el sujeto y el verbo de la cláusula subordinada adverbial incrustada coincidían con los principales, o no. En español, teníamos la condición congruente (*Esa chica, cada vez que un chico viene a casa, se pone nerviosa*) e incongruente (*Esas chicas, cada vez que un chico viene a casa, se ponen nerviosas*). La misma manipulación se aplicó a la condición control. Para investigar el rasgo de la categoría gramatical de la representación mantenida, también manipulamos el orden dentro de la cláusula incrustada en español, cambiando de lugar el sujeto (*un chico*) y el verbo (*viene*) de la cláusula. Encontramos un mayor coste de procesamiento en la condición experimental comparado con la condición control para el sustantivo de sujeto incrustado, pero no para el verbo. Este efecto surgió en

los tiempos de lectura *first pass* y *go past*, así como en las regresiones. Dado que el efecto solo se da en el sujeto incrustado, antes del elemento de integración (verbo), y solo en los ítems experimentales, concluimos que la categoría del sustantivo se mantiene activamente, causando una interferencia con el elemento con los mismos rasgos (sustantivo de sujeto). Además, encontramos que la concordancia en número incrementó los tiempos de lectura *first pass* y las regresiones en el sustantivo, dando a entender que el rasgo de número también se mantiene activamente. Sin embargo, la dirección de este efecto varió para los diferentes órdenes de palabras y condiciones (experimental/control), y es difícil concluir si la interferencia debido a la similitud para el rasgo de número ocurre realmente debido a un mantenimiento activo y, por consiguiente, debido a la predicción.

Para investigar en más detalle el mantenimiento del rasgo de número, aplicamos la misma manipulación de congruencia al inglés. También manipulamos el número en la cláusula subordinada adverbial incrustada (singular/plural), para ver si los dos números se mantienen de forma diferente. Esto crea condiciones congruentes tanto en singular como en plural (singular: *That student, as soon as a professor finishes the class, leaves the classroom,* "Ese estudiante, tan pronto como el profesor termina la clase, se va del aula"; plural: *Those students, as soon as professors finish the class, leave the classroom,* "Esos estudiantes, tan pronto como los profesores terminan la clase, se van del aula"), y condiciones incongruentes en singular y en plural (singular: *Those students, as soon as a professor finishes the class, leave the classroom,* "Esos estudiantes, tan pronto como el profesor termina la clase, se van del aula"; plural: *That student, as soon as professors finish the class, leaves the classroom,* "Ese estudiante, tan pronto como los profesores terminan la clase, se va del aula"). Una vez más, la misma manipulación se aplicó a la condición control. Al igual que en español, encontramos un mayor tiempo de lectura *first pass* y *go-past* para el sujeto incrustado en la condición experimental, confirmando el mantenimiento de la categoría de sustantivo. Sin embargo, cuando atendemos a la congruencia con el número, solo encontramos tiempos mayores de lectura para la condición congruente en el verbo en el tiempo de lectura *first pass*. Considerándolo todo, los resultados de los experimentos en español e inglés sugieren que el rasgo de la categoría de sustantivo se mantiene activamente, causando una interferencia basada en la similitud en los elementos

interpolados. Sin embargo, los hallazgos relacionados con el mantenimiento del rasgo del número, o las diferencias entre el número singular el plural, no están claros.

Por ello, diseñamos dos experimentos en euskera, una lengua de núcleo final. Investigaciones anteriores han sugerido que las dichas lenguas pueden mostrar mecanismos de predicción más fuertes, dado que la información estructuralmente importante aparece al final de la oración (Lago et al., 2015; Vasishth et al., 2010). En los experimentos en euskera, investigamos el mantenimiento del número en la concordancia sujeto-verbo mediante un paradigma diferente. Es decir, en lugar de mirar a la interferencia debida a la similitud en las palabras dentro de la cláusula incrustada, lo cual proveyó de resultados inconclusos, quisimos ver si sustantivos morfológicamente ambiguos podían desambiguarse en su valor numérico mediante la representación mantenida. Creamos oraciones en euskera donde la dependencia entre el sujeto y el verbo principal era interrumpida por una cláusula incrustada que contenía un sustantivo marcado ambiguamente con *-ak*. En euskera, esta marca hace al sustantivo ambiguo, pudiendo ser un sustantivo singular en caso ergativo (siendo así el sujeto de la cláusula incrustada) o sustantivo plural en caso absolutivo (siendo el objeto de la cláusula incrustada). Los sustantivos eran desambiguados más tarde en la frase, mediante el verbo auxiliar. Manipulamos el número del sujeto principal, creando así una condición con el sujeto principal en singular (*Nere ahizpa, dirudienez mutilak asko maite duena, desagertu egin zen*, “Mi hermana, a quien el chico quiere mucho, desapareció”) y una condición con el sujeto principal en plural (*Nere ahizpek, dirudienez mutilak asko maite dituenak, kotxe bat erosi zuten*, “Mis hermanas, a quienes el chico quiere mucho, han comprado un coche”). Al igual que en los Experimentos 1 y 2, también creamos ítems control, donde los sustantivos ambiguos no interrumpían la concordancia sujeto-verbo. En el experimento de lectura (Experimento 3), no encontramos ninguna diferencia en el sustantivo ambiguo entre la condición singular y plural en los tiempos de lectura *first pass*, *go-past* o en las regresiones, lo cual indicaría un mantenimiento del rasgo singular o plural. Sin embargo, cuando los mismos estímulos fueron testeados en el paradigma del mundo visual (Experimento 4), los resultados fueron diferentes. Encontramos que se generaron más miradas hacia las imágenes singulares en la condición de sujeto principal singular mientras se escuchaban los sustantivos que aún eran ambiguos

numéricamente. Esto sugiere que la interpretación de sustantivos ambiguos tenía una tendencia hacia el número de la representación mantenida, lo cual a su vez implica que el rasgo de número forma parte de la representación del sujeto principal que se mantiene activamente.

En definitiva, en la presente tesis hemos investigado si la concordancia sujeto-verbo durante la comprensión de oraciones en tiempo real se consigue mediante un mantenimiento activo de los rasgos morfosintácticos de categoría gramatical y número. Usamos tres lenguas distintas tanto tipológicamente como morfológicamente (español, inglés y euskera) y dos efectos morfosintácticos diferentes (interferencia debido a similitud y desambiguación). También usamos dos paradigmas de movimientos oculares diferentes (lectura y paradigma del mundo visual), lo cual nos permitió testear dos modalidades de lengua diferentes (lengua hablada y escrita). Encontramos que la dependencia sujeto-verbo sí que implica un mantenimiento activo, y que al menos algunos rasgos morfosintácticos implicados en la concordancia sujeto-verbo son mantenidos activamente en el procesamiento de oraciones en tiempo real.

Nuestros resultados, aparentemente, van en contra de los dos modelos más influyentes de la comprensión de oraciones. Tanto el modelo SPLT/DLT (Gibson, 1998, 2000) como el modelo de recuperación basada en pistas (en inglés *cue-based retrieval model*, Lewis & Vasishth, 2005; McElree et al., 2003) asumen que existe la predicción en la concordancia sujeto-verbo, pero no mantenimiento activo. Así, en frases con concordancia de sujeto y verbo a distancia (como en la presente tesis), el modelo SPLT presupone la predicción del verbo principal, pero sin coste de procesamiento. Esto se opone a nuestra visión, en la que la predicción se realiza mediante el mantenimiento activo, lo cual aumenta el coste de procesamiento. Sin embargo, el modelo de recuperación basada en pistas sugiere que la representación relevante para la concordancia está codificada en el sujeto, pero después se quita del foco atencional y así no se mantiene activa. Esto también está en contra de nuestra visión, ya que intentamos probar que parte de esas representaciones son mantenidas activamente. Por tanto, proponemos que los modelos deberían adaptarse a nuestros hallazgos y a otros similares (Chen et al., 2005). Más específicamente, el modelo SPLT/DLT debería asumir costes de procesamiento para la predicción del verbo principal, mientras que el modelo de recuperación basada en pistas debería

ajustar su arquitectura para permitir que algunos rasgos relevantes para la concordancia se mantengan. Esto se podría conseguir asumiendo que algunas representaciones parciales se mantienen en el foco de atención, o en otra subestructura de memoria de trabajo que se active (Oberauer, 2002), desde donde puede influir en otros elementos.

Además, tanto estudios teóricos (Gibson, 1998; Lewis & Vasishth, 2005) como experimentales (Chen et al., 2005) de la predicción de la concordancia sujeto-verbo sugieren que lo que se predice es el verbo principal. Sin embargo, nuestros estudios demuestran que la representación activamente mantenida pertenece al sujeto. Esto concuerda con evidencias de mantenimiento activo de otras dependencias sintácticas a distancia, como la dependencia *filler –gap* (Wagers & Phillips, 2014, Ness & Meltzer- Asscher, 2019; Chow & Zhou, 2019). Así, la predicción en la concordancia sujeto-verbo se realiza mediante un mantenimiento activo de la representación que contiene rasgos relacionados con el sujeto (aunque posiblemente también rasgos relacionados con el verbo). Dado que declarar que un elemento se predice en el procesamiento del lenguaje requiere mostrar que se preactiva antes de encontrarlo, podemos decir que nuestros resultados evidencian que la concordancia sujeto-verbo emplea mecanismos de predicción. De hecho, la concordancia sujeto-verbo es uno de las operaciones sintácticas centrales, y es comprensible que el sistema de compresión o *parser* quiera establecerlo correctamente. Nuestros resultados también muestran que la fuerza de esta predicción puede diferir dependiendo de la modalidad del lenguaje, tipo de tarea (como en Ferreira & Chantavarin, 2018), y la lengua.

Para terminar, el haber encontrado que la concordancia sujeto-verbo depende de mecanismos de predicción, que se dan mediante un mantenimiento activo de rasgos morfosintácticos, prueba que la concordancia sujeto-verbo ocurre en tiempo real. El Programa Minimalista sugiere que los elementos que llevan los rasgos no interpretables (verbos) necesitan encontrar un elemento que los coteja (sujetos). Mantener los sustantivos de sujeto activos hasta que se llega al verbo puede ser la forma que tiene el *parser* de asegurarse de que los rasgos necesarios son llevados al dominio del verbo. La presente tesis, así, aporta evidencia de que la concordancia sujeto-verbo es *psicológicamente real*.



# Abstract

The two most influential sentence comprehension models at the moment postulate that the subject-verb dependency establishment is either maintained, but causes no processing cost (SPLT/DLT model, Gibson, 1998, 2000), or that there is no active maintenance at all (cue-based retrieval model, Lewis & Vasishth, 2005; McElree, et al., 2003). The current dissertation tests whether the long-distance subject-verb establishment is maintained active over the course of the sentence, by looking at whether there is an increased processing cost on the elements over which it is maintained. Furthermore, we provide the first steps into investigating the nature of the actively maintained representation. More specifically, we test if it entails morphosyntactic information, such as syntactic category and number feature. To this end, we looked at how the maintained representation affects the interpolated elements, focusing on two effects that the maintained features might generate: similarity-based interference and disambiguation. In two eye-tracking during reading experiments in Spanish and English, we show that subject-verb dependency establishment is characterized by active maintenance, which increases processing cost over the interpolated elements. Moreover, we showed that the category feature (and possibly number feature) can cause similarity-based (encoding) interference on those elements, suggesting that those features are actively maintained. However, contrary to previous research (Chen et al., 2005), our results suggest that the maintained representation belongs to the matrix subject, and not the matrix verb. Furthermore, our visual world paradigm study in Basque confirms that number feature is maintained, disambiguating the number-ambiguous nouns interpolated between the subject and the verb. Given that both disambiguation and similarity-based (encoding) interference occur at the nouns that are positioned before the integration-triggering verbs, our effects can be ascribed to the top-down preactivation mechanisms. We thus believe that active maintenance of the morphosyntactic features in subject-verb agreement is an instance of syntactic prediction, which the parser employs to keep the information necessary for its establishment preactivated, facilitating integration downstream. Importantly, this implies that agreement, seen as feature checking or valuation between two elements, occurs in real-time sentence comprehension, suggesting that it is *psychologically real*.





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# Introduction

Online sentence comprehension involves performing several operations simultaneously: the morphology and meaning of words are processed as they are encountered, and, more importantly, relations are established between words that are processed at different time points. These relations can extend over quite a lot of elements of different categories that carry different information –as in subject-verb agreement. Still, the system somehow manages to use the right information and establishes dependency between the correct noun and the correct verb, and the grammaticality of a sentence is thus ensured. How does the system achieve this? How does it make sure that the right information persists over all the elements that are encountered between the subject and the verb?

The broad aim of the current dissertation is to answer this question. More specifically, we aim to investigate whether the system, in order to assure that the essential subject-verb agreement takes place, keeps the necessary information actively maintained over the course of the sentence. We will measure this by looking at whether there is a processing cost on the elements over which the dependency is being maintained. Then, we will test whether the content of the maintained representation is morphosyntactic, contrasting three morphosyntactically different languages: Spanish, English and Basque. We defend that the parser's active maintenance is a way to keep the information preactivated, i.e. predicted.

## *Outline of the current dissertation*

In Chapter 1, we present the theoretical background relevant for the current dissertation. First we describe syntactic prediction and its place within the recent broader interest in prediction in language processing. In this dissertation, we try to show that syntactic prediction is realized through active maintenance of the representation, and we try to clarify both what active maintenance means and what that representation could look like in subject-verb dependency establishment. We also give a

brief overview of the linguistic accounts of agreement processing, focusing on the Minimalist Program. We then turn to the experimental evidence on the psychological reality of subject-verb agreement, as well as how that relation is dealt with within sentence comprehension models. We note that the most commonly adopted sentence comprehension models do not assume active maintenance of a subject-verb dependency, which we aim to refute. Finally, we end the chapter with an overview of the technique that we will adopt, the eye-tracking technique, as well as its two most widely used paradigms: the eye tracking during reading paradigm, and the visual world paradigm.

In Chapter 2, we tackle the issue of whether a subject-verb dependency is actively maintained, thus causing processing cost over the interpolated material, in this case an embedded adverbial clause. Interestingly, sentence processing models assume that the matrix verb in such configurations is predicted, but not actively maintained. Adopting our idea introduced in Chapter 1 that syntactic prediction *is* active maintenance, we demonstrate in two experiments that actively maintaining subject-verb dependencies increases processing cost over the interpolated elements.

We then turn to the question of the nature of the maintained representation, asking what its features are. In line with the previous research on both subject-verb and filler-gap dependencies, we test whether the content of the maintained representation might be morphosyntactic, and, more specifically, whether it contains the grammatical category and the number feature. We measure the potentially active state of the category feature and number feature through two mechanisms. In particular, in Chapter 3, we investigate whether the actively maintained features cause similarity-based interference on the interpolated elements of different types (nouns and verbs). This chapter provides additional analyses of the experiments presented in Chapter 2. In both experiments, we show that the category feature is maintained. However, contrary to the previous proposals on the processing of subject-verb dependencies, our results show that it is not the representation of the matrix verb that is predicted, i.e. kept active. Rather, the representation seems to belong to the matrix subject, as both our Spanish and English experiments suggest.

However, our results in Spanish and English do not paint a clear picture regarding the maintenance of the number feature, which is why we further investigate this issue in Basque in Chapter 4, using the morphosyntactic disambiguation paradigm. While the reading study in Basque provides inconclusive evidence for number feature maintenance, the visual world paradigm experiment provides a better measure of incremental language processing and suggests that number feature is indeed actively maintained in subject-verb agreement.

The dissertation ends with a discussion on how our results relate to the current sentence processing models, as well as with reflections on how we define and measure syntactic prediction, and how prediction and integration work together in long-distance dependency processing. Furthermore, we reflect on our results in relation to the linguistic theory and, more specifically, the Minimalist Program. Our results suggest that at least some agreement operations must be *psychologically real*, as we prove that the agreement-relevant features are actively maintained in the online computation of this dependency.





# I. Theoretical Background

*“It is only a question of finding the right words and putting them in the right order. But we cannot do it because they do not live in dictionaries, they live in the mind.”*

Virginia Woolf, *On Craftsmanship*

## Sentence comprehension and prediction

Prediction in language comprehension has received a lot of attention in the last decades. Studies have found that syntactic, lexico-semantic, orthographic, phonological, and even phonetic information about a word can be active before its actual encounter (Ilkin & Sturt, 2011; Staub & Clifton, 2006; Foucart, Ruiz-Tada, & Costa, 2015; Wicha, Moreno, & Kutas, 2004; Laszlo & Federmeier, 2009; DeLong, Urbach, & Kutas, 2005; Monsalve, Bourguignon, & Molinaro, 2018). It has been suggested that the parser actively uses the information available from the context to preactivate the incoming information so that integration is facilitated, and so that language processing develops more efficiently and smoothly. The idea of the brain as a prediction machine (Clark, 2013) and language as one of its functions has become more readily accepted, although the debate exists concerning the extent and fundamentality of the predictive processing in language (Huettig, 2015; Huettig & Mani, 2016; Yan, Kuperberg, & Jaeger, 2017).

But, unlike word-level prediction, where the information is preactivated based on the accumulating context information (and this applies to both lexico-semantic properties of words, as well as their form), syntactic prediction has clear borders in a sentence. It spans exactly from the element that opens a dependency until the element that closes it. In the terminology introduced by Kamide (2008), syntactic prediction has a clearly established *predictor*, i.e. the element that triggers prediction, and *predictee*, i.e. the element that is predicted. Furthermore, syntactic prediction is exceptional as failure to satisfy it means processing an ungrammatical sentence, which creates a very big processing cost.

When talking about syntactic prediction, various researchers have defined it as the expectation of a certain syntactic structure or relation, by means of maintaining it or anticipating its conclusion (DeLong, Troyer, & Kutas, 2014; Ilkin & Sturt, 2011; Staub & Clifton, 2006). Sentence comprehension models recognize that the parser uses the knowledge of grammar in a top-down manner to predict the occurrence of syntactic categories such as verbs, and that some information

involved in establishing sentential relations such as long-distance dependencies must be expected, predicted or kept maintained (Gibson, 1998, 2000; Lewis & Vasishth, 2005; McElree, Foraker, & Dyer, 2003). However, there is little elaboration on what it means to be predicted in syntactic processing, and the terms *maintenance*, *expectation* and *prediction* are used almost interchangeably. Importantly, the question of how this maintenance is put into practice in sentence comprehension is not dealt with sufficiently. We will try to make a step towards answering these questions.

Additionally, recent studies on prediction in language suggest that, in order to talk about the prediction of an element, we need to find evidence for its activation prior to encountering it. That is, rather than looking at how the processing of an element is facilitated once it is encountered (due to it being predicted), it is important to find evidence that the representation of that element (or part of it) is active prior to its encounter (Ilkin & Sturt, 2011; Kuperberg & Jaeger, 2016).

In the current dissertation, we will follow this suggestion and consider syntactic prediction to be the activation of a (syntactically relevant part of a) representation prior to encountering the element that this representation belongs to. In other words, we believe that syntactic prediction/ expectation/ anticipation is conducted *through* active maintenance. This also means that, if a representation is preactively maintained, it should influence the processing of the elements over which it is being kept active. A related issue is what it means to be active and how we can measure this activity, and we deal with it in Sections 1.3 and 1.4.

Since syntactic prediction is best understood as maintenance of a representation from one element to another, the ideal candidates to study this issue are long-distance dependencies. In the current dissertation, we choose a long-distance dependency that is flexible enough to span over a large number of elements unrestrictedly, and still doesn't fail to be established in virtually every sentence – subject-verb agreement.

## **1.2. Subject-verb agreement: from linguistics to psychology**

Somewhat surprisingly, many researchers have noted that the usefulness of performing subject-verb agreement is not so straightforward (Acuña-Fariña, 2009; Corbett, 2006). The lack of agreement does not make the languages that don't have it less expressive or informative, which implies the redundancy of agreement. Agreement thus presents an enigma for both the theoretical (Corbett, 2006) and empirical work on language (Acuña-Fariña, 2009; Eberhard, Cutting, & Bock, 2005). Still, agreement is present in the majority of world languages (over 70%, Acuña-Fariña, 2009) and continues to be viewed as a core sentential operation. In essence, agreement nicely illustrates what syntax is all about - two elements being combined according to certain rules, in order to create a grammatical sentence. This relation is essential for the languages that have it as every sentence has to respect it, which has led some researchers to claim that agreement is what builds the sentence (Acuña-Fariña, 2009), or that it is a “quintessential morphosyntactic phenomenon” (Preminger, 2011). Luckily for the experimental research in language, the syntactic relation between the subject and the verb is overtly expressed via morphology in many languages. While syntax is often not visible on the elements over which it operates, and thus not easily measurable, agreement's reliance on morphology makes it a perfect candidate to study structural sentential relations. Thus, for psycholinguists, agreement is both puzzling and convenient.

### **1.2.1. Subject-verb agreement in linguistic theory**

Traditionally, agreement is defined as covariance between two elements in one or more morphosyntactic features, whereby one element receives the features of another (Steele, 1978). Therefore, agreement is usually seen as an asymmetric process, with one element being *the controller*, i.e. the element that determines the features of another element, which is *the target* (Corbett, 2006). Yet, the view on agreement asymmetry and its directionality differs in some approaches.

In generative grammar, and more specifically, within the Minimalist Program, an AGREE operation is proposed (Chomsky, 2001), by which the *uninterpretable* features (i.e. those that cannot be interpreted, i.e. cannot reach semantic interpretation) are valued and erased. This *valuing* and subsequent elimination of the uninterpretable features are seen as essential steps in sentence derivation. Sentences cannot be passed on to the semantics if all the uninterpretable features are not valued (Chomsky, 2000), which essentially means that the sentences cannot be interpreted and understood. Depending on the language, different morphosyntactic features can be uninterpretable – syntactic category feature, number, person, gender, etc. Here, the element whose features need to be valued is a *probe*, and the element whose features are copied in order to conduct the valuation is a *goal*. Thus, the operation AGREE in minimalism (besides other operations) ensures that the necessary requirements are met for the generation of interpretable sentences, which locates this operation in a very important place in sentence building. The existence of the features that need to be valued (uninterpretable features) makes the elements that carry them *active* and causes them to look for other elements which could value them (Acuña-Fariña, 2009). In the minimalist view, the *probe* would correspond to the *target* (verb), while the *goal* would correspond to the *controller* (subject, Corbett, 2006). The direction of agreement in minimalism thus seemingly differs from the more traditional view (for the debate on the directionality of agreement in minimalism, see Preminger, 2013 and Zeijlstra, 2012). The exchange of feature values is not triggered by the subject noun, but by another element, and the reason why agreement occurs in the first place is to be able to have interpretable sentences. But, importantly, in this, as well as in many other frameworks, agreement is always seen as a process where the features of the noun are somehow transferred onto the features of the verb, regardless of what triggers this transfer.

It is worth mentioning that there are some theoretical accounts that give less importance to the directionality of the subject-verb agreement, and that assume no asymmetry, such as the unification approach, where the features of elements are combined into a single one (Sag et al., 1986), or head-driven phrase structure (HDPS), which relies more on the lexicon and where agreement is seen as a selection process - a verb with a certain feature selects a noun with the same feature (Kathol, 2000;

Pollard & Sag, 1994). Also, in some accounts, several types of agreement are proposed, such as concord, index and semantic agreement (Wechsler & Zlatić, 2003).

Given the research questions of the current dissertation, we believe that the most suitable framework to discuss our findings is the one that assumes that subject-verb agreement computation involves feature transmission from one element to another, where these elements are somehow *active*, and that is the Minimalist Program.

### **1.2.2. Psychologically real subject-verb agreement**

In light of bridging the gap between linguistic theory and psycholinguistics, many researchers have adopted the concepts proposed by the theory and tested them experimentally. In principle, this has boiled down to proving that linguistic operations or concepts are *psychologically real*. That is, the question is whether the operations postulated by the linguistic theory have their cognitive equivalents (and, if they do, whether and how we can measure them). There are undoubtedly many challenges that need to be overcome in order to connect linguistics to both psychology (Lewis & Phillips, 2015; Phillips & Lewis, 2013; Phillips & Wagers, 2007) and neuroscience (Poeppel & Embick, 2005), but, fortunately, the gap has been shrinking over the years. It is now well accepted that parsing (i.e. the mental processes that determine the grammatical structure of word sequences, Phillips, 2003) incorporates grammatical knowledge as a top-down information in real-time sentence comprehension. However, it is still debated whether this grammatical knowledge is incorporated exactly according to the operations proposed by different linguistic models.

When it comes to subject-verb agreement specifically, a well replicated finding is that the brain very effectively recognizes violations of subject-verb agreement. This has been shown both behaviourally, with robust increases in reading times (Braze, Shankweiler, Ni, & Palumbo, 2002; Deutsch & Bentin, 2001; for a review see Clifton, Staub, & Rayner, 2007), and in the brain response (EEG evidence: Osterhout & Mobley, 1995; for a review see Molinaro, Barber, & Carreiras, 2011; fMRI evidence: Mancini, Quiñones, Molinaro, & Hernandez-Cabrera, 2017; Quiñones, Molinaro,

Mancini, Hernández-Cabrera, & Carreiras, 2014). Studies have also found that the agreement of different features employs different brain mechanisms (Biondo, Vespignani, Rizzi, & Mancini, 2018; Mancini, Molinaro, Rizzi, & Carreiras, 2011; Mancini, Postiglione, Laudanna, & Rizzi, 2014; see Mancini, 2018 for a comprehensive review on both behavioral, electrophysiological and neuroanatomical evidence).

Phenomena related to agreement errors which occur in natural speech have also provided a window into the processes involved in agreement computation. An extensively studied phenomenon in both language comprehension and production has been number agreement *attraction*, where the verb's number is erroneous due to the presence of a non-subject noun in the sentence (usually within the subject noun phrase, e.g. \**The key to the cabinets are missing*). Franck, Lassi, Frauenfelder, & Rizzi (2006) show that the attraction effects are found in interrogative sentences with the VS word order (see also Vigliocco & Nicol, 1998), but not in declarative sentences with the same word order. Franck et al. (2006) claim that these two types of the sentences have the same surface structure, and that the attraction effects in the interrogative sentences thus must occur in one of the intermediate representations. Namely, the generativist syntactic theory presupposes that abstract intermediate representations are generated in the interrogative sentences, as the sentence derivation proceeds in a stepwise fashion. The generation of intermediate representations is triggered by operations such as AGREE and MOVE. These results suggest that those operations proposed within generativism might have their psychological equivalents.

Additionally, establishing a relation between a subject and a verb in real-time language comprehension goes beyond morphosyntactic feature concordance. Research has found that a lot of different information takes part in the establishment of the relation between subjects and verbs, such as animacy, the plausibility of one word being the argument of another, and other semantic factors (Barker, Nicol, & Garrett, 2001; Haskell & MacDonald, 2003; Thornton & MacDonald, 2003). All this information is built into the semantic or event representation of a sentence and it enfold the operation of subject-verb agreement, which has to do with the very form of the two elements. In the current dissertation, we will distinguish between *subject-verb dependency/dependencies* establishment

(which involves all these different relations), and *subject-verb agreement* (which refers to morphosyntactic feature congruence). We will use both of these terms, firstly talking about subject-verb dependency establishment, without focusing on any particular part of it (Chapter 2), and then testing subject-verb covariance in specific morphosyntactic features and thus agreement (Chapters 3 and 4).

### ***1.3. Sentence comprehension models and subject-verb agreement***

Already in the early stages of the generativist syntax, language performance (unlike language competence) was claimed to be limited by working memory (Chomsky, 1965). Nowadays, the intertwinement of language processing and memory structures is a widely accepted fact. It is not surprising then that the sentence comprehension models were essentially built onto the working memory proposals that describe cognitive functioning in general. Naturally, all of the sentence comprehension models had to account for subject-verb agreement as a core sentential operation. And, importantly for the current dissertation, the two most dominant models in the last decades make prediction/maintenance an important part of their models.

Gibson's Syntactic Prediction Locality Theory (SPLT, 1998), also known as the Dependency Locality Theory (DLT, 2000), is a storage-based model. It deals with the processing cost related to establishing syntactic dependencies, based on the storage cost upon predicting the elements needed to conclude those dependencies. However, this model doesn't ascribe the processing cost during sentence comprehension only to top-down mechanisms such as expectation/prediction. Rather, it suggests that the second source of the processing cost is integration, i.e. the cost related to the integration of the upcoming elements into the existing structure. Thus, in this model, sentence processing is seen as a combination of top-down predictions and bottom-up integration. The idea that working memory combines both mechanisms can be seen in Unsworth & Engle's working memory proposal (for a view of working memory as a combination of active maintenance in the primary memory, and the retrieval from the secondary memory, see Unsworth and Engle's proposal described



in Box 1.1). Interestingly, matrix subject-verb dependency in the SPLT model does imply verb prediction, but this prediction, being always expected, incurs no processing cost (see Figure 1.1).

The other stream of sentence comprehension models that have had a great impact on psycholinguistic research are the cue-based retrieval models (Jäger, Engelmann, & Vasishth, 2017; Lewis & Vasishth, 2005; McElree et al., 2003). In these models, the elements are accessed, i.e. retrieved at each word with the help of retrieval cues, after which integration takes place. The focus is, therefore, on bottom-up integration. When it comes to subject-verb agreement, these models would postulate that upon encountering the matrix subject noun, its representation is encoded in memory, together with a representation of the predicate that is expected to occur (Lewis, Vasishth, & Van Dyke, 2006). Then, at the matrix verb, the retrieval cues are launched and the item from memory rapidly accessed and integrated. It is clear how this model resembles the ideas about working memory architecture suggested by Unsworth & Engle (2007) and Oberauer (2002; see Box 1.1 for their descriptions of working memory): the items need to be retrieved from the (probably secondary) memory, and only a limited number of items can be kept in the active state, within single-chunk *buffers*. But, the subject and the verb of a matrix long-distance subject-verb dependency are seemingly not one of them (see Figure 1.2).

Therefore, when talking about subject-verb dependencies, sentence processing models mostly recognize that some information involved in establishing them must be expected, predicted or kept maintained (Gibson, 1998; Lewis & Vasishth, 2005; McElree et al., 2003). Cue-based retrieval models (e.g. Lewis & Vasishth, 2005) do predict that the representation of the verb is built up upon processing the matrix subject and that the prediction is created, together with the representation of the matrix subject. However, it is not postulated that this prediction is kept active and it is not clear what happens with the representations encoded at the matrix subject before the matrix verb is reached, i.e. over the *storage interval* (i.e. the elements between the matrix subject and the matrix verb). Nevertheless, it is inferable that those representations are not part of active processing as they need to be retrieved (and McElree et al., 2003 indeed say that explicitly). Thus, the cue-based retrieval models claim that the linguistic material must be maintained, but also that there is no processing effort related

to keeping the prior constituents active (they simply decay). Importantly, working memory focus is really limited and only the contents of the buffers are held in a distinguishable state that makes the content available for processing. On the other hand, Gibson's SPLT/DLT model claims that the prediction of the matrix (main) verb is maintained throughout the sentence, but it is cost-free. The parser is always expecting a predicate and a subject for it, so this prediction is built into the parsing mechanism (it is automatic). However, claiming that a representation is cost-free implies that it is not maintained active and that it is not available (see Box 1.2).

The assumptions about the status of a subject-verb dependency proposed by the models presented above might seem rather counterintuitive. Namely, we saw in Section 1.2.1 that theoretical linguistic approaches mostly assume that a subject-verb dependency implies certain agreement operations. It would thus be plausible that some of the agreement related operations are psychologically real (as also suggested by Franck et al., 2006). After all, it doesn't seem unlikely to us that the parser has a mechanism that ensures, on a word-to-word basis, that the features that have to be matched are available throughout the sentence, as the point of their checking is unknown in natural, incremental language processing. However, the sentence comprehension models outlined above don't seem to embrace this idea entirely: Gibson (1998, 2000) proposes no processing cost to the matrix verb prediction, implying that no computational resources are dedicated to make matrix subject and matrix verb agree. Lewis & Vasishth (2005), on the other hand, seem to imply that the subject is somehow put aside until the verb is reached, assuming no active maintenance of the relevant features. In the current dissertation, we aim to prove that a subject-verb dependency (and subject-verb agreement) does imply active maintenance of the features. By doing this, we try to once again reconcile linguistics, which proposes the existence of agreement operations, and psycholinguistics, which is supposed to unravel the mechanisms that are putting these operations into practice in real-time sentence comprehension.

The word-by-word SPLT memory cost profile for the processing of the object-extracted relative clause sentence 'The reporter who the senator attacked admitted the error'

Syntactic prediction	Input word								
	The	reporter	who	the	senator	attacked	admitted	the	error
Matrix verb	0	0	0	0	0	0	0	0	0
Matrix subject	M(0)	*	-	-	-	-	-	-	-
Matrix object NP	-	-	-	-	-	-	M(0)	M(0)	*
Embedded subject NP	-	-	-	M(0)	*	-	-	-	-
Embedded verb	-	-	M(0)	M(0)	M(1)	*	-	-	-
Wh-pronoun gap	-	-	M(0)	M(0)	M(1)	*	-	-	-
Total cost (MUs)	M(0)	0	2M(0)	3M(0)	2M(1)	0	M(0)	M(0)	0

Figure 1.1. Table 1 taken from (Gibson, 1998, Table 1). Highlighted is the memory cost for the matrix verb prediction at each word of a sentence containing an embedded relative clause. Syntactic prediction in this model is seen as a syntactic category prediction and the nature of the maintained representation is not specified. Matrix verb is the only element for which prediction incurs no processing cost.

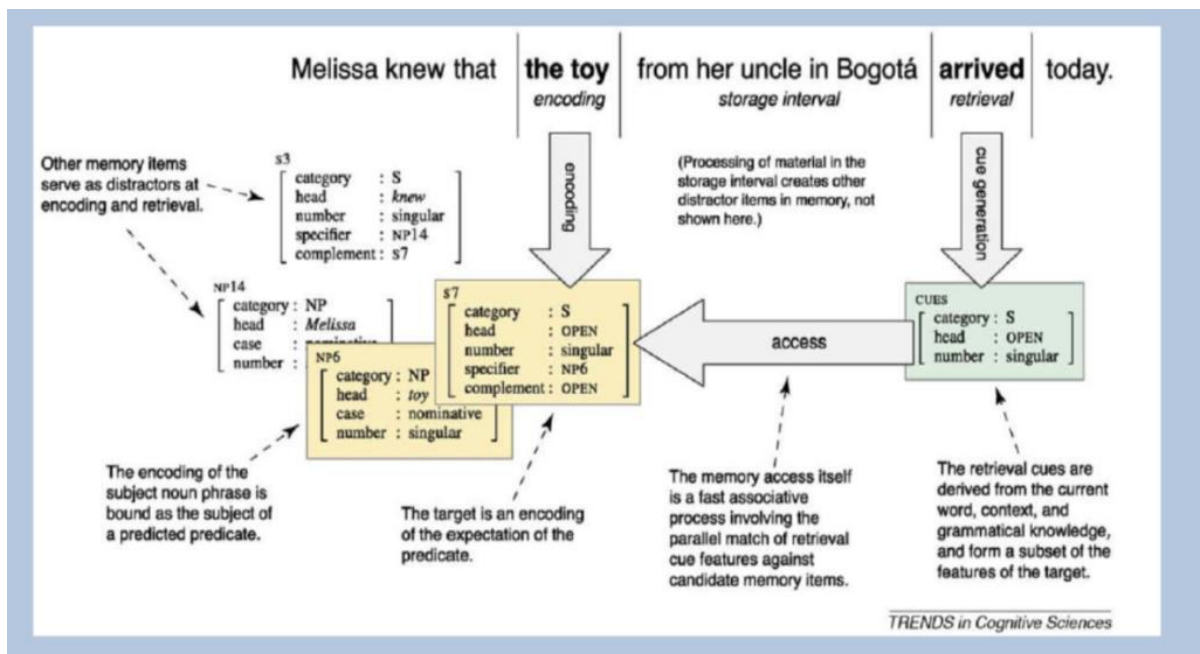


Figure 1.2. The representation of how a dependency is established between the subject (the toy) and the verb (arrived) according to the cue-based retrieval account, taken from Lewis et al. (2006, Figure 1). According to the authors, linguistic items are represented as feature bundles in the memory, and both the representation of the subject NP and the representation of the prediction of the predicate are encoded. This prediction remains in memory until its retrieval at the verb, but it is outside the focus of attention.

### **BOX 1.1. WORKING MEMORY ARCHITECTURE**

In cognitive psychology, working memory has been seen both as active maintenance (Miyake & Shah, 1999), as context-based retrieval process (Capaldi & Neath, 1995), as well as the combination of both (Unsworth & Engle, 2007). Unsworth & Engle (2007) claim that working memory consists of primary and secondary memory. The primary one is related to maintaining a number of representations active for ongoing processing by means of the continued allocation of attention, with an upper bound of approximately four items (Cowan, 2001). The items that are displaced from the primary memory (which depends on many factors, such as incoming information, secondary task etc.), must be recovered from the secondary memory by means of retrieval. Similarly, Oberauer (2002) suggests that working memory comprises three different types of representations, which differ on their level of activation and thus accessibility. While usually only one representation is in *the focus of attention*, more representations can be in *the region of direct access*, while the rest of them are in *the activated part of long-term memory*. Retrieval brings representations belonging to the last two types into the focus of attention.

### **BOX 1.2. ACTIVE MAINTENANCE**

An important issue to consider is what it means to be *maintained active*. What makes a representation active, and how does an active representation differ from a passive one? One way to test if the representation of an element (or some part of it) is active is to see if it interacts with other words that are being processed. Thus, if a subject-verb dependency is actively maintained, the representation that is being maintained is expected to interact with the interpolating elements. This should be seen as increased processing cost. Additionally, if we manipulate the features of the interpolated elements, and if that causes certain effects on those elements, that implies that those features form part of the representation that is being actively maintained over them. In the current dissertation, the effects that we will try to elicit to prove the active status of the maintained representation are encoding interference (a type of similarity-based interference), where the actively maintained feature increases the processing cost of the elements with the same feature, and disambiguation, where the actively maintained feature biases the interpretation of a temporarily ambiguous word.

### **1.4. What is maintained?**

If we assume that establishing a subject-verb dependency does incur processing cost, an issue of the nature of the maintained representation arises naturally. What is causing the processing cost? As Chen, Gibson, & Wolf (2005) claim, there are several possible causes of the processing cost related to the subject-verb agreement dependency: maintaining the prediction of the syntactic head, i.e. syntactic category, maintaining the incomplete dependency, maintaining the open phrase structure rule, and maintaining the incomplete clause (see also Gibson, 1991, 1998). According to the authors, it is the prediction of the syntactic head, i.e. the matrix verb that creates the cost.

On the other hand, when it comes to the cue-based retrieval accounts, both the representation of the predicted verb and the representation of the matrix subject as the agreement controller are encoded at the matrix noun and retrieved later at the verb (Lewis et al., 2006). These representations include category information, number, person, case and gender information, position within the hierarchical syntactic structure, etc. However, according to this model, these representations are not part of active processing over the storage interval. Therefore, there is a possibility that the maintained representation belongs to either the element that opens the dependency (matrix subject), the predicted element (matrix verb), or both.

A good way to investigate the nature of the maintained representation is to look at its content and try to unravel its possible features. This approach has already been taken in studies investigating maintenance in another long-distance dependency: the filler-gap dependency. This dependency is established between an element that is displaced from its canonical position, i.e. the filler (“pen”), and the position where it originates from, i.e. the gap (underlined).

- 1) This is the pen that I got \_\_\_ for my birthday.

Whether the fillers are actively maintained in sentence processing or not is still an open question in the filler-gap dependency literature. Wagers & Phillips (2014) summarize the two views as follows:

“Under a maintenance view, the filler is stored in a short-term memory location until the point at which it can be integrated directly with a gap host. Under a retrieval view, the filler is not purposely kept in short term memory and must be retrieved and reactivated when the parser posits a gap. According to the maintenance account, the filler is continuously accessible to the parser but potentially exacts an overhead cost by consuming the comprehender’s short-term memory capacity. According to the retrieval account, there is no taxing maintenance but there is a possibility for error later when the filler has to be reactivated (Wagers & Phillips, 2014, page 1277).”

Numerous existing demonstrations that filler–gap dependencies exact a cost on the comprehender have been taken as evidence for maintenance (Gibson, 1998, 2000; King & Just, 1991; Sprouse, Wagers, & Phillips, 2012; Kluender & Kutas, 1993). However, they cannot inform us about the actual content of what is being maintained in this active, privileged state (Fiebach et al., 2002; Wagers & Phillips, 2014). For that reason, Wagers & Phillips (2014) tested whether the semantic content of the filler can be maintained in the focus of attention to actively construct dependency formation across different dependency lengths. They compared sentences such as (2a) and (2b) and expected to observe a semantic anomaly effect at the critical verb (“erect”) in (2b). Namely, if the filler is active and if it is initially treated as the direct object of the verb “erect”, then the initial interpretation describes a plausible situation in (2a), but not in (2b).

2a) The monument which the pilgrim erected \_\_\_ to appease the gods...

2b) The gods which the pilgrim erected the monument to appease \_\_\_...

The authors found that comprehenders were sensitive to the semantic fit of the filler with the verb that hosted its gap. However, while the category (noun phrase, NP) information was shown to be available across the dependency lengths, the effect of semantic fit decayed as the dependency length increased. Thus, together with other experiments, their results suggest that the category identity of the filler is maintained active, whereas its semantic details are not. The authors thus propose interplay of predictive, leading processes, and retrospective, lagging processes in sentence comprehension. This suggests a hybrid mechanism for sentence comprehension: both maintenance (for category information) and reactivation (for semantic details), which also goes in line with some working memory architecture proposals (Section 1.3). However, a study by Chow & Zhou (2019) found that

semantic information can be maintained across all the dependency lengths, which implies that a more fine-grained information can be maintained after all. Converging evidence comes from Ness & Meltzer-Asscher (2019), where the authors compared sentences in Hebrew containing a filler-gap dependency, and those not containing it, and where the results showed that the maintained representation contains animacy information. These studies suggest that the maintenance component of the hybrid sentence comprehension mechanism might be stronger than initially thought. In sum, the literature on filler-gaps has looked at the content of the maintained representation and demonstrated that both the category information and the semantic details are actively maintained during the online establishment of this long-distance dependency.

When it comes to long-distance subject-verb dependencies, the nature of the maintained representation is still unknown and it hasn't been directly tested. Given that subject-verb agreement is usually described as covariance between two elements in one or more morphosyntactic features, the current dissertation investigates the possible morphosyntactic nature of the maintained representation (Chapters 3 and 4), after attesting that maintenance takes place in subject-verb dependency processing (Chapter 2). To this end, we use the eye-tracking technique.

### ***1.5. Eye-tracking in sentence comprehension***

The eye-tracking technique has been used in language research for many decades now, and its informative value regarding the underlying cognitive processes is undeniable. We will apply two of its most developed and most often used paradigms: eye tracking during reading and visual world paradigm. Both of these techniques can provide a very reliable measure of how comprehension develops over the course of the sentence, but the difference in language modality (written vs. spoken language) makes them quite different.

### 1.5.1. Eye tracking during reading

Tracking eye movements during reading has been one of the favorite methods in psycholinguistics in the last several decades (see Rayner, 1978 for an early overview, and Kliegl & Laubrock, 2018 for a recent one). As noted by Bornkessel-Schlesewsky & Schlewsky (2009), this method provides a sensitive measure of processing during reading, which is able to accommodate the multidimensionality of language comprehension. Importantly, as Staub & Rayner (2007) underline, eye movements are a natural part of reading, so performing experiments with this technique doesn't require an additional task that is not part of usual language processing (except for the comprehension questions which are often added to make sure the sentences are understood and that the attention has been kept - but the reading analyses are not performed on them).

The nature of eye movements is, obviously, shaped by the features of the human visual system. Natural human reading can be seen as a series of fixations, which is when the eye pauses on a word, and fast saccades, which is when the eye jumps from one fixation to the next one. These jumps can span over 8 to 9 characters (although this varies with reading skill), and last around 20 to 40 ms (Clifton et al., 2007). During the fixations, unlike saccades, the information is extracted from the text. They can last from 200 to 250 ms, with some variability that can be either individual or driven by the factors related to the text itself. These factors, in turn, can be related both to the physical properties of the text (such as length, visibility, etc.), and, importantly for us, on the underlying cognitive processes needed for its computation. Namely, the amount of time spent on a word has been considered to be very informative about the ease/difficulty with which the word is processed. This connection is not perfect, but it is a rather good estimate (for the connection between the "eye and the mind", see Just & Carpenter, 1980 and Staub & Rayner, 2007).

Distinction is usually made between early and late measures, which can help to investigate the time course of language comprehension. Early measures are usually considered to be *first fixation duration* and *first pass reading time* (the sum of all fixations in a region from first entering it until leaving it), while the late measures usually include *second pass reading time* (the sum of all fixations



in a region that are subsequent to first pass) and *total reading time* (the sum of all fixations and regressions in a region). Additionally, *go-past reading time* or *regression path duration* (the sum of all fixations from first entering a region until moving to the right, including the regressions to the previous region) is sometimes regarded as an early and sometimes as a late measure. The same applies to the *regressions out* (regressions to the previous regions, before moving right to the region). Clifton et al. (2007) claim that the regressions out can be considered to reflect an early effect of difficulty to integrate a word, while the go-past measure also reflects the effort to overcome that difficulty, which might be related to a bit later processing stages.

In the current dissertation, we will always look at the first pass reading times, go-past reading times and regressions out, regarding them as the measures related to the early stages of processing, i.e. the processing that is not affected by the subsequent words. Importantly, researchers have warned that these measures should not be mistaken for a direct equivalent of different processing stages as proposed by sentence comprehension models (Bornkessel-Schlesewsky & Schlewsky, 2009; Clifton et al., 2007; Staub & Rayner, 2007; Vasishth, von der Malsburg, & Engelmann, 2013). Undoubtedly, looking at different measures is informative about the differences in the time course of effects during language comprehension. Thus, effects related to the word identification, and lexical factors such as word length and frequency are found already on the first fixation, while the first and second pass, regressions out, go-past and total reading times effects very commonly reflect syntactic, semantic and pragmatic effects (see Clifton et al., 2007 for an overview).

All the measures mentioned above correspond to what is called foveal vision. Namely, when fixating, we can see the written text either foveally or parafoveally. The foveal region is the one that allows high visual acuity and takes around 1 degree of visual angle, which normally corresponds to 3 to 4 letters to the left and right of the fixations. Beyond that, i.e. parafoveally, the text is seen with much less visual acuity, but the readers still extract some information (7-8 characters to the right, usually). This information is mostly orthographic, phonological or lexical, while the parafoveal processing of higher levels of representation, such as semantic or syntactic, is still to be determined

(Staub & Rayner, 2007; for a comprehensive review on evidence on parafoveal processing, see Schotter, Angele & Rayner, 2012).

### 1.5.2. Visual world paradigm

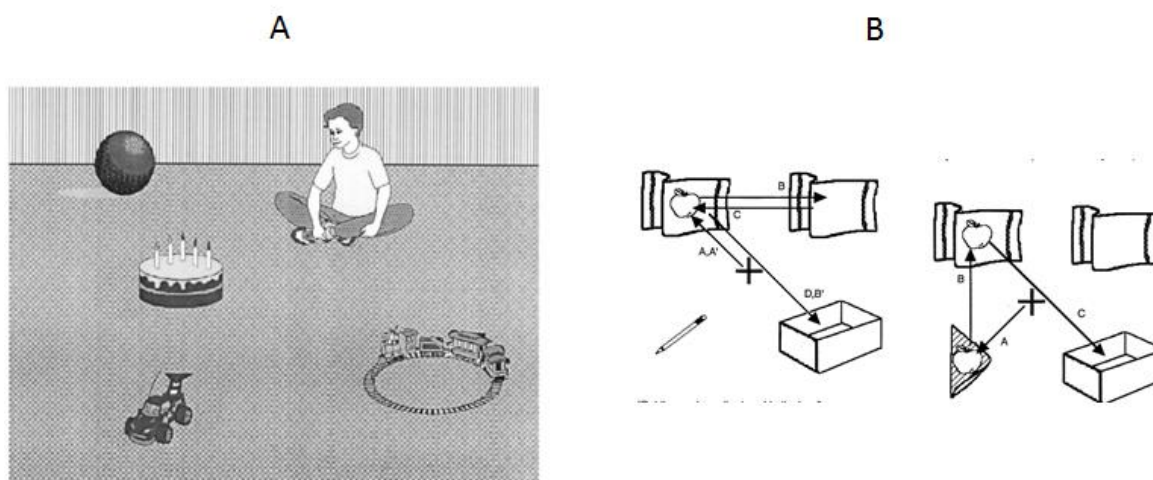
The eye-tracking technique is a valuable tool in investigating spoken language comprehension too. Cooper (1974) first observed that there is a tight link between spoken language and visual scene processing (see also Altmann, 2011). This led to the creation of the so called *visual world paradigm* (Allopenna, Magnuson, & Tanenhaus, 1998), first introduced by Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy (1995), which has been widely used in language research ever since. In their seminal paper, Tanenhaus et al. (1995) report that the participants moved their eyes towards objects immediately after hearing the words that the objects represent, which enabled them to observe the online language comprehension on a millisecond time scale. Aiming to test if the (visual) context guides syntactic analysis from the earliest stages of processing, Tanenhaus et al. (1995) presented the participants with the temporarily syntactically ambiguous spoken sentences such as *Put the apple on the towel in the box*. Here, the prepositional phrase *on the towel* (before encountering *in the box*) can be interpreted denoting either location or destination, and the finding that the destination interpretation is preferred had been attributed to syntactic simplicity. Visual scenes were presented while listening to these temporarily ambiguous sentences, which contained either: an empty towel, a box, an apple on a towel, and a pencil (thus allowing only the interpretation where *on the towel* should mean direction), or: an empty towel, a box, an apple on a towel, and another apple on a napkin (thus allowing *on the towel* to be interpreted as location, see Figure 1.3, panel B). Based on the participants' looks to the visual scenes, the authors found that the ambiguous phrase was initially interpreted as a destination in the one-apple context, and as a location in the two-apple context, proving that contextual information is used quite early in processing. Thus, their paradigm shows how tracking the movements of the eyes on the carefully designed visual scene can inform us about the syntactic analysis processes that are developing during sentence comprehension.

Many researchers have later developed this paradigm to study various aspects of language, such as lexical factors, semantics, pronominal reference, syntactic ambiguity, word order, prediction and anticipation in language, etc. (Altmann, 2011; for a detailed overview on visual world paradigm in sentence and discourse processing, see Huettig, Rommers, & Meyer, 2011). The paradigm can thus have many variations, depending on the topic of investigation, but the visual display usually contains several (usually four) images, whose nature and distribution on the screen can vary (for a more realistic scenes, see Figure 1.3, panel A, taken from Altmann & Kamide, 1999). The visual stimuli usually represent the critical word(s) mentioned in the sentence, as well as distractor images. Again, the visual stimuli can differ depending on the research question, and sometimes the images are substituted by printed words (Huettig & McQueen, 2007).

The timing of the presentation of the visual display is also important. Usually the visual display is presented together or slightly before the onset of the spoken stimuli (with some differences). While the objective is to see what happens during or immediately after the presentation of a word in question, it has been proven that the interval prior to the onset of the critical word is also very important, as the amount of preview seems to matter. This might be due to the fact that planning a saccade takes up to 200 ms (Tanenhaus et al., 1995). Importantly, looking at the eye-movements prior to the encounter of the critical word has been shown to be very fruitful in the investigation of the predictive or anticipative processing in language comprehension. Altmann & Kamide (1999) showed that in sentences such as *The boy will eat the...*, the participants' eye movements move towards an edible object referent (the cake) even before hearing it. This proves that the semantic information of verbs is used to predict their possible arguments. Many subsequent studies have shown that different information can be used to launch anticipatory eye movements in sentence comprehension (Altmann & Kamide, 2007; Kamide, Altmann, & Haywood, 2003; Kamide, Scheepers, & Altmann, 2003; Sussman & Sedivy, 2003).

The visual world paradigm thus allows us to study a wide range of effects, including higher order language processing, such as prediction, grammatical information (Kaiser & Trueswell, 2008; Kamide, Altmann, et al., 2003) and differences in syntactic complexity (Wendt, Brand, & Kollmeier,

2014). Importantly, the advantage of this paradigm is that it enables us to study language as it unfolds over time (i.e. spoken language). In other words, the visual world paradigm allows investigating different sentence comprehension effects as they arise. This guarantees that the observed effects can be ascribed to real time, word-by-word language processing.



**Figure 1.3. Panel A: An example visual screen from Altmann & Kamide (1999). Panel B: An example visual screen from Tanenhaus et al. (1995)**

## **II. Maintenance of subject-verb dependency**

*“When we read, it is not ours to absorb all that is written.”*

Milorad Pavić, *Dictionary of the Khazars: A Lexicon Novel*

In the current chapter, we will present evidence that long-distance subject-verb agreement is conducted through active maintenance of the information relevant for its establishment, and that this incurs processing cost over the interpolated elements. Moreover, we will provide cross-linguistic evidence for this claim by presenting data from English and Spanish.

As explained in Chapter 1, Section 1.3, sentence processing models do not assume that the matrix subject-verb dependency is actively maintained in the configurations with the embedded clauses. However, interestingly, the same models do assume that the matrix verb is predicted. We think that there might be certain inconsistencies regarding the terminology in the syntactic prediction field (see Chapter 1, Section 1.1), and it is certainly not clear what is meant by prediction or expectation in syntax. We take it that prediction in syntax has clear boundaries, spanning from one element to another, between which a representation related to the syntactic relation in question is actively maintained. As active maintenance for us inevitably includes an increase in processing cost on the elements that are enveloped by it (we will talk about the origin of that processing cost in Chapters 3 and 4), we expect syntactic prediction in a subject-verb dependency to manifest itself as increased processing cost over the elements that are interpolated between the subject and the verb.

## ***2.1. Previous studies on subject-verb agreement maintenance***

Although sentence comprehension models postulate no processing cost related to the prediction of the matrix verb or to the establishment of the matrix subject-verb dependency, several studies have tested this claim empirically. One of the first studies to provide evidence for processing cost related to subject-verb dependency maintenance was the phoneme monitoring task by Hakes, Evans, & Brannon (1976), where the subjects listened to sentences and were expected to identify words with specific phonemes. Although Hakes et al. (1976) set out to test self-embedded vs. right branching clauses, without explicitly ascribing the cost to subject-verb dependency establishment, their Experiment 1 provides a relevant contrast. Namely, they compared sentences containing subject

modifying relative clauses, and thus embedded between the matrix subject and verb (3a) with those containing object modifying clauses, and thus located after all the arguments of the matrix clause (3b).

3a) After the final curtain on opening night, the director (*that*) *the repertory company had hired* praised the star performer.

3b) After the final curtain on opening night, the star performer praised the director (*that*) *the repertory company had hired*.

No difference in phoneme monitoring performance (and thus comprehension difficulty) was found. The authors conclude that their results do not support the claim that self-embedded sentences are more difficult to process, which suggests that there is no additional cost related to the subject-verb dependency being held over the relative clause.

In a self-paced reading task, Van Dyke & Lewis (2003) compared embedded relative clauses of different complexities. This allowed testing if there is an increase in processing cost with more complexity of the material over which the prediction is being maintained. Thus (besides other conditions in their study), they compared reading times over the complex embedded clause in (4a) and less complex embedded clause in (4b). However, they found no significant difference.

4a) The frightened boy understood *the man who said the townspeople are dangerous* was paranoid about dying.

4b) The frightened boy understood *the man who was swimming near the dock* was paranoid about dying.

Importantly, both Hakes et al. (1976) and Van Dyke & Lewis (2003) studies involve paradigms with relative clauses. But, the processing of relative clauses is quite specific due to additional relations being established between the matrix clause elements and relative clause elements

(such as filler-gap dependencies). Additionally, Hakes et al. study used phoneme monitoring task, which might not be so informative in sentence processing, while Van Dyke & Lewis (2003) compare clauses of different structures.

Chen et al. (2005) studied whether matrix verb prediction causes processing cost with a different paradigm: they measured reading times over the clause which was a complement of a verb/noun, and which was identical across the conditions. Here, the manipulation concerned the number of the verb predictions over the same clause – none, one, or two. They hypothesized that, if processing cost is proportional to the number of predicted verbs held in memory, then the zero predicted verbs condition (5a) should be read fastest, and the two predicted verbs condition (5d, the predicted verbs are underlined) the slowest.

5a) Zero predicted verbs:

The detective suspected that the thief knew *that the guard protected the jewels* and so he reported immediately to the museum curator.

5b) One late predicted verb:

The detective suspected that the knowledge *that the guard protected the jewels* came from an insider.

5c) One early predicted verb:

The suspicion that the thief knew *that the guard protected the jewels* worried the museum curator.

5d) Two predicted verbs:

The suspicion that the knowledge *that the guard protected the jewels* came from an insider worried the museum curator.

The results confirmed their hypothesis - condition (5a) elicited the shortest reading times, while condition (5d) elicited the longest reading times. Thus, Chen et al. (2005) conclude that the parser keeps track of predicted syntactic heads, and that there is some cost associated with maintaining these predictions. Again, this doesn't align with the main sentence comprehension models presented in Chapter 1. On the one hand, Gibson's SPLT/DLT model claims that the prediction of



the matrix (main) verb does exist and is maintained throughout the sentence, but is cost-free. That is, no increase in processing cost is expected in relation to its establishment. On the other hand, according to cue-based retrieval models (Lewis & Vasishth, 2005; McElree et al., 2003), the information related to the subject-verb dependency is retrieved at the verb and thus it is not part of active processing over the interpolated elements (the storage interval, see Figure 1.2 in Chapter 1), which in turn implies no additional processing cost. The evidence by Chen et al. (2005), therefore, challenges these assumptions.

## *2.2. Current chapter*

Although a handful of studies have tested the possible maintenance of the subject-verb dependency, their results are rather mixed. Furthermore, none of the studies so far tested this question using a more naturalistic reading paradigm. In the current chapter, we present eye tracking data that prove that matrix subject-verb dependency maintenance incurs processing cost over the embedded clause. The eye tracking technique has been widely used in sentence comprehension (see Chapter 1, Section 1.5) and has proven to be very ecological, offering an experimental setting which closely resembles natural reading.

Furthermore, following Chen et al. (2005), we do not make use of embedded relative clauses to avoid additional dependencies and thus predictions. But, unlike Chen et al. (2005), we do not use complement clauses either, as they also might incur complement predictions initiated at the matrix clause. Rather, we use adverbial clauses, which represent an adjunct for the matrix clause and thus no predictions other than the one related to the matrix subject-verb dependency are created. Importantly, we compare these sentences to the control conditions, where the same adverbial clauses are not interrupting subject-verb dependency and no processing cost is expected related to maintenance.

## 2.3. Experiment 1: Spanish

In Experiment 1, we test whether subject-verb dependency is maintained in Spanish, a morphologically rich language.

### 2.3.1. Methodology

#### 2.3.1.1. Participants

Fifty six participants (26 male, 30 female) took part in the experiment. They were all native Spanish native speakers aged 18 to 41, with the average age of 28.64 (SD=6.96). Eight participants were monolingual, while the rest of them were either Spanish dominant (39) or balanced (9) Spanish-Basque bilinguals. The experiment was approved by the BCBL Ethics Review Board and complied with the guidelines of the Helsinki Declaration.

#### 2.3.1.2. Stimuli

The stimuli consisted of 112 Spanish sentences, created by a native Spanish speaker (see Table 2.1). The experimental sentences were created by embedding an adverbial (temporal or conditional) clause after the subject NP of the main clause. The main subject NP (matrix NP) consisted of a determiner and a noun only (*esa chica*, “that girl”). The embedded clause consisted of a conjunction (*cuando*, “when”, *cada vez que*, “every time”, or *si*, “if”) followed by an embedded subject NP (*un chico*, “a boy”), an embedded VP (*viene*, “comes”) and an adverbial. In order to further investigate the morphological effects related to subject-verb dependency, which will be presented in the next chapter, we also manipulated word order within the embedded clause, as well as matching in number between the subject-verb agreement of matrix and embedded clause. The Matching status was manipulated in the following way: in the match condition, the embedded subject and verb had the same number as the matrix one, while in the mismatch condition, the number of the

two mismatched. In this experiment, the number of embedded clause subject-verb agreement was thus not manipulated and was constant across the conditions (see Table 2.1, underlined), but it was balanced across the items (56 singular and 56 plural). To create the control items, the word *para* (“for”) was added prior to the matrix subject, thus making it a non-argumental NP. Consequently, the rest of the main clause (after the embedded clause) was different in the control items. The additional 4 conditions with VS word order were created by permuting the order of the embedded noun and verb, as illustrated in Table 2.1. The full set of stimuli is provided in Appendix A1.

Word Order	Manipulation	Matching	sentence
SV	exp	Match	Esa chica, <b>cada vez que <u>un chico viene</u> a casa</b> , se pone nerviosa. “That girl, every time a boy comes to the house, gets nervous.”
		Mismatch	Esas chicas, <b>cada vez que <u>un chico viene</u> a casa</b> , se pone nerviosa. “Those girls, every time a boy comes to the house, get nervous.”
	control	Match	Para esa chica, <b>cada vez que <u>un chico viene</u> a casa</b> , todo lo demás es aburrido. “To that girl, every time a boy comes to the house, everything else is boring.”
		Mismatch	Para esas chicas, <b>cada vez que <u>un chico viene</u> a casa</b> , todo lo demás es aburrido. “To those girls, every time a boy comes to the house, everything else is boring.”
VS	exp	Match	Esa chica, <b>cada vez que <u>viene un chico</u> a casa</b> , se pone nerviosa. “That girl, every time a boy comes to the house, gets nervous.”
		Mismatch	Esas chicas, <b>cada vez que <u>viene un chico</u> a casa</b> , se ponen nerviosas. “Those girls, every time a boy comes to the house, get nervous.”
	control	Match	Para esa chica, <b>cada vez que <u>viene un chico</u> a casa</b> , todo lo demás es aburrido. “To that girl, every time a boy comes to the house, everything else is boring.”
		Mismatch	Para esas chicas, <b>cada vez que <u>viene un chico</u> a casa</b> , todo lo demás es aburrido. “To those girls, every time a boy comes to the house, everything else is boring.”

Table 2.1. An example of an experimental item with singular embedded NP in Experiment 1. The embedded clause is in bold, with the embedded noun and verb underlined

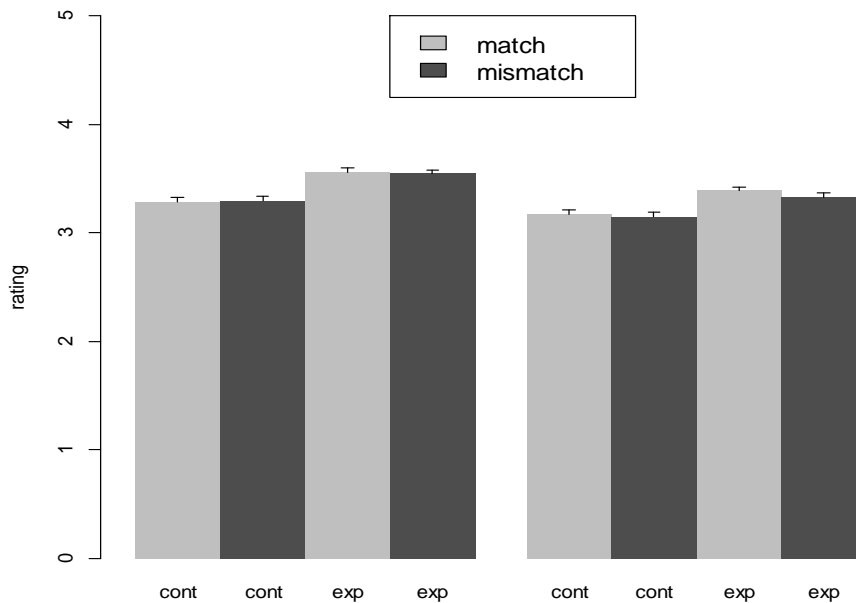
The stimuli were created in such a way that each of the 112 nouns at the matrix NP position was different, and each of the 112 nouns in embedded NP position was different. Also, the nouns at the matrix NP positions were used as the nouns in the embedded NP position, in order to make sure that the nouns in the experiment are of comparable frequencies (this was achieved for 98 nouns, while the remaining 14 sentences contained non-repeated nouns of comparable frequencies). However, the same noun never occurred at both positions within the same item. The gender in both NPs was balanced across the items. The stimuli were Latin squared into 8 lists, and 80 filler items were added to each list. As sentences including center-embedded clauses are rather complex, the stimuli were rated for naturalness.

### *Naturalness judgment task*

In order to avoid possible confounding of the results coming from the unnaturalness of the stimuli sentences, we conducted a naturalness judgement task with 32 native Spanish speakers who did not take part in Experiment 1. Their task was to read the sentences and rate whether they sound natural, on a scale from 0 (=completely unnatural, unusual) to 5 (=completely natural, usual). They were instructed to answer spontaneously and naturally. The sentences were presented using PsychoPy software, version 1.83.04 (Peirce et al., 2019). At each trial, a sentence appeared in the middle of the screen. The participants were instructed to read it at their own pace and click when they are ready to rate it. Then, a screen with a 5-point scale appeared, and the participants were supposed to click on a number on the scale that corresponds to their judgment. The rating started with 6 practice trials during which the experimenter made sure that the participants understand the task.

The overall rating was 3.32 (SD=1.29), with experimental items rated with 3.45, (SE=0.02), and control items with 3.23 (SE=0.02). We fitted linear mixed effects models with the rating score as the dependent variable (effect coding was applied), and with the Manipulation (control, experimental), Matching (match, mismatch) and Word Order (SV, VS) as dependent variables. By-item and by-subject random intercepts were also included. This model was chosen to be in line with the analysis

performed in Experiment 1, and the model selection and the analysis procedure followed the one described in Experiment 1. The analysis showed a main effect of Manipulation, such that experimental condition was rated as more natural [Intercept: 3,32, Estimate: 0.10, SE: 0.01,  $t = 8.25$ ], and a main effect of Word Order, such that SV word order was rated as more natural [Intercept: 3,32, Estimate: -0.09, SE: 0.01,  $t = -7.49$ , see Figure 2.1]. No other effects were significant (all  $t$ s  $< 1.5$ ).



**Figure 2.1.** The scores for naturalness judgment task in Experiment 1.  
exp= experimental items; cont= control items

### 2.3.1.3. Procedure

We used an SR EyeLink 1000 eyetracker with the sampling rate of 1000 Hz to record the eye movements. To minimize head movements, the participants' head was located on the chinrest, 60 cm from a CRT monitor. Reading was binocular, but only the right eye was tracked. The experiment was presented using the Experiment Builder software, version 2.1.45 (SR Research, Ontario, Canada), while the initial stages of data preprocessing were carried out using Data Viewer software, version 2.3.1 (SR Research, Ontario, Canada). The session consisted of a practice block (5 items), followed

by the two experimental blocks (100 items each). The sentences were presented in 19-point Times New Roman font on a black background in one or two lines, depending on the sentence length. There was a 2.5 lines space between the two lines. We performed 9-point calibration before the experiment, between the two blocks, and additionally in the case fixation stability was lost. Before each trial, participants had to fixate a red point, positioned on the left side of the screen, where the first word of each item appeared.

Participants were tested individually. They were asked to read the sentences for comprehension and answer the yes/no comprehension questions that appeared after 50% of the sentences (e.g. for the example in Table 1, the question would be *Is it a boy that was coming to the house in the sentence?*), by pressing keys on the keyboard. They were asked to reduce blinking and body movements as much as possible during the presentation of the items. The experiment lasted approximately 45 minutes.

#### 2.3.1.4. Data trimming and analysis

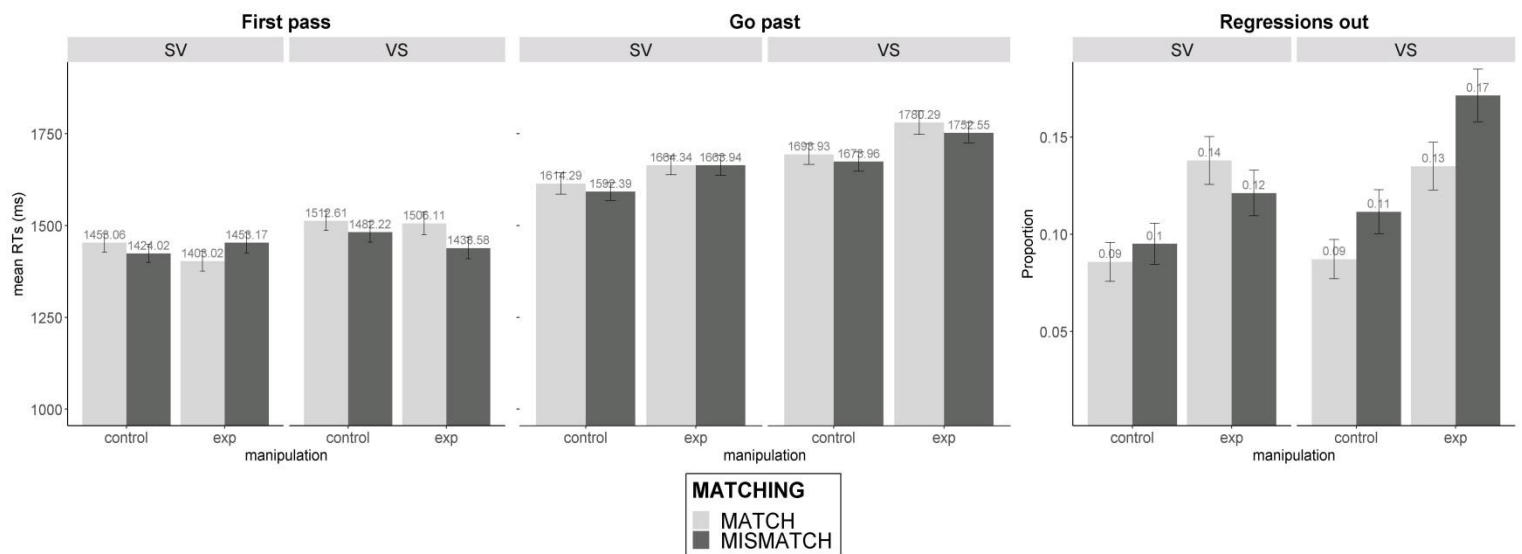
Prior to the analysis, short fixations ( $\leq 80$  ms) were merged with a preceding/following fixation if it was within one character (0.37 degrees); otherwise, the short fixations were removed. The interest area to be analyzed comprised the entire embedded clause (e.g. *Esa chica,[cada vez que viene un chico,] se pone nerviosa*). We calculated first pass and go-past reading times, as well as the regressions out of the interest area to the previous part of the sentence (i.e. the matrix NP). These measures were chosen as they are believed to reflect early stages of processing (see Chapter 1, Section 1.5.1), which is when maintenance effects are expected to be visible. Late measures, such as total reading times, reflect processing that might be affected by the subsequent regions and thus more easily ascribed to integration processes, and they will thus not be analyzed in the current dissertation. The analyses were performed for each separate measure. All the analyses were done using the package *lme4* (Bates, Machler, Bolker, & Walker, 2015) in R Statistical software (R Core Team, 2017). We fitted linear mixed-effect models (for reading times) or generalized linear mixed-effect

models (for proportion of regressions), with Manipulation (control, experimental), Matching (match, mismatch) and Word Order (SV, VS) as fixed effects. We tested a series of models for exclusion of random by-item and by-subject slopes (by-item and by-subject random intercepts were left by default, except when resulting in a non-converging model, in which case by-subject intercept was kept), using a backward-direction model selection method and the “best-path” algorithm (Barr, Levy, Scheepers, & Tily, 2013). The slopes were included if falling below the model-selection  $\alpha$  level, which was .05 in this study. When encountering non-convergence problems, the random effects structure was progressively simplified (by removing random slopes – by-item and by-participant) until reaching convergence. The dependent variables were: first pass reading times, go-past reading times and the proportion of the regressions from the interest area to the earlier interest area. Effect coding was used for all the independent variables. We report the intercept, the estimate, standard error, and the  $t/z$  value in tables. An effect was considered significant when the  $t/z = 2$ .

### **2.3.2. Results**

The mean accuracy on comprehension questions in Experiment 1 was 91.68% (SD=5.3). All participants scored between 68.75% and 96.87%.

For the first pass reading time, we found a significant effect of Word Order, driven by longer first pass reading times for the VS word order, and a marginal Matching x Word Order interaction, as matching conditions elicited longer reading times in VS word order. Also, there was a marginal Manipulation x Matching x Word Order interaction, as matching conditions elicited longer reading times in VS word order in the experimental items (see Figure 2.2 and Table 2.2).



**Figure 2.2. First pass reading times, go-past reading times and regressions out of the embedded clause in Experiment 1. The numbers on the top of the bars represent the mean values for that level of the factor. SV= SV word order, VS= VS word order; exp=experimental conditions, control= control conditions**

Regarding the go-past reading times, longer go-past reading times for the VS word order generated a significant effect of Word Order, while the increase in the go-past reading items for the experimental items generated a significant main effect of Manipulation (see Figure 2.2 and Table 2.2).

The analysis for the regressions out of the embedded clause to the previous interest areas showed a marginal effect of Word Order, as more regressions occurred in VS word order, a significant effect of Manipulation, as more regressions were made in experimental items, as well as a marginal effect of Matching, as more regressions emerged in the mismatch condition. Finally, we found a strong marginal Word Order x Matching interaction, as more regressions were made in the VS word order for the mismatch items (see Figure 2.2, Table 2.2).

Additionally, as the direction of the effect in first pass reading times was opposite to what we hypothesized and opposite to the other measures, we further investigated it by looking at whether the effects change over the course of the experiment. Therefore, we introduced Trial number as a variable. The model including Manipulation x Matching x Word Order x Trial Number as fixed



effects, as well as by-item and by-subject random intercepts, significantly improved the fit. We found a significant Manipulation x Matching x Trial Number x Word Order interaction, such that first pass reading times increased over the course of experiment for experimental condition, and this was more prominent in SV word order, and for the matching condition [Intercept: 1471.28, Estimate: 0.60, SE: 0.25,  $t = 2.46$ ]. This implies that the difference between the control and the experimental condition changes over the course of the experiment in the direction that aligns with the results for the go-past reading times and regressions out.

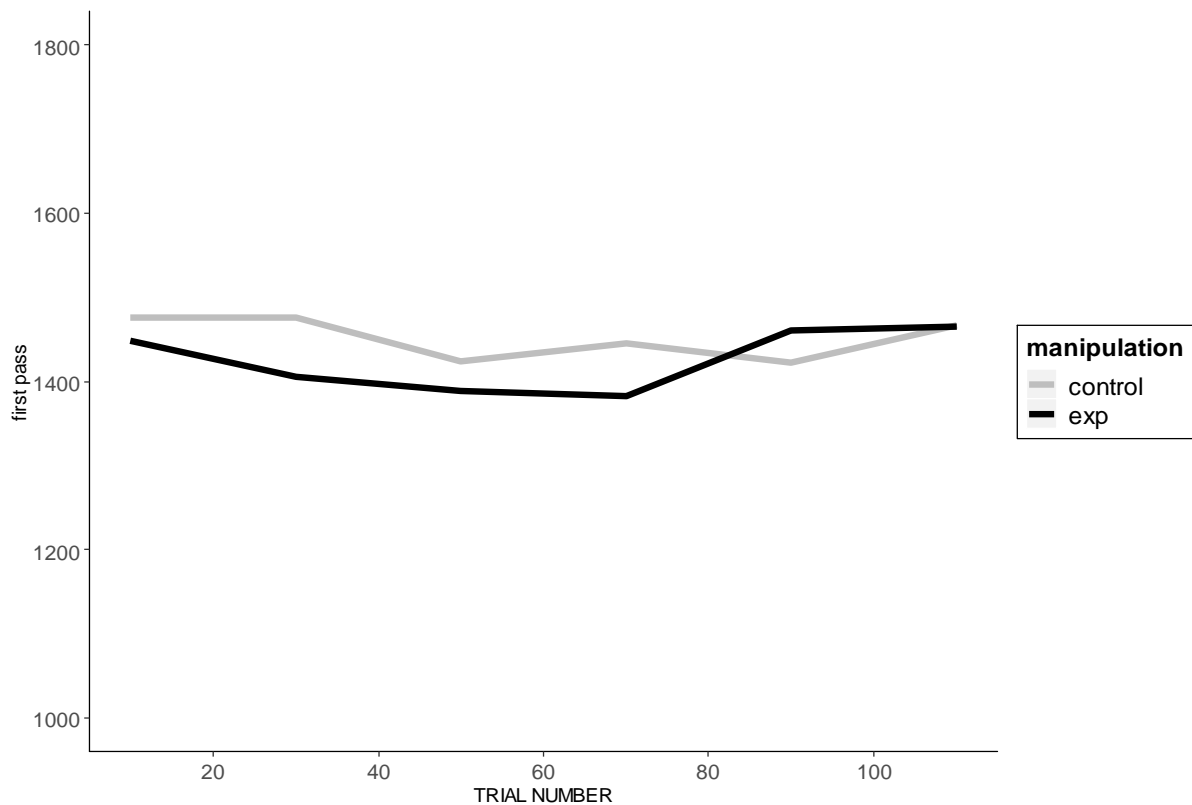


Figure 2.3. The change in first pass reading times over trials for experimental and control items.

### 2.3.3. Interim Discussion

The findings from the embedded clause analysis in Experiment 1 support our main hypothesis: the information related to the to-be-established subject-verb dependency is actively maintained over the interpolating elements, which generated increased processing cost on the embedded clause, seen in the main effect of Manipulation. Although this effect didn't show up on first pass reading times, an additional analysis confirmed that it started emerging as the experiment progressed. Nevertheless, both the go-past reading times and regressions out of the relative clause to the previous interest areas were significantly increased in the experimental condition (i.e. when the embedded clause interrupts subject-verb dependency) compared to the control condition (i.e. when the same clause doesn't interrupt the subject-verb dependency). This suggests that in this experiment, the effect was driven by regressive eye movements, rather than first pass reading of the embedded clause. Moreover, the effect of Manipulation cannot be ascribed to the complexity or the unnaturalness of the experimental items, as the naturalness judgments suggests the opposite direction of the effect.

The main effect of Word Order was stable across the measures, and goes in line with our naturalness judgment task, where VS word order was rated as less natural. The longer reading times and the increase in regressions reflect the difficulty to process and integrate the elements in the dispreferred word order.

Moreover, in first pass reading times, the effect of Word Order and Manipulation interacted with the effect of Matching, as the reading times increased in VS word order on the experimental items when the number of the matrix subject and the embedded clause subject matched. For the regressions out, however, the pattern was different: the Word Order x Matching interaction was driven by the increase in the mismatch (and not match) condition in the VS word order. Thus, matching or mismatching between the matrix and embedded subject-verb dependency in number might modulate the maintenance effect, and this might be manifested differently in different measures. This will be further investigated in Chapter 3.

**Embedded clause – first pass reading times**

**model: firstpass ~ manipulation \* matching \* WO + (1 | participant) + (1 | item)**

	estimate	se	t.value	conf.low	conf.high
(Intercept)	1458.58	60.23	24.22	1340.53	1576.63
manipulation1	-8.37	7.795	-1.07	-23.65	6.91
matching1	-9.03	7.79	-1.16	-24.31	6.24
WO1	25.90	7.79	<b>3.32</b>	10.63	41.18
manipulation1:matching1	5.88	7.79	0.75	-9.39	21.16
manipulation1:WO1	-3.13	7.79	-0.40	-18.40	12.15
matching1:WO1	-14.56	7.79	<u>-1.87</u>	-29.84	0.72
manipulation1:matching1:WO1	-14.33	7.79	<u>-1.84</u>	-29.60	0.95

**Embedded clause – go-past reading times**

**model: gopast ~ manipulation \* matching \* WO + (1| participant) + (1| item)**

	estimate	se	t.value	conf.low	conf.high
(Intercept)	1679.29	71.74	23.41	1538.67	1819.90
manipulation1	36.19	6.86	<b>5.28</b>	22.75	49.63
matching1	-8.04	6.86	-1.17	-21.49	5.40
WO1	45.95	6.86	<b>6.70</b>	32.50	59.39
manipulation1:matching1	2.28	6.86	0.33	-11.16	15.72
manipulation1:WO1	6.13	6.86	0.89	-7.31	19.58
matching1:WO1	-2.71	6.86	-0.40	-16.16	10.73
manipulation1:matching1:WO1	-3.60	6.86	-0.52	-17.04	9.84

**Embedded clause – regressions out**

**model: regout ~ manipulation\* matching \* WO + (1+manipulation|participant) + (1|item)**

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.36	0.13	-18.02	0.00	-2.61	-2.10
manipulation1	0.23	0.05	<b>4.49</b>	0.00	0.13	0.34
WO1	0.08	0.04	<u>1.95</u>	0.05	-0.00	0.165
matching1	0.07	0.04	<u>1.77</u>	0.08	-0.01	0.15
manipulation1:WO1	0.03	0.04	0.67	0.50	-0.05	0.11
manipulation1:matching1	-0.03	0.04	-0.80	0.42	-0.11	0.05
WO1:matching1	0.08	0.04	<u>1.97</u>	0.05	0.00	0.16
manipulation1:WO1:matching1	0.04	0.04	0.94	0.34	-0.04	0.12

Table 2.2. Analyses for the embedded clause in Experiment 1. Coding; for the Manipulation factor, -1=control, 1=experimental; for the Matching factor, -1=match, 1=mismatch; for the Word Order factor, -1=SV word order, 1= VS word order. Significant effects are in bold, and marginal effects are underlined.

## 2.4. Experiment 2: English

After establishing that the subject-verb dependency is actively maintained in Spanish, we proceed to ask the same question in English.

### 2.4.1. Methodology

#### 2.4.1.1. Participants

Fifty six participants (10 male, 46 female) aged 18 to 23 (mean age = 19.69, SD = 1.02) took part in the experiment for a course credit. They were all native English speakers who acquired English from birth, with 41 of them being monolingual, and 15 acquiring other languages from an early age as well<sup>1</sup>. Experiment 2 was approved by the UMass Institutional Review Board.

#### 2.4.1.2. Stimuli

The stimuli consisted of 80 English sentences (see Table 2.3), similar to those in Experiment 1. However, word order in the embedded clause wasn't manipulated in Experiment 2, given that English doesn't allow for VS word order in this configuration. Instead, both the number of the matrix subject NP (singular/plural) and the number of the embedded NP (singular/plural) were manipulated. This allowed us to reveal potential differences in singular and plural subject-verb dependency maintenance. Like in Experiment 1, experimental sentences were created by embedding an adverbial (temporal or conditional) clause after the subject NP of a main clause (matrix NP). The matrix NP consisted of a determiner and a noun (*that student/ those students*). The embedded clause consisted of a conjunction (*when, whenever, every time, as soon as, if*), followed by an embedded NP (*a professor/*

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<sup>1</sup> The languages include: Korean, Cantonese, Bengali, Portuguese, Spanish, Hindi, Vietnamese, Tamil, German, Arabic and Cape Verdean Creole.

*professors*), an embedded VP (*finishes/ finish*) and an adverbial. As in Experiment 1, we manipulated matching in number between the matrix and the embedded clause. The Matching status was manipulated in the following way: in the match condition, the embedded NP/VP had the same number as the matrix NP/VP, while in the mismatch condition, the number of the embedded NP/VP was different from the number of the matrix NP/VP.

The control items were slightly different from those in Experiment 1, as all the obligatory matrix clause elements were placed before the embedded clause. To create them, a subject and a verb were added prior to the matrix NP. An additional clause was thus created before the embedded clause,

Manipulation	Embedded subject number	Matching	sentence
exp	Sg	Match	That student, <b>as soon as <u>a professor finishes</u> the class</b> , leaves the classroom.
		Mismatch	Those students, <b>as soon as <u>a professor finishes</u> the class</b> , leave the classroom.
	Pl	Match	Those students, <b>as soon as <u>professors finish</u> the class</b> , leave the classroom.
		Mismatch	That student, <b>as soon as <u>professors finish</u> the class</b> , leaves the classroom.
control	Sg	Match	I watched that student, <b>and as soon as <u>a professor finishes</u> the class</b> , she leaves the classroom.
		Mismatch	I watched those students, <b>and as soon as <u>a professor finishes</u> the class</b> , they leave the classroom.
	Pl	Match	I watched those students, <b>and as soon as <u>professors finish</u> the class</b> , they leave the classroom.
		Mismatch	I watched that student, <b>and as soon as <u>professors finish</u> the class</b> , she leaves the classroom.

Table 2.3. An example of an experimental item in Experiment 2. The embedded clause is in bold, with the embedded noun and verb underlined

in which the matrix NP was transformed into a direct object or a part of a PP. The rest of the sentence (after the embedded clause) was the same as in experimental items, except for an additional pronoun (*she*; see Table 2.3). Also, the conjunction *and* was added at the beginning of the embedded clause in the control items. The complete list of stimuli is provided in Appendix A2.

Like in Experiment 1, the stimuli were created in such a way that all the 80 nouns at the matrix NP position were different, as well as the 80 nouns that occurred at the embedded NP positions. When it comes to embedded VPs, no verb was repeated across 80 items. The sentences were created and checked by 3 native English speakers. We used Latin square design to divide the stimuli into 8 lists, to which 80 filler items were added.

#### 2.4.1.3. Procedure

We used SR EyeLink 1000 eyetracker (SR Research, Ontario, Canada) with the 1000 Hz sampling rate to record the eye movements. To minimize movements, the participants' head was located on the chinrest, 60 cm from a CRT monitor. Reading was binocular, but only the right eye was tracked. The session consisted of a practice block (8 items), followed by an experimental block. The sentences were presented in 11-point Monaco font on a white background in one line. We performed 3-point calibration before the experiment, and additionally if the fixation stability was lost. The participants triggered each sentence by fixating a box at the left edge of the monitor. The experiment was carried out using the EyeTrack software, and initial stages of data analysis were performed with Robodoc and EyeDry (<http://blogs.umass.edu/eyelab/software/>).

Participants were tested individually. They were asked to read for comprehension and answer yes/no comprehension questions that appeared after 50% of the sentences, by pressing buttons on a console. The questions were similar to those in Experiment 1. The participants were asked to reduce blinking and body movements as much as possible during the presentation of the items. The experiment lasted approximately 40 minutes.

#### 2.4.1.4. Data trimming and analysis

As in Experiment 1, the short fixations ( $\leq 80$  ms) were merged with the preceding/following fixation that was within one character of the short fixation (0.37 degrees); otherwise, the short fixations were removed. The interest area to be analyzed comprised the entire embedded clause (e.g. *Those students,[ as soon as professors finish the class,] leave the classroom.*). We calculated first pass and go-past reading times, as well as the regressions out of the interest area to the previous part of the sentence (i.e. the matrix NP). The analyses were performed for each separate measure.

All the analyses were done using the package lme4 (Bates, Mächler, Bolker, & Walker, 2015) in R Statistical software (Team, R. C. 2014, version 3.4.1). We fitted linear mixed-effect models (for reading times) or generalized linear mixed-effect models (for proportion of regressions), with Manipulation (control, experimental), Matching (match, mismatch) and Embedded NP Number (singular, plural) as fixed effect. The model selection procedure followed the one in Experiment 1. The dependent variables were: first pass reading times, go-past reading times and the proportion of the regressions from the interest area to the earlier interest area. Effect coding was used for all the independent variables. We report the intercept, the estimate, standard error, and the t/z values in tables.

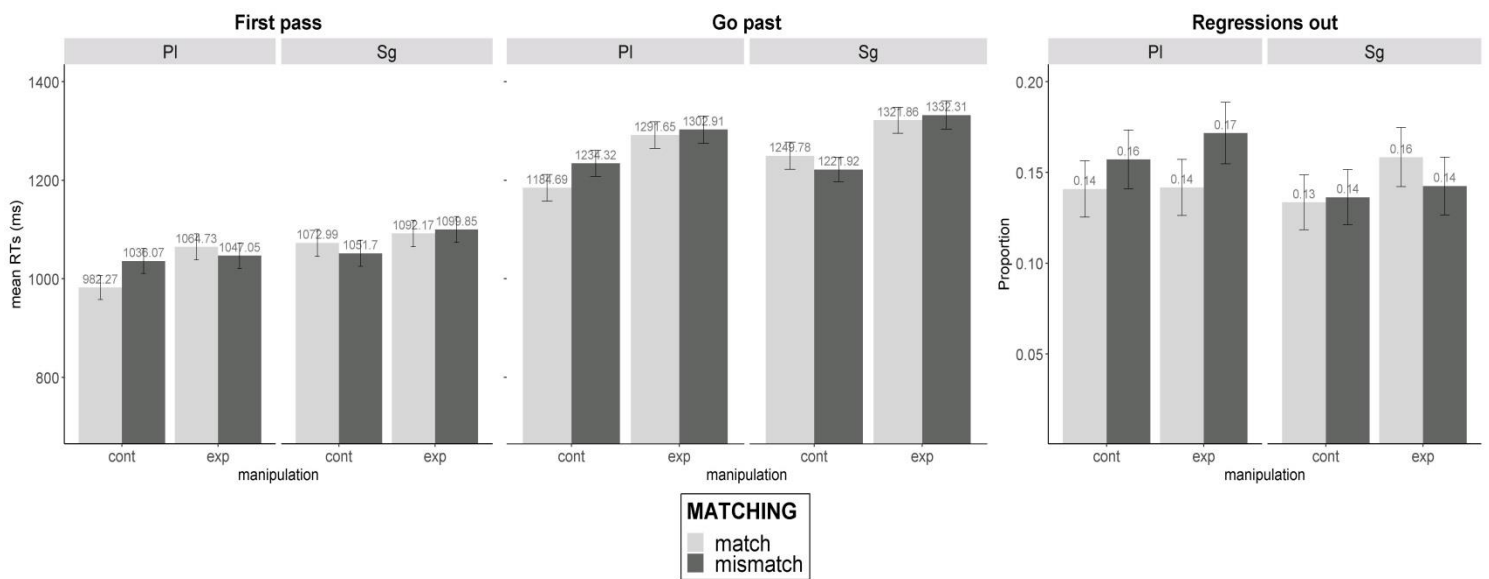
### 2.4.2. Results

The mean accuracy on comprehension questions in Experiment 2 was 90.80% (SD=6.5). All participants scored between 70% and 100%.

In the first pass reading times, we found a marginal effect of Manipulation, as first pass reading times increased in the experimental condition. Also, the effect of Embedded NP Number was significant, as the singular embedded clauses elicited longer first pass reading times than the plural ones (see Figure 2.4 and Table 2.4).

In the go-past reading time analysis, we observed the same effects, and in the same directions as those in the first pass reading time analysis. However, the effect of Manipulation was significant, while the effect of Embedded NP Number was marginal (see Figure 2.4 and Table 2.4).

When it comes to regressions out, no significant effects emerged (all  $z$ s < 1.00, see Figure 2.4 and Table 2.4).



**Figure 2.4.** First pass reading times, go-past reading times and regressions out of the embedded clause in Experiment 2. The numbers on the top of the bars represent the mean values for that level of the factor. PI= plural embedded NP, Sg= singular embedded NP



**Embedded clause – first pass reading times**

model: firstpass~manipulation\*embedded\*matching+(1+manipulation|participant)+(1+manipulation|item)

	estimate	se	t.value	conf.low	conf.high
(Intercept)	1063.56	42.90	24.79	979.48	1147.64
manipulation1	21.42	12.26	<u>1.75</u>	-2.61	45.44
embedded1	22.05	7.58	<b>2.91</b>	7.19	36.90
matching1	3.10	7.59	0.41	-11.77	17.97
manipulation1:embedded1	-3.08	7.59	-0.41	-17.95	11.79
manipulation1:matching1	-5.71	7.59	-0.75	-20.59	9.16
embedded1:matching1	-5.44	7.59	-0.72	-20.31	9.43
manipulation1:embedded1:matching1	12.77	7.59	1.68	-2.11	27.66

**Embedded clause – go-past reading times**

model: gopast ~ manipulation\*embedded\*matching + (1|participant) + (1|item)

	estimate	se	t.value	conf.low	conf.high
(Intercept)	1276.37	54.84	23.27	1168.89	1383.86
manipulation1	46.03	6.91	<b>6.66</b>	32.49	59.57
embedded1	12.58	6.90	<u>1.82</u>	-0.93	26.10
matching1	5.82	6.90	0.84	-7.70	19.34
manipulation1:embedded1	0.24	6.90	0.03	-13.29	13.76
manipulation1:matching1	0.04	6.90	0.01	-13.48	13.57
embedded1:matching1	-10.27	6.90	-1.49	-23.79	3.25
manipulation1:embedded1:matching1	9.41	6.91	1.36	-4.13	22.95

**Embedded clause – regressions out**

model: regout ~ manipulation\*embedded\*matching + (1 |participant) + (1|item)

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-1.93	0.11	-17.55	0.00	-2.15	-1.72
manipulation1	0.05	0.05	1.00	0.32	-0.04	0.13
embedded1	-0.04	0.05	-0.93	0.35	-0.13	0.05
matching1	0.03	0.05	0.77	0.44	-0.05	0.12
manipulation1:embedded1	0.02	0.05	0.34	0.73	-0.07	0.10
manipulation1:matching1	0.00	0.05	-0.05	0.96	-0.09	0.09
embedded1:matching1	-0.06	0.05	-1.32	0.19	-0.15	0.03
manipulation1:embedded1:matching1	-0.03	0.05	-0.71	0.48	-0.12	0.06

Table 2.4. Analyses for the embedded clause in Experiment 2. Coding: for the Manipulation factor, -1=control, 1= experimental; for the Matching factor, -1=control, 1=experimental; for the Embedded NP Number factor, -1=plural, 1=singular. Significant effects are in bold, and marginal effects are underlined.

### 2.4.3. Interim Discussion

The analyses of the embedded clause region in Experiment 2 showed similar effects as those in Experiment 1: we found a significant effect of Manipulation, such that the reading times increased when this clause was interpolated between a matrix subject and a matrix verb (experimental condition). This effect was marginally significant already in the first pass reading times in Experiment 2, as well as in the go-past reading times. However, although numerically present, it was not significant on the regressions out of the embedded clause to the previous areas. This is in opposition to the results in Experiment 1, where the effect did not emerge on the first pass reading times, but it did on the go-past reading times and regressions out. This difference might simply be explained by the difference in the reading behaviors in the two samples. It is possible that Experiment 1 sample responded to the effect by increasing regressive eye movements and Experiment 2 sample by increasing fixation durations. This latency-regression tradeoff is quite common for reading experiments and is rather natural to people's reading behavior (i.e. while some participants read slowly, with few regressions, the others read fast and regress more).

Furthermore, we also found that the clauses containing singular embedded subject-verb agreement were harder to process, eliciting longer first pass and go-past reading times. This suggests that singular and plural-marked NPs might interact differently with the maintained content, causing different processing difficulties. Thus, in line with Experiment 1, we will further analyze this issue in Chapter 3.

## **2.5. General Discussion**

In the current chapter, we explored whether the parser keeps the information that is relevant for subject-verb dependency active over the sentential elements. We set out to explore whether the successful long-distance subject-verb dependency is established by means of its active maintenance over the course of the sentence, resulting in increased processing cost. Both the English and the Spanish experiment showed that there is an increase in the processing cost on the elements interpolated between the matrix subject and the matrix verb. Like Chen et al. (2005), we measured reading times on embedded (non-relative) clauses that are identical across conditions. In line with their findings (and contra Hakes et al., 1976), we show that there's an increase in processing cost over the interpolated elements, suggesting that active maintenance takes place.

Our results go against the sentence comprehension models that claim that the matrix verb is predicted, but there is no processing cost to it (SPLT/DLT, Gibson, 1998, 2000), or those that claim that the information necessary to establish subject-verb dependency, such as the prediction of the verb's representation, is not active before the retrieval at the verb (cue-based retrieval accounts, e.g. Lewis & Vasishth, 2005). We believe that these models should be enriched to accommodate for the findings that support active maintenance in subject-dependency establishment. However, the cue-based retrieval models are very strict in their claims related to the limitations of working memory, stating that the number of the elements that are active is extremely limited. Therefore, it might seem improbable for the parser to keep the full noun and/or verb representation active, while processing other intervening elements.

While we will address this issue in more depth in Chapter 5, it is worth mentioning that one possibility might be that only the relevant features of the long-distance dependency are kept active. Indeed, the interaction with the effect of Matching found in Experiment 1 and the difference between singular and plural embedded number in Experiment 2 suggest that the number feature might be one of those relevant features. In Chapter 3, we move on to the second question of the current dissertation by examining the possible features that might form part of the maintained representation.



### **III. The nature of the maintained representation: Similarity-based interference**

*“The recollection is always slightly different from what escaped your memory. And in that difference lies the message.”*

Milorad Pavić, *The Writing Box*

In Chapter 2, we presented the evidence that the parser actively maintains the information necessary for the establishment of a long-distance subject-verb dependency, which causes increased processing cost over the interpolated elements. In the current and the following chapter, we will explore this in more detail, by looking at what the maintained representation includes, i.e. what features it is marked for.

As elaborated in Section 1.1 of Chapter 1, sentence processing literature has often used the terms *maintenance*, *expectation* and *anticipation* to talk about prediction. This is not without reason. When it comes to syntax, prediction has its clear *predictor* element and *predictee* element, between which it is maintained. However, this seemingly terminological issue has also affected how the content of the maintained representation has been described. For example, Chen et al. (2005) claim that it is the prediction of the syntactic head, i.e. the matrix verb, that creates the processing cost in subject-verb dependency establishment (see Chapter 1, Section 1.4). Thus, they suggest that the cost arises due to maintaining the prediction or the expectation of the *predictee*.

Conversely, the abundant research on filler-gaps suggests that the maintained representation in this long-distance dependency establishment corresponds to the element that opens it (the *predictor*, in this case the filler), rather than the one that closes it (the *predictee*, in this case the gap). Although Phillips, Kazanina, & Abada (2005) claim that filler-gap dependencies involve displacement of an element (filler) from its canonical position, while the subject-verb dependency doesn't, generativist approaches to syntax do postulate that the subject moves out of its canonical position (which is hierarchically closer to the verb) in the early stages of sentence derivation. Thus, both dependencies could be said to involve establishing a relationship between an element that opens a dependency, and that element's canonical site. This leads to the possibility that the element that opens the dependency (the *predictor*, i.e. the subject), is also maintained in the subject-verb dependency, rather than the one that closes it (the *predictee*, i.e. the verb). The third possibility is that both the verb and the subject representation (or parts of it) are maintained. Somewhat similarly to the last option,

cue-based retrieval accounts postulate that both the representation of the predicted verb and the representation of the matrix subject are encoded when the matrix subject noun is encountered (Lewis et al., 2006, see Figure 1.2 in Chapter 1) – although they are not assumed to be actively maintained throughout the sentence, but retrieved later at the verb.

Indeed, many possible causes for the processing cost in a subject-verb dependency have been proposed, such as maintaining an incomplete dependency, maintaining an open phrase structure rule, maintaining an incomplete clause, etc. (Chen et al., 2005; Gibson, 1991, 2000). A good direction in resolving this issue might be focusing on the concrete features of the maintained representation. Research on the filler-gap dependency has already shown that the content of the filler is maintained, and that this representation includes word category (Wagers & Phillips, 2014), as well as semantic details (Chow & Zhou, 2019; Ness & Meltzer-Asscher, 2019).

In the current chapter, we focus on the potential morphosyntactic content of the maintained representation in a subject-verb dependency by looking at whether some of the morphosyntactic features are maintained, thereby causing the processing cost found in Chapter 2. This way, we test whether covarying the subject's and verb's features in subject-verb dependency establishment takes place in real-time sentence processing, through their active maintenance. By focusing on the possible maintenance of the morphosyntactic features, we are moving from investigating the maintenance of the *subject-verb dependency* to investigating the maintenance of *subject-verb agreement* (see Chapter 1, Section 1.2.2) and, consequently, the “psychological reality” of agreement operations.

As explained in Box 1.2 (Chapter 1), a way to test if a representation is actively maintained is to see whether it interacts with the other elements that are being processed. We thus look at whether the maintained representation interacts with the specific features of the elements over which it is maintained, which is in turn informative about potentially active status of those features within the maintained representation.

To our knowledge, there are no studies that test how morphosyntactic features of an actively maintained representation affect subject-verb agreement. Nevertheless, psycholinguistic research has

provided a lot of evidence on how other sentential elements' features affect it. Most notably, the processing of a subject-verb dependency has been shown to be susceptible to the *similarity-based interference*, a memory-related effect found in sentence comprehension. Therefore, we also make use of this well established effect and test morphosyntactic feature maintenance through the similarity-based effects that it triggers.

### 3.1. Sentence comprehension and similarity-based interference

Long-distance dependencies have repeatedly been found to be prone to similarity-based interference, which occurs when two elements in the sentence share some features. In a subject-verb dependency, similarity-based interference has been shown to affect processing of verbs in the presence of an intervening distractor noun that shares the number feature the subject. This has been shown to cause misretrievals, giving rise to the effect referred to as *number attraction* (e.g. Wagers, Lau, & Phillips, 2009; see Eberhard, Cutting, & Bock, 2005; Franck et al., 2006; Staub, 2009 for other, non-retrieval accounts of attraction phenomena). Indeed, almost all of the studies investigating similarity-based interference in subject-verb comprehension have focused on number attraction effects, testing how a distractor's number facilitates processing disruption at the verb that mismatches in number with the subject, but matches with the distractor (i.e. how it reduces ungrammaticality effect). Thus, in (6), taken from Wagers et al. (2009), reading the verb *praise* in the ungrammatical sentence in b) causes less processing cost than reading the same verb in the ungrammatical sentence in a), due to the presence of the number-matching distractor *the musicians*. The explanation for this is that, upon encountering the verb *praise*, retrieval mechanisms are launched using the features of the verb. If a noun matching those features (*the musicians*) is encountered, the processing disruption is reduced.

6. a) \**The musician who the reviewer praise so highly will probably win a Grammy.*

b) \**The musicians who the reviewer praise so highly will probably win a Grammy.*



Importantly, as highlighted by Jäger, Benz, Roeser, Dillon, & Vasishth (2015), there can be two sources of similarity-based interference: besides *cue-based retrieval interference*, which occurs at the retrieval of an item (and which the attraction studies focus on), a subject-verb dependency could also be prone to *encoding interference*. This type of interference occurs between the features of the similar items while they are encoded or maintained in memory (Jäger et al., 2015; Nairne et al., 1990; Oberauer & Kliegl, 2006). Thus, while retrieval interference can inform us about the retrieval cues at the verb, encoding interference can be used to study the information that is being maintained during subject-verb dependency establishment. Any encoding interference effects should be therefore taken as a proof for maintenance of the features involved in it<sup>2</sup>.

In the current chapter, we aim to find evidence for encoding interference with number and word category information. But, as both maintenance and retrieval related effects are informative about subject-verb agreement computation, and as the latter have been the focus of a wide number of studies, we provide the analyses for both the region where encoding interference is expected to occur and where maintenance is measured, as well as the region where the retrieval interference is expected to occur. Below we outline the existing evidence for both retrieval and encoding interference for the relevant contrasts.

### 3.1.1. Retrieval interference

In their comprehensive review and meta-analysis of the published studies on retrieval interference in comprehension, Jäger et al. (2017) demonstrate that the existing evidence on interference effects in subject-verb dependencies in grammatical sentences (their *target match* condition) shows different directions depending on the cue (or feature) in which the subject and the distractor match. Reviewing the effects on the critical verb (i.e. the verb where the retrieval of the

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<sup>2</sup> Ness & Meltzer-Asscher (2019) also propose that their effects found on an NP interrupting a filler-gap dependency are caused by encoding interference, and that they reflect maintenance processes.

manipulated noun is expected to take place), as well as the spillover region, the authors demonstrate that the matching in number feature either causes no effects on the verb, or it causes a facilitation effect (with the exception of Franck, Colonna, & Rizzi, 2015 and Villata, Tabor, & Franck, 2018)<sup>3</sup>. Moreover, it is important to note that the majority of the published studies were focused on singular verbs (e.g. *The musician/musicians that the reviewer/\*reviewers was highly praising...*, Lago, Shalom, Sigman, Lau, & Phillips, 2015), while the several studies that also provide results for the plural verbs show mixed results.

When it comes to other cues used in subject-verb dependencies, such as semantic cues (e.g. animacy) or syntactic cues (e.g. subjecthood), the published results (albeit exclusively on singular verbs) mostly show inhibitory effects for the matching conditions, with several experiments showing no significant results. Additionally, a series of studies by Gordon and colleagues (Gordon, Hendrick, & Johnson, 2001, 2004; Gordon, Hendrick, Johnson, & Lee, 2006; Gordon, Hendrick, & Levine, 2002) shows that the matching in the NP type (either a definite NP, a proper noun, or a pronoun) also increases RTs. However, in these studies, the critical region involved both the embedded noun and the verb, and it is thus hard to directly compare it to the other experiments.

In sum, the results for the similarity-based interference in subject-verb agreement that can be ascribed to retrieval suggest that a match in number between the matrix subject and the distractor causes either no effects, or facilitation on the critical verb in the grammatical sentences (with some exceptions). In contrast, matching in other cues that are relevant for agreement, such as subjecthood or animacy, as well as those that are not relevant, such as the type of the NP, causes inhibition at the retrieval site.

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<sup>3</sup> We refer the reader to Table 2 and Table A1 in Jäger et.al (2017) for a detailed review. Note that the study by Villata et al. (2018) is not included in the review.

### 3.1.2. Encoding interference

While interference at retrieval in subject-verb agreement has received a lot of attention in both comprehension and production, very few studies have set out to investigate if interference occurs during the encoding stage of subject-verb dependency establishment, and therefore whether it is mediated by the maintenance mechanisms. There are two ways in which encoding interference can be studied separately from retrieval: either manipulating the cues not used at the verb for retrieval, or by measuring interference on the elements before the retrieval takes place (Van Dyke & McElree, 2006; Villata et al., 2018).

The former method has been employed by several studies that used paradigms where the match between the retrieval-irrelevant features of elements was manipulated and measured at the verb. As these features are believed not to be used for retrieval, the interference effects occurring at the verb are ascribed to encoding stages of processing. For example, Villata et al. (2018) manipulated matching of the subject and a distractor noun in cues that are either used for retrieval (number on present tense verb in English) or not (number on past tense verb in English and gender in Italian). They found a weak effect of subject-distractor gender match, giving rise to a slight increase in RTs, and a strong effect in accuracy, ascribing their results to encoding interference. Furthermore, Gordon et al. (2001) found that the disadvantage in the object relative clauses (compared to subject relative clause) was increased when the subject and the object were of the same type, compared to when they weren't (both were definite NPs, or one of them was a pronoun, e.g. *The barber that the lawyer/you admired climbed the mountain*). Whether a noun is a definite NP or a pronoun is not believed to be used as a retrieval cue at the verb, and therefore the authors conclude that the match inhibition effect can be ascribed to encoding. In a different paradigm, Gordon et al. (2002) presented the participants with memory load items, i.e. a list of three nouns (e.g. *Joel, Greg, Andy*) before reading cleft sentences. The memory load nouns either matched the nouns in the sentence (*It was Tony that liked Joey/Joey liked before the argument began*) or not (*It was the dancer that liked the fireman/the fireman liked before the argument began*). The authors found that the match between the memory

load items and the nouns in the sentences caused increased reading times on the nouns. However, both in Gordon et al. (2001) and Gordon et al. (2002), the analyzed region contained the relative clause subject and the verb merged together (see also Gordon et al., 2004, 2006). Commenting on Gordon et al. (2002) study, Van Dyke & McElree (2006) note that the definite proof for encoding interference would be to find the match inhibition as soon as a noun that shares the features with the maintained ones is encountered (at *the dancer*), which is before the retrieval takes place at the verb (see also Jäger et al., 2015; Villata et al., 2018).

Measuring interference on the first noun encountered after another noun has been encoded in the memory (but before the verb and thus before the retrieval) is the second way in which encoding interference can be measured. We refer to the first processed noun, and thus the noun maintained in the memory, as NP1, and as the second processed noun that (mis)matches its features as NP2. To our knowledge, there is no study that experimentally manipulated the NP2 region that is located prior to the retrieval site to study encoding interference.

Nevertheless, several studies provide analyses for the pre-retrieval regions, besides their critical region analyses. Table 3.1 provides an overview of the studies that have reported the analysis for the NP2 that matches NP1 in at least one feature, and that occurred before the retrieval triggered at the verbs (either relative clause or the main clause verb). The table shows the results based on the sentential structure within which the NP2 is located, type of the NP1 it matches, features that the two NPs match on, technique, as well as the direction of the effect (match inhibition or facilitation). We should point out that the results here are rather heterogeneous, as they come from experiments using different sentential configurations, tasks and techniques. Nevertheless, we can see that the effect on NP2 is always inhibitory, regardless of the feature (noun type, word category, number or gender). For example, Gordon et al. (2001) found that the match between NP1 and NP2 within a sentence can cause increased reading times on NP2 (object clefted sentences in their Experiment 4). Moreover, Gordon et al. (2002) report an increase in reading times on the clefted object NPs (*It was NP that...*) when their type matched that of the memory load nouns. Van Dyke & McElree (2006) found that the memory load nouns caused general increase on the clefted objects and the subjects of the relative

clauses, which are all pre-retrieval NPs. As the memory load items, as well as objects and subjects in Van Dyke & McElree (2006) were all nouns, this could be interpreted as an increase in reading times when NP2 matches the word category feature of the maintained NPs (which is also true for all of the abovementioned studies, besides the manipulated features). This is important for the experiments presented in the current chapter, as it implies that maintaining a noun and encountering another noun causes interference at encoding, increasing reading times.

When it comes to number feature, however, the existing results are rather weak. The few studies that provide analyses on the pre-verbal NP2s have dealt with number attraction in comprehension, and report either no effect on NP2 (Franck et al., 2015), or a weak effect just for plural nouns (Wagers et al., 2009, Experiment 3). Similarly, Villata et al. (2018) report a weak effect when the two NPs match in gender. Importantly, in both cases, the weak effect is inhibitory, with feature matching causing longer RTs on the NP2.

In sum, studies so far suggest that the cues/features such as word category and NP type cause inhibitory effects both on the retrieval-triggering verb (i.e. the inhibitory retrieval interference), as well as the pre-retrieval NP2 (i.e. the inhibitory encoding interference). When it comes to the number feature, however, the patterns of the interference effects on the pre-retrieval NP2 and the critical verb seem to be in opposition: while match in the number feature increases RTs on NP2 (i.e. causes inhibitory encoding interference), it seems to either cause no effects, or to facilitate the processing at retrieval, i.e. on the verb (except for Franck et al., 2015 and Villata et al., 2018). In the experiments presented here, we test the interference effects that the number and the category features of the maintained representation potentially trigger, on both the pre-retrieval NP (which is the area of our primary focus, as it is where maintenance can be measured), as well as the VP.

<i>study</i>	<i>technique</i>	<i>region and configuration</i>	<i>memory items that match</i>	<i>feature</i>	<i>effect type</i>
<b>Gordon et al. (2001), Exp 4</b>	SPR	subject in cleft sentences	clefted object & subject	description/ name	match inhibition
<b>Gordon et al. (2002)</b>	SPR	subject or object in cleft sentences	memory load items & subject and object	description/ name	match inhibition
<b>Van Duke &amp; McElree (2006)</b>	SPR	object in clefted sentences	memory load items & clefted object	word category match *	match inhibition
		subject in clefted sentences	memory load items & subject	word category match*	match inhibition
<b>Franck et al. (2015)</b>	SPR	subject of object relative/ complement clause	matrix clause object & relative/complement clause subject	number match	no effect
<b>Wagers et al. (2009), Exp 3</b>	SPR	relative clause subject, S-V agreement	matrix subject & embedded clause subject	number match	PL match inhibition
<b>Villata et al. (2018), Exp 1</b>	ETR	relative clause subject, S-V agreement	matrix subject & embedded subject	gender match	FEM match inhibition

Table 3.1. The overview of the studies on subject-verb dependencies that provide analysis on the pre-retrieval NP2. PL=plural, FEM=feminine; ETR=eye tracking experiment, SPR= self-paced reading experiment, S-V=subject-verb. \*Word category match was not directly manipulated in this study; we are here reinterpreting their results for the purposes of the current summary.

### 3.2. Current chapter

In order to test the possible maintenance of the number feature through similarity-based (encoding) interference, we manipulate number match of the matrix subject-verb dependency with the interpolated elements (NP2 and VP). Previous evidence on similarity-based interference outlined above suggests that number matching and mismatching conditions behave differently. Importantly, we investigate primarily those number interference effects that can be ascribed to encoding interference, and thus maintenance (those found on the pre-verbal NP2), but also those that can be ascribed to retrieval interference (those found on the embedded VP). Previous research suggests that number

matching should cause inhibitory interference at encoding (on NP2) and possibly facilitatory interference or no effect on the verb.

If the maintained representation in the online subject-verb computation contains number information, the number on the interpolated elements should interact with the maintained number feature. Thus, we expect to see a difference between match (i.e. the number feature of the interpolated element corresponds to the maintained number feature) and mismatch (i.e. the number feature of the interpolated element doesn't correspond to the maintained number feature) condition. Importantly, in order to make sure that interference effects are occurring due to maintenance of the subject-verb dependency, we analyze the control conditions too, where the clause with the manipulated NP and VP doesn't interrupt the matrix subject-verb dependency. Therefore, we expect the maintenance effects to occur in the experimental conditions, where the subject-verb dependency is being maintained over the clause, and not in the control conditions, where it is not.

Furthermore, looking separately at different interpolated elements (NP2 and VP) allows us to test the possible maintenance of another morphosyntactic feature – the word category feature. Namely, if NP2 and the embedded verb interact with the maintained representation differently, this can tell us whether the maintained representation contains category information, and whether it originates from the subject noun or from the verb. Previous studies, although not manipulating the word category feature directly, have shown that maintaining NP1 and encountering NP2 causes increased processing cost on NP2. If the maintained representation contains noun category marking, we expect the overall increased RTs on the interpolated NP2 but not on VP. Previous studies on maintenance in subject-verb agreement suggest that the maintained representation belongs to the verb prediction (e.g. Chen et al., 2005), and measuring RTs on both the NP2 (embedded subject noun) and the verb allows us to test this claim and see how the maintained representation interacts with the elements of different categories. Additionally, this helps us to test how that interaction develops over the course of the sentence, which we investigate by manipulating word order in Spanish.

Finally, we expect encoding interference for the number feature to occur on the embedded subject noun, in the form of increased reading times for the match condition (Villata et al., 2018; Van Dyke & McElree, 2006; Gordon et al., 2006). The finding that number matching increases processing cost even before any retrieval has taken place (on NP2) would constitute evidence that the number feature is actively maintained in subject-verb agreement. When it comes to the verb, however, retrieval interference is expected to either cause no effects, or to cause decreased reading times for the match, compared to mismatch condition (Jäger et al., 2017). Furthermore, finding differences between the embedded subject and the embedded verb, regarding the effect of matching and the experimental/control difference would mean that the maintained representation also contains category (noun/verb) information. In the current chapter, we are able to see how the maintained representation interacts with the elements of different categories and how that develops over the course of the sentence, by looking at different word orders within the embedded clause. As in Chapter 2, we compare our findings in Spanish (Experiment 1) to a morphosyntactically different language, namely English (Experiment 2). Since this chapter focuses on the possible morphosyntactic content of the maintained representation, we find this comparison very valuable.

### ***3.3. Experiment 1: Spanish***

In Experiment 1, we test the potential morphosyntactic content of the maintained representation in Spanish. Spanish is a morphologically rich language with a rather free word order. Besides manipulating the matching of the interpolated material and the maintained representation in number, we also look at the word order within the embedded clause to explore potential category feature maintenance, as well as the temporal progression of the possible effects. We hypothesize that the maintained representation would interact differently with different elements (telling us whether the category information is maintained), which also might depend on the position of the element



within the embedded clause. Importantly, the effects are expected to occur in the experimental, but not in the control conditions.

### 3.3.1. Methodology

#### 3.3.1.1. Participants, Stimuli, Procedure

The participants, the stimuli and the procedure for this experiment are described in Chapter 2, Experiment 1.

#### 3.3.1.2. Data trimming and analysis

Two interest areas were analyzed - embedded noun and embedded verb (e.g. *Esa chica, cada vez que [un chico] [viene], se pone nerviosa*, see Table 2.1 in Chapter 2). We calculated first pass and go-past reading times, as well as the regressions out of the interest area to the previous part of the sentence. The analyses were performed separately for each interest area.

We fitted linear mixed-effect models (for reading times) or generalized linear mixed-effect models (for proportion of regressions). The fixed effects were the interaction between Manipulation (control, experimental), Word Order (SV, VS) and Matching (match, mismatch) between the matrix clause subject and embedded clause subject (NP2) and verb. Data trimming, analysis, and model selection were performed following the steps described in Chapter 2. In order to better disentangle 3-way interactions, when they were significant, we performed separate analyses for SV and VS word order. In those cases, the model selection procedure also followed the one described in Chapter 2. An effect was considered significant when the  $t/z = 2$ .

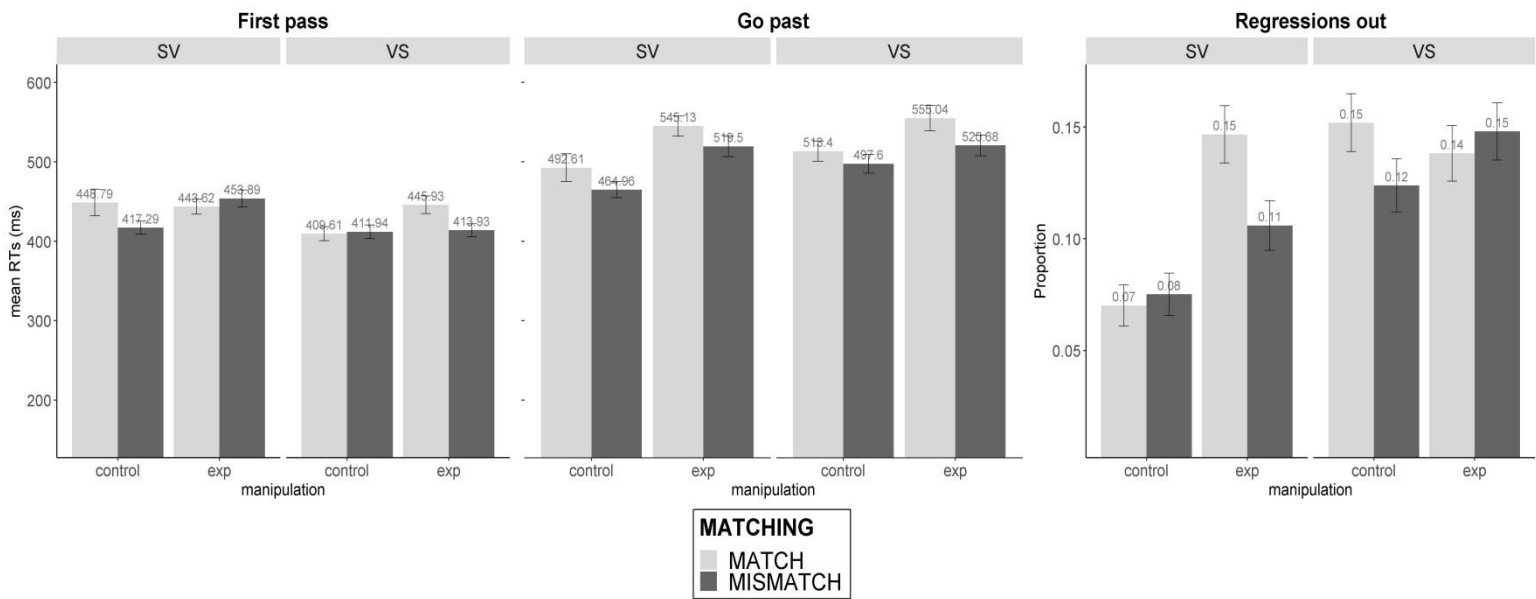
Additionally, the *coef* function from *stats* package (R Core Team, 2017) was used to obtain *p* values and check for significance when the marginal effects had values close to 2. In those cases, the *p* values are also provided in brackets.

### 3.3.2. Results

The accuracy results for the comprehension task are provided in Chapter 2, Experiment 1. The overview of the results for the reading measures is provided in Table 3.8 at the end of the chapter.

#### 3.3.2.1. Embedded subject NP (NP2)

For the first pass reading times, we found a significant effect of Manipulation, so that first pass reading times were increased for the experimental condition, a significant effect of Word Order, as reading times were shorter for VS word order, as well as a marginal effect of Matching, as reading times were marginally longer for the match condition. Also, we found a significant Manipulation x Matching x Word Order interaction. In the separate analysis for SV word order, we found a significant ( $p=0.04$ ) Manipulation x Matching interaction, generated by longer reading times on the match condition in the control items. The analysis for VS word order revealed a significant effect of Manipulation, as first pass reading times were increased in the experimental condition, a marginal effect of Matching ( $p=0.05$ ), as matching conditions generated longer reading times, as well as a significant Manipulation x Matching interaction, such that the increase in first pass reading times for the matching conditions was stronger in the experimental items (see Figure 3.1 and Table 3.2).



**Figure 3.1. First pass reading times, go-past reading times and regressions out of the embedded subject NP in Experiment 1. The numbers on the top of the bars represent the mean values for that level of the factor. SV= SV word order, VS= VS word order; exp= experimental conditions, control= control conditions**

In the go-past reading times analysis, we found a significant effect of Manipulation, given that first pass reading times were longer for experimental items, as well as a marginal effect of Word Order, as reading times were longer for VS word order. The effect of Matching was also significant, triggered by longer go-past reading times in the matching condition (see Figure 3.1 and Table 3.3).

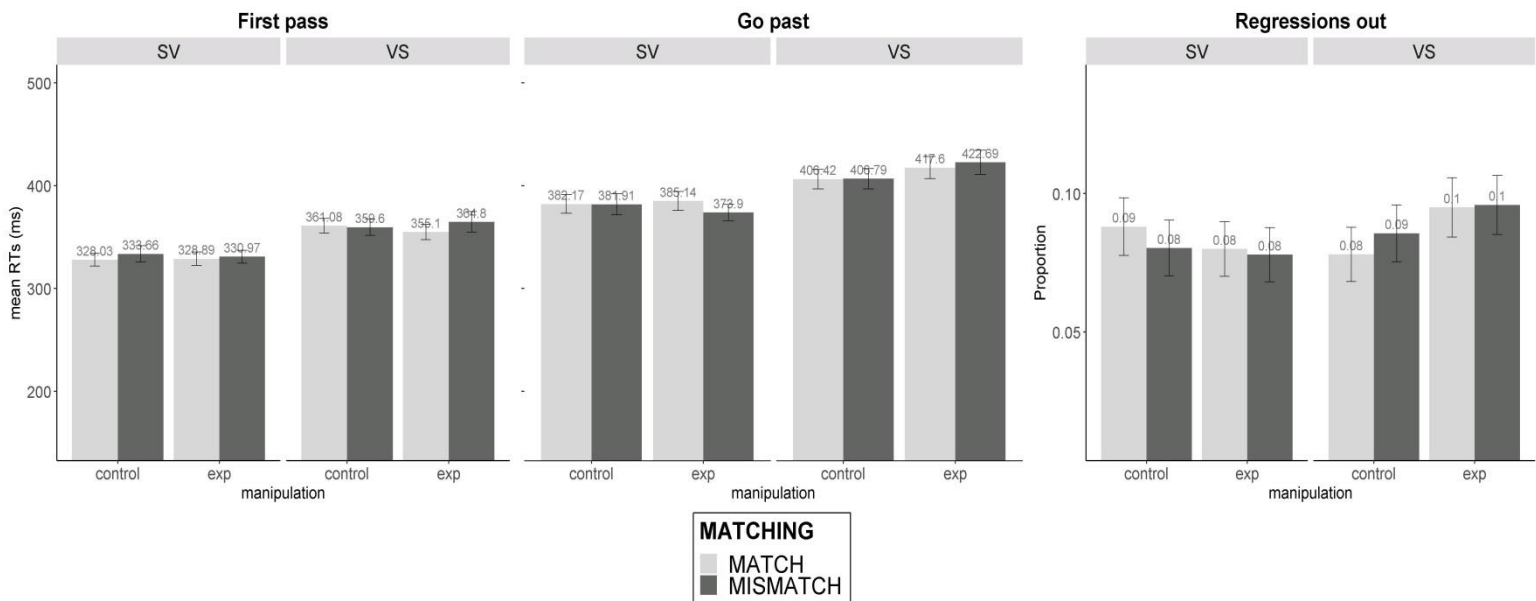
When it comes to the regressions out, there was a significant effect of Manipulation, as more regressions were made from experimental items, and a significant effect of Word Order, as more regressions were made in VS word order. Also, we found a significant Manipulation x Word Order interaction, driven by bigger difference between experimental and control conditions in the SV word order, as well as a significant Manipulation x Matching x Word Order interaction. In the separate analysis for SV word order, the effect of Manipulation was significant, as more regressions were made in the experimental condition, while the Manipulation x Matching interaction was marginal and driven by the increase in the regressions in the match condition for the experimental items. In the separate analysis for VS word order, no significant effects emerged (see Figure 3.1 and Table 3.3).

### 3.3.2.2. Embedded verb

The first pass reading times analysis revealed a significant effect of Word Order, given that first pass reading times were increased in VS condition (see Figure 3.2 and Table 3.4)

The go-past reading times analysis also revealed a significant effect of Word Order in the same direction as in first pass reading time analysis (see Figure 3.2 and Table 3.4).

No effects were found for the regressions out (all  $t_s < 1.10$ , see Figure 3.2. and Table 3.4).



**Figure 3.2. First pass reading times, go-past reading times and regressions out of the embedded verb in Experiment 1. The numbers on the top of the bars represent the mean values for that level of the factor. SV= SV word order, VS= VS word order; exp= experimental conditions, control= control conditions**

<u>Embedded noun – first pass reading times</u>					
<u>SV and VS</u>					
model: firstpass~ manipulation *matching * WO + (1 participant)+(1+manipulation item)					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	429.32	20.61	20.83	388.93	469.70
manipulation1	8.55	3.31	<b>2.58</b>	2.06	15.05
matching1	-5.86	3.16	<u>-1.85</u>	-12.05	0.34
WO1	-10.17	3.16	<b>-3.22</b>	-16.36	-3.98
manipulation1:matching1	0.66	3.16	0.21	-5.54	6.85
manipulation1:WO1	1.23	3.16	0.39	-4.96	7.43
matching1:WO1	-1.33	3.16	-0.42	-7.53	4.86
manipulation1:matching1:WO1	-9.49	3.16	-3.00	-15.68	-3.30
<u>SV</u>					
model: firstpass~ manipulation *matching + (1 participant)+(1+manipulation item)					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	439.67	21.80	20.17	396.94	482.40
manipulation1	7.34	5.65	1.30	-3.73	18.41
matching1	-4.42	5.06	-0.88	-14.34	5.49
manipulation1: matching1	10.00	5.06	<b>1.98</b>	0.09	19.91
<u>VS</u>					
model: firstpass~ manipulation *matching + (1 participant)+(1+manipulation item)					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	419.22	20.45	20.50	379.14	459.29
manipulation1	9.79	3.88	<b>2.52</b>	2.19	17.38
matching1	-7.15	3.71	<u>-1.93</u>	-14.43	0.13
manipulation1: matching1	-8.56	3.71	<b>-2.30</b>	-15.84	-1.28

Table 3.2. Analyses for the first pass reading times on the embedded clause subject in Experiment 1. Coding: for the Manipulation factor, -1=control, 1=experimental; for the Matching factor, -1=match, 1=mismatch; for the Word Order factor, -1= SV word order, 1= VS word order. Significant effects are in bold, and marginal effects are underlined.

**Embedded noun – go-past reading times****SV and VS**

model: gopast~manipulation \*matching \* WO + (1|participant)+(1|item)

	estimate	se	t.value	conf.low	conf.high
(Intercept)	512.00	26.16	19.57	460.72	563.28
manipulation1	21.22	4.03	<b>5.26</b>	13.32	29.13
matching1	-12.39	4.03	<b>-3.07</b>	-20.29	-4.49
WO1	8.17	4.03	<b>2.03</b>	0.26	16.07
manipulation1: matching1	-2.47	4.03	-0.61	-10.37	5.43
manipulation1:WO1	-4.97	4.03	-1.23	-12.88	2.93
matching1:WO1	0.02	4.03	0.01	-7.88	7.93
manipulation1: matching1:WO1	-2.53	4.03	-0.63	-10.43	5.37

**Embedded noun – regressions out****SV and VS**

model: regout ~ manipulation \*matching \* WO + (1|participant)+(1|item)

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.26	0.11	-20.66	0.00	-2.48	-2.05
manipulation1	0.17	0.04	<b>4.17</b>	0.00	0.09	0.25
matching1	-0.06	0.04	-1.52	0.13	-0.14	0.02
WO1	0.23	0.04	<b>5.61</b>	0.00	0.15	0.31
manipulation1:matching1	-0.02	0.04	-0.44	0.66	-0.10	0.06
manipulation1:WO1	-0.15	0.04	<b>-3.57</b>	0.00	-0.23	-0.07
matching1:WO1	0.02	0.04	0.49	0.63	-0.06	0.10
manipulation1:matching1:WO1	0.10	0.04	<b>2.51</b>	0.01	0.02	0.18

**SV**

model: regout ~ manipulation \* matching + (1|participant)

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.44	0.12	-20.44	0.00	-2.67	<b>-2.20</b>
manipulation1	0.31	0.06	<b>4.97</b>	0.00	0.19	0.44
matching1	-0.08	0.06	-1.26	0.21	-0.20	0.04
manipulation1:matching1	-0.12	0.06	<u>-1.90</u>	0.06	-0.24	0.00

**VS**

model: regout ~ manipulation \* matching + (1|participant)

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.05	0.12	-17.02	0.00	-2.28	-1.81
manipulation1	0.03	0.05	0.48	0.63	-0.08	0.13
matching1	-0.04	0.05	-0.80	0.42	-0.15	0.06
manipulation1:matching1	0.09	0.05	1.62	0.11	-0.02	0.19

Table 3.3. Analyses for the go-past reading times and regressions out of the embedded clause subject in Experiment 1. Coding: for the Manipulation factor, -1=control, 1=experimental; for the Matching factor, -1=match, 1=mismatch; for the Word Order factor, -1= SV word order, 1= VS word order. Significant effects are in bold, and marginal effects are underlined.

**Embedded verb – first pass reading times**

SV and VS					
model: firstpass~manipulation *matching * WO + (1 participant)+(1 item)					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	340.88	14.14	24.11	313.18	368.59
manipulation1	0.03	2.23	0.01	-4.35	4.41
matching1	2.11	2.23	0.94	-2.27	6.49
WO1	15.42	2.23	<b>6.90</b>	11.04	19.80
manipulation1: matching1	1.42	2.23	0.63	-2.96	5.80
manipulation1:WO1	-0.18	2.23	-0.08	-4.56	4.19
matching1:WO1	0.18	2.23	0.08	-4.20	4.56
manipulation1: matching1:WO1	2.46	2.23	1.10	-1.92	6.83

**Embedded verb – go-past reading times**

SV and VS					
model: gopast~manipulation *matching * WO + (1 participant)+(1 item)					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	392.36	16.67	23.54	359.70	425.03
manipulation1	3.11	3.04	1.02	-2.84	9.06
matching1	-0.44	3.04	-0.14	-6.39	5.51
WO1	17.04	3.04	<b>5.61</b>	11.09	23.00
manipulation1: matching1	-0.17	3.04	-0.06	-6.12	5.78
manipulation1:WO1	3.81	3.04	1.25	-2.14	9.76
matching1:WO1	2.34	3.04	0.77	-3.62	8.29
manipulation1: matching1:WO1	2.53	3.04	0.83	-3.42	8.48

**Embedded verb – regressions out**

SV and VS						
model: regout~manipulation *matching * WO + (1 participant)+(1 item)						
	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.54	0.09	-26.97	0.00	-2.72	-2.35
manipulation1	0.03	0.05	0.54	0.59	-0.07	0.12
matching1	0.00	0.05	-0.02	0.98	-0.09	0.09
WO1	0.05	0.05	1.01	0.31	-0.04	0.14
manipulation1:matching1	0.00	0.05	-0.04	0.97	-0.09	0.09
manipulation1:WO1	0.06	0.05	1.33	0.18	-0.03	0.15
matching1:WO1	0.03	0.05	0.75	0.46	-0.06	0.13
manipulation1:matching1:WO1	-0.02	0.05	-0.47	0.64	-0.11	0.07

Table 3.4. Analyses for the first pass and go-past reading times, as well as regressions out of the embedded clause verb in Experiment 1. Coding: for the Manipulation factor, -1=control, 1=experimental; for the Matching factor, -1=match, 1=mismatch; for the Word Order factor, -1= SV word order, 1= VS word order. Significant effects are in bold, and marginal effects are underlined.

### 3.3.3. Interim Discussion

In the current section, we aimed to provide evidence that morphosyntactic features, i.e. word category and number features, form part of the actively maintained representation in subject-verb agreement computation in Spanish. We expected that the active features would cause similarity-based interference effects on the interpolated elements. More importantly, we wanted to elicit encoding interference, which would have to take place prior to the retrieval at the verb, and which would confirm maintenance (Jäger et al., 2015; Van Dyke & Lewis, 2003; Villata et al., 2018). When it comes to the potential number and category feature maintenance, it is important to consider two word orders separately, as they imply two different dynamics of information encountering in the online sentence comprehension.

In the SV word order, the embedded subject noun, NP2, is encountered first. At this stage, the embedded verb is still not encountered and thus any effects that we might find can be ascribed to maintenance processes, i.e. to encoding interference. As suggested by Jäger et al. (2015), encoding interference occurs when one representation is maintained and an element overlapping with that representation in some features is encountered. Similarly, Gordon et al. (2006) suggest that keeping two unintegrated NPs active causes processing cost. Our analysis for this region revealed the effect of Manipulation, seen in longer reading times on NP2 in experimental condition compared to control condition. This effect was significant both in go-past reading times, and in the regressions to the previous interest areas. This suggests that the maintained representation contains category information, as maintaining the category feature of NP1 and encountering another element with the same feature (NP2) caused encoding interference. This is in line with the previous research on encoding interference (see Table 3.1). The direction of the main effect of Word Order for the overall analysis confirms this claim: in the first pass reading times, NP2 was harder to process when encountered before the verb, i.e. in the SV word order. But, regressive eye movements are informative about the need to reanalyze the word. Thus, go-past reading times and regressions out showed the Word Order effect in the opposite direction to the one in first pass reading times (more cost for NP2 in



VS word order), reflecting the overall difficulty of integrating the dispreferred VS word order inside of the embedded clause.

However, the results for the Matching effect in SV word order, which can inform us about the potential number maintenance, are less clear. The Manipulation x Matching interference found for the regressions out suggests an increase in the regressions in the match condition for the experimental items. The match inhibition for the experimental items on NP2 in SV word order could be a proof for the encoding interference with the number feature. However, the direction of this effect was reversed in the first pass reading times (although this is only marginally significant): the match inhibition was stronger for the control items. This reversed effect suggests that the presence of the matrix noun's number feature might not be a result of subject-verb dependency maintenance (as it is not only seen in experimental conditions). This difference in the directions of the interactions between first pass and regressions out resulted in the main effect of Matching in go-past reading times, but no interaction. It is thus hard to conclude whether number feature is maintained or whether it is present and causes interference through some other mechanisms, such as priming.

After processing the embedded subject noun in SV word order, encountering the embedded verb triggered shorter first pass and go-past reading times compared to the VS word order. This result goes in line with the rating questionnaire, where VS conditions were rated as less natural. Therefore, we believe that this effect simply reflects the preferred word order and the decreased difficulty to integrate the verb in this position. No effect of Manipulation was found, suggesting that the verb category feature is not part of the maintained representation and doesn't cause interference. Also, the lack of Matching effect implies that similarity-based interference did not take place at the retrieval and goes in line with the studies that show no significant similarity interference effects in the match condition on the critical verb (Jäger et al., 2017).

In the VS word order, the verb is encountered first. Importantly, we found no Manipulation or Matching effect on the verb in this word order either. Rather, the same effects as those found in SV word order apply. Reading times were overall increased compared to the verb in the SV word order,

reflecting the difficulty upon integrating the verb in the dispreferred word order. The lack of interference with either category information or number information at the retrieval is again in line with the studies that show no similarity interference effects on the verb.

The analysis of the NP2 in VS word order showed the main effect of Matching in go-past and marginally first pass reading times, which also interacted with Manipulation in the first pass. The direction of the interaction was the same as the one observed on the regressions out of the subject noun in SV word order: match inhibition was stronger for the experimental items, suggesting that the maintained number information caused encoding interference with the encountered number feature of the NP2. However, since NP2 in this word order is encountered after the verb, we cannot unequivocally ascribe the effects in this region to maintenance and encoding. However, it is not clear how this effect could be ascribed to retrieval either. Firstly, finding Matching or Manipulation effects on the verb would be necessary to ascribe the effects to retrieval. Secondly, it is hard to explain why retrieval would be reinforced in experimental, and not control items<sup>4</sup>. This leaves open the possibility that the number information is being maintained after all. Furthermore, the main effect of Manipulation in first pass and go-past reading times replicated our findings in the SV word order. However, like for the interaction mentioned above, we cannot straightforwardly interpret this effect as a result of maintenance, although it would be hard to explain it by retrieval mechanisms also.

Overall, the persistence of the Manipulation effect on the embedded subject nouns (NP2) in both word orders, as well as the lack of it on the embedded verb, suggests that the maintained representation carries noun, but not verb category feature. Our proposal that noun feature information

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<sup>4</sup> A somewhat similar comparison to our experimental vs. control contrast was provided by Van Dyke & McElree (2011), where they compared whether the match between *the witness* and *the attorney* causes different interference effects in a) *The judge who had declared that **the witness** was inappropriate realized that **the attorney** in the case compromised* vs. b) ***The attorney** who the judge realized had declared that **the witness** was inappropriate compromised*, and indeed found that the interference on *compromised* was stronger in b). Although the authors aimed to contrast *retroactive interference* in b) (when retrieval of a target element, here *the attorney*, is impaired by the elements processed after it), and *proactive interference* in a) (when retrieval of an element is impaired by the elements processed before it), we can see that the interference in b) comes from a distractor that interrupts matrix-subject verb agreement, while the distractor in a) is located within a preceding clause. However, the comparison here is made between sentences of different configurations – complement clause in a) and relative clause in b). In our experiment, the critical noun is always within an adverbial clause. Also, both our experimental and control items can be said to test *proactive interference* (Jäger et al., 2017; Van Dyke & McElree, 2011).

is part of the representation that is actively maintained in subject-verb dependency is in line with the previous studies in similarity-based interference that found increased reading times on NP2 when another NP1 is maintained in memory (see Table 3.1). Also, this is in line with Wagers & Phillips (2014), who suggest that the maintained representation includes the information about the category of the element that opens a long-distance dependency (the filler, in their case). The results related to the number feature maintenance, however, are more inconclusive and we further investigate them in Experiment 2.

### ***3.4. Experiment 2: English***

After establishing that the subject-verb dependency is actively maintained in Spanish and that noun category and potentially number feature form part of the maintained representation, we proceed to ask the same question in English. As the results regarding the potential number feature within the maintained representation are rather inconclusive, we investigate this issue in more detail in Experiment 2. To this end, we manipulate the number of both the matrix and the embedded subject-verb dependency (singular/plural), testing for the potential differences in maintaining singular and plural number feature. As plural number has been proven to be more morphologically marked and thus triggering stronger interference effects in subject-verb agreement processing (Eberhard, 1997; Eberhard et al., 2005; Pearlmutter, Garnsey, & Bock, 1999; Wagers et al., 2009), it is possible that plural matrix subject-verb dependency establishment is characterized by stronger or more prominent maintenance of the number feature.

Additionally, the control items in the current experiment are different from those in Experiment 1 (see Table 2.3 in Chapter 2), as all the arguments of the firstly encountered clause occur

prior to the embedded clause<sup>5</sup>. We therefore expect to see clearer difference between experimental and control items when it comes to the Matching effect.

### 3.4.1. Methodology

#### 3.4.1.1. Participants, Stimuli, Procedure

The participants, stimuli, and procedure for this experiment are described in Chapter 2, Experiment 2.

#### 3.4.1.2. Data trimming and analysis

We analyzed two interest areas - embedded noun and embedded verb (e.g. *Those students, as soon as [a professor] [finishes] the class, leave the classroom*). We fitted linear mixed-effect models (for reading times) or generalized linear mixed-effect models (for proportion of regressions), with the interaction between Manipulation (control, experimental), Embedded NP (NP2) Number (singular, plural) and Matching (match, mismatch) as fixed effects. The rest of the procedure, including model selection and data trimming, followed the one in Experiment 1. In order to better disentangle 3-way interactions, when they were significant, we performed separate analyses for singular and plural embedded NP.

### 3.4.2. Results

The accuracy results for the comprehension task in Experiment 2 are provided in Chapter 2. The overview of the results for the reading measures is provided in Table 3.8 at the end of the chapter.

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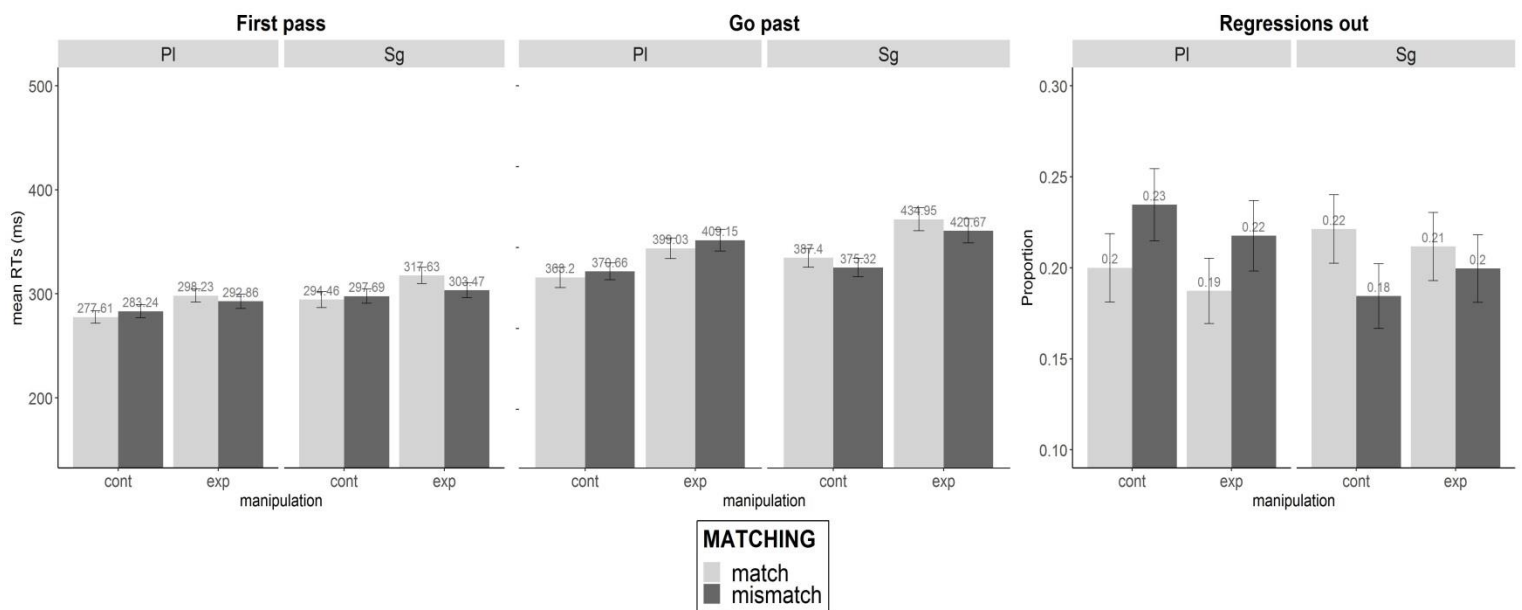
<sup>5</sup> In the control items, we refer to the first clause, containing NP1, as the “matrix clause”, and the second clause, containing NP2, as the “adverbial clause”. Although these two clauses are in different relation than those in the experimental items, we use the same terminology for the sake of uniformity.

### 3.4.2.1. Embedded subject NP (NP2)

In the first pass, we found a significant effect of Manipulation, since reading times increased for experimental condition, as well as a significant effect of Embedded NP Number, as the singular embedded NPs caused longer reading times (see Figure 3.3 and Table 3.5).

The go-past reading times analysis showed the same effects as those found for the first pass reading times (see Figure 3.3 and Table 3.5).

When it comes to the regressions out, a significant Embedded NP Number x Matching interaction emerged, driven by an increase in regressions from the matching singular embedded NPs (see Figure 3.3 and Table 3.5).



**Figure 3.3. First pass reading times, go-past reading times and regressions out of the embedded subject NP in Experiment 2. The numbers on the top of the bars represent the mean values for that level of the factor. PI= plural embedded NP, Sg= singular embedded NP; exp= experimental conditions, control= control conditions**

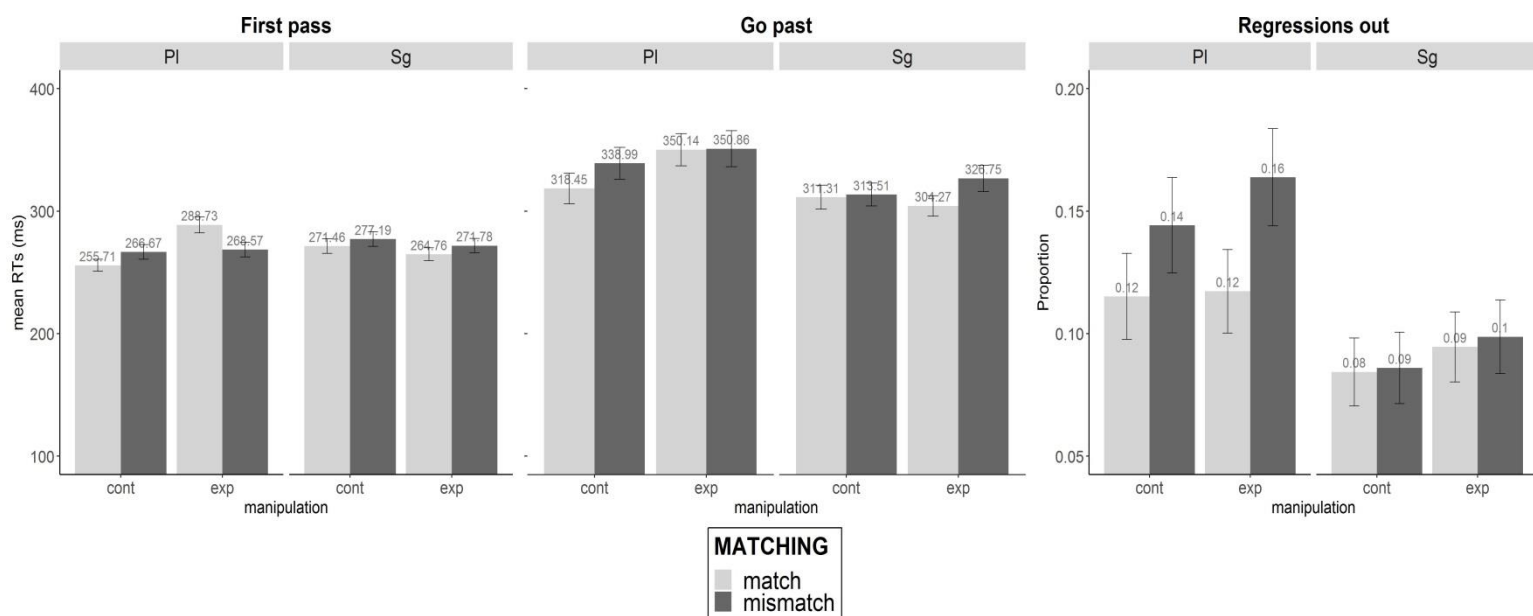
### 3.4.2.2. Embedded verb

The first pass reading time analysis showed a marginal Matching x Manipulation interaction, driven by the increase in the longer reading times in the match condition for the experimental items. Furthermore, there was a significant Manipulation x Embedded NP Number interaction, due to the

smaller difference between experimental and control items in the singular embedded NP condition, as well as a significant Manipulation x Matching x Embedded NP Number interaction. The analysis for singular embedded NP showed no significant effects. The analysis for plural embedded NP revealed a significant effect of Manipulation, driven by longer reading times in the experimental condition, as well as a significant Manipulation x Matching interaction, driven by increased reading times in matching condition in experimental items (see Figure 3.4 and Table 3.6).

Go-past reading times analysis showed a marginal Manipulation effect, driven by longer reading times for experimental condition, as well as a significant effect of the Embedded NP Number, such that singular embedded number condition triggered longer go-past reading times (see Figure 3.4 and Table 3.7).

The analysis for the regressions out showed a significant effect of Embedded NP Number, as more regressions were made from the verbs in plural embedded NP condition (see Figure 3.4 and Table 3.7).



**Figure 3.4. First pass reading times, go-past reading times and regressions out of the embedded verb in Experiment 2. The numbers on the top of the bars represent the mean values for that level of the factor. PI= plural embedded NP, Sg= singular embedded NP; exp= experimental conditions, control= control conditions**

**Embedded noun – first pass reading times**

<b>SG and PL</b>					
<b>model: firstpass~ manipulation *matching * embedded + (1 participant)+(1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	293.23	8.77	33.45	276.04	310.41
manipulation1	7.53	2.21	<b>3.40</b>	3.19	11.87
embedded1	8.37	2.21	<b>3.79</b>	4.04	12.70
matching1	-1.68	2.21	-0.76	-6.02	2.65
manipulation1:embedded1	-0.33	2.21	-0.15	-4.67	4.00
manipulation1:matching1	-2.96	2.21	-1.34	-7.30	1.37
embedded1:matching1	-1.08	2.21	-0.49	-5.41	3.26
manipulation1:embedded1:matching1	-0.36	2.21	-0.16	-4.70	3.98

**Embedded noun – go-past reading times**

<b>SG and PL</b>					
<b>model: gopast~ manipulation *matching * embedded + (1 participant)+(1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
(Intercept)	390.07	16.56	23.55	357.61	422.52
manipulation1	20.91	4.02	<b>5.20</b>	13.03	28.79
embedded1	10.32	4.01	<b>2.57</b>	2.45	18.19
matching1	-1.77	4.02	-0.44	-9.64	6.10
manipulation1:embedded1	1.68	4.02	0.42	-6.20	9.56
manipulation1:matching1	0.76	4.02	0.19	-7.11	8.64
embedded1:matching1	-4.81	4.02	-1.20	-12.68	3.06
manipulation1:embedded1:matching1	-0.22	4.02	-0.05	-8.10	7.66

**Embedded noun – regressions out**

<b>SG and PL</b>						
<b>model: regout~ manipulation *matching * embedded + (1 participant)+(1 item)</b>						
	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-1.58	0.13	-12.28	0.00	-1.83	-1.32
manipulation1	-0.02	0.04	-0.59	0.56	-0.11	0.06
embedded1	-0.02	0.04	-0.48	0.63	-0.10	0.06
matching1	0.01	0.04	0.18	0.86	-0.08	0.09
manipulation1:embedded1	0.03	0.04	0.68	0.49	-0.05	0.11
manipulation1:matching1	0.02	0.04	0.55	0.58	-0.06	0.11
embedded1:matching1	-0.10	0.04	<b>-2.27</b>	0.02	-0.18	-0.01
manipulation1:embedded1:matching1	0.02	0.04	0.55	0.59	-0.06	0.11

Table 3.5. Analyses for the embedded clause subject NP in Experiment 2. Coding: for the Manipulation factor, -1=control, 1= experimental; for the Matching factor, -1=control, 1=experimental; for the Embedded NP Number factor, -1=plural, 1=singular. Significant effects are in bold.

**Embedded verb – first pass reading times**

<b><u>SG and PL</u></b>					
<b>model: firstpass~manipulation *matching * embedded + (1  participant)+(1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	263.76	6.93	38.05	250.17	277.35
<b>manipulation1</b>	3.24	2.57	1.26	-1.80	8.27
<b>embedded1</b>	1.27	1.86	0.68	-2.37	4.91
<b>matching1</b>	0.30	1.86	0.16	-3.34	3.93
<b>manipulation1:embedded1</b>	-6.11	1.86	<b>-3.29</b>	-9.75	-2.47
<b>manipulation1:matching1</b>	-3.32	1.86	<u>-1.78</u>	-6.96	0.33
<b>embedded1:matching1</b>	1.93	1.86	1.04	-1.71	5.57
<b>manipulation1:embedded1:matching1</b>	4.10	1.86	<b>2.20</b>	0.45	7.74
<b><u>SG</u></b>					
<b>model: firstpass~manipulation *matching + (1 participant)+(1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	266.04	7.23	36.81	251.88	280.21
<b>manipulation1</b>	-2.74	2.58	-1.06	-7.80	2.32
<b>matching1</b>	2.73	2.58	1.06	-2.33	7.78
<b>manipulation1:matching1</b>	0.78	2.58	0.30	-4.29	5.84
<b><u>PL</u></b>					
<b>model: firstpass~manipulation *matching + (1  participant)+(1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	264.20	7.18	36.82	250.14	278.26
<b>manipulation1</b>	9.39	2.72	<b>3.45</b>	4.06	14.72
<b>matching1</b>	-1.84	2.71	-0.68	-7.15	3.47
<b>manipulation1:matching1</b>	-7.93	2.72	<b>-2.92</b>	-13.25	-2.60

Table 3.6. Analyses for the first pass reading times on the embedded clause verb in Experiment 2. Coding: for the Manipulation factor, -1=control, 1= experimental; for the Matching factor, -1=control, 1=experimental; for the Embedded NP Number factor, -1=plural, 1=singular. Significant effects are in bold, and marginal effects are underlined.



**Embedded verb – go-past reading times**

**SG and PL**

model: gopast~ manipulation \*matching \* embedded+ (1|participant) + (1|item)

	estimate	se	t.value	conf.low	conf.high
(Intercept)	319.30	10.47	30.48	298.77	339.83
manipulation1	6.68	3.80	<u>1.76</u>	-0.77	14.14
embedded1	-11.91	3.79	<b>-3.14</b>	-19.35	-4.48
matching1	5.75	3.79	1.52	-1.68	13.19
manipulation1:embedded1	-5.23	3.79	-1.38	-12.67	2.20
manipulation1:matching1	1.18	3.80	0.31	-6.26	8.63
embedded1:matching1	-0.98	3.79	-0.26	-8.42	6.45
manipulation1:embedded1:matching1	5.65	3.80	1.49	-1.79	13.10

**Embedded verb – regressions out**

**SG and PL**

model: regout ~manipulation \*matching \*embedded + (1|participant) + (1|item)

	estimate	se	z.value	p.value	conf.low	conf.high
(Intercept)	-2.15	0.09	-23.72	0.00	-2.33	-1.97
manipulation1	0.05	0.06	0.77	0.44	-0.07	0.16
embedded1	-0.22	0.06	<b>-3.77</b>	0.00	-0.34	-0.11
matching1	0.09	0.06	1.59	0.11	-0.02	0.21
manipulation1:embedded1	0.01	0.06	0.25	0.80	-0.10	0.13
manipulation1:matching1	0.02	0.06	0.28	0.78	-0.10	0.13
embedded1:matching1	-0.08	0.06	-1.29	0.20	-0.19	0.04
manipulation1:embedded1:matching1	-0.01	0.06	-0.19	0.85	-0.13	0.11

Table 3.7. Analyses for the go-past reading times and the regressions out of the embedded clause verb in Experiment 2. Coding: for the Manipulation factor, -1=control, 1= experimental; for the Matching factor, -1=control, 1=experimental; for the Embedded NP Number factor, -1=plural, 1=singular. Significant effects are in bold, and marginal effects are underlined.

### 3.4.3. Interim Discussion

The aim of the current section was to find evidence on word category and number features maintenance in subject-verb agreement in English, as well as to see if singular and plural number features are maintained differently. Like in Spanish, we hypothesized that these features will trigger encoding interference on the pre-retrieval NPs (NP2). In English, and thus in our Experiment 2, the only possible word order in the adverbial clause is SV word order. Therefore, all the potential effects on the embedded subject noun (NP2) can be ascribed to maintenance mechanisms. The effects found on the embedded subject NP in Experiment 2 are thus comparable to those found in SV word order in Experiment 1 (see overview in Table 3.8).

Firstly, we observed increased reading times for experimental items compared to the control items on NP2 (embedded subject). This increase in reading times reflects the encoding interference upon maintaining the representation containing noun category information and encountering another noun (Jäger et al., 2015; Van Dyke & Lewis, 2003; Villata et al., 2018). This aligns with the results obtained in Experiment 1, and corroborates our finding that the maintained representation is marked for the noun category feature. Furthermore, we found more processing cost on singular than plural NP2. As the critical region in the singular condition of Experiment 2 was longer, we can probably ascribe this singular NP processing difficulty to word length, which has widely been shown to affect eye movements (see Chapter 1, Section 1.5.1). This is further supported by the interaction with the Matching factor, which showed that the regressions were most common in the condition with the singular NP1 and singular NP2.

For the embedded verb, however, the results differed from those observed in Experiment 1. In the first pass reading times, we found a main effect of Manipulation and a significant Manipulation x Matching interaction, as the match inhibition was stronger for the experimental items. These results are very similar to those on NP2 in Experiment 1 (first pass reading times in VS word order and regressions out in SV word order). It is thus possible that these results in the current experieent

represent spillover from the noun, as many studies report similarity-based interference effects only in the spillover region (see Jäger et al., 2017).

In Experiment 1, it was also hard to tell with certainty whether these effects on NP2 emerge through maintenance of the subject-verb dependency, as either the verb is located prior to the noun (VS word order), or the pattern changes across the measures (SV word order). If the interaction in the current experiment, seen as match inhibition for the experimental items, really does represent a spillover effect from the preceding NP2, this would support our hypothesis that the interference with the number feature is indeed taking place at the encoding stage through number feature maintenance.<sup>6</sup> However, as no interaction is found on the NP2 in the current experiment, we cannot be certain that the interaction found in the first pass reading times on the verb is indeed an instance of spillover effect, and it remains unclear whether number feature is maintained.

Additionally, the effect of Embedded NP Number that emerged on the NP2 was reversed on the verb: plural embedded verb elicited longer go-past reading times and regressions out (but not on the first pass reading times). As this effect was driven by regressive eye movements, we can attribute it to the difficulty upon processing marked, plural verb. This differs from the Embedded NP Number effects on the NP2, which we ascribed to the word length.

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<sup>6</sup> Indeed, obtaining a stronger difference in the Matching effect between the experimental and the control conditions in Experiment 2 would be expected. Namely, the control items in this experiment are different from those in Experiment 1, as the subject noun from the experimental items is turned into the object of an independent clause in the control items. This enabled all the argument slots from the first clause to be filled in before reaching the adverbial clause. As Gibson (1998) suggests, the clause-based closure applies in this case, since opening a new clause shunts the material in the previous clause out of working memory.

<b>Experiment 1</b>						
	<i>first pass</i>		<i>go-past</i>		<i>regressions out</i>	
	<i>SV</i>	<i>VS</i>	<i>SV</i>	<i>VS</i>	<i>SV</i>	<i>VS</i>
<u><i>noun</i></u>						
<b>Manipulation (exp&lt;cont)</b>		t=2.53	t=5.17		t=4.96	
<b>Matching (M&gt;MM)</b>		t=-1.92	t=-3.10			
<b>Manipulation X Matching (MM &gt; M in exp)</b>	t=1.94					
<b>Manipulation X Matching (M &gt; MM in exp)</b>		t=-2.33			t=-1.89	
<b>Word Order (VS &gt; SV)</b>			t=1.89		t=5.61	
<b>Word Order (SV &gt; VS)</b>		t=-3.21				
<u><i>verb</i></u>						
<b>Word Order (VS &gt; SV)</b>		t= 6.76	t=5.51			
<b>Experiment 2</b>						
<u><i>noun</i></u>						
	<i>SG</i>	<i>PL</i>	<i>SG</i>	<i>PL</i>	<i>SG</i>	<i>PL</i>
<b>Manipulation (exp&lt;cont)</b>	t=2.10	t=2.72	t=3.83	3.47		
<b>NP2 Number (SG &gt; PL)</b>		t=3.78	t=2.57			
<b>Matching (MM &gt; M)</b>						t=1.72
<u><i>verb</i></u>						
<b>Manipulation (exp&lt;cont)</b>		t=3.45	t=1.76			
<b>NP2 Number (PL &gt; SG)</b>			t=-3.14		t=-3.77	
<b>Manipulation X Matching (M &gt; MM in exp)</b>		t=-2.92				

Table 3.8. Overview of the results in Experiments 2 and 3 in Chapter 3. exp=experimental items, cont =control items; M=match condition, MM=mismatch condition; VS= VS word order, SV= SV word order; PL= plural embedded NP, SG= singular embedded NP

### **3.5. General Discussion**

In the current chapter, we tried to answer our second research question: what is the content of the maintained representation in subject-verb agreement computation? Namely, some studies claim that the cost of the subject-verb dependency could be ascribed to different sources: the prediction of the verb, the maintenance of the incomplete (subject-verb) dependency, the maintenance of the open phrase structure rule, the incomplete clause, etc. The most commonly accepted option, as mentioned previously, is that the matrix verb is predicted, i.e. the syntactic category of the verb is predicted. However, following research on filler-gaps, we considered that the maintained representation might belong to the matrix subject. Importantly, we wanted to investigate the nature of the maintained representation by looking at two features that it might be specified for: word category and number feature.

We have addressed this issue through similarity-based interference, by looking at how the maintained information interacts with the interpolated elements that are either matching or mismatching in category (subject or verb) and number. Importantly, the effects found on the embedded subject noun (NP2) in Experiment 2 and Experiment 1 (in SV word order) can only be ascribed to the encoding interference, which has been claimed to reflect maintenance mechanisms (Jäger et al., 2015).

An overview of our results can be found in Table 3.8. Our main finding concerns the word category feature. The reading times on the noun were significantly increased in the experimental, compared to the control conditions. Since the critical words in the experimental conditions interrupted a subject-verb dependency, and in the control condition they did not, this confirms our hypothesis that the maintained representation in subject-verb dependency contains the information about the noun category. This effect was also found on the noun in VS word order in Experiment 1, where maintenance processes probably occur in parallel with the retrieval processes. Importantly, this effect was missing on the embedded verb (except for the first pass reading times and marginally go-past in Experiment 2; however, this occurred only with the plural number and might actually be a spillover

from NP2), suggesting that the maintained representation is not marked for verb category. These findings go in line with the previous studies that suggest that maintaining a noun and encountering another noun increases processing cost (Gordon et al., 2001, 2002; Van Dyke & McElree, 2006), causing encoding interference with the category feature (see Section 3.1.2). They also support research on filler-gap dependencies, where the maintained representation was claimed to correspond to the filler, rather than to the gap (Wagers & Phillips, 2014). However, our results are seemingly in contrast to the previous studies on maintenance in subject-verb dependency which suggest that the processing cost is related to the prediction of the verb (Chen et al., 2005; see also Gibson, 1998). We elaborate on this comparison in Chapter 5.

Unfortunately, we cannot draw any clear conclusion as to whether the number feature forms part of the maintained representation. We found that matching of the matrix subject number (NP1) with the interpolating subject noun (NP2) number created an increase in reading times. This match inhibition interacted with the Manipulation effect on some measures, which is when we can attribute it to maintenance. However, this interaction either changed its direction (as in NP2 in Experiment 1, in SV word order), or could also be ascribed to retrieval mechanisms, as it occurred at the verb (Experiment 2) or after the verb (NP2 in Experiment 1, VS word order). In sum, the question of whether the number feature is part of the actively maintained representation remains open.

Cue-based retrieval accounts suggest that, upon encountering the matrix noun, both the representation of that noun, and the representation of the expected verb are created. However, according to this account, those representations are not part of active processing until the matrix verb is reached (see Lewis et al., 2006). Our findings suggest that at least some features of those representations – category and, potentially, number feature – are maintained active over the interpolated material (over the *storage interval*, as referred to by Lewis et al., 2006). We discuss the implications of our findings for the sentence processing models in Chapter 5.

When it comes to the similarity-based interference effects that are triggered by retrieval mechanisms (those found on the verb), previous findings suggest that matching in number between

the matrix subject and the distractor noun causes either no effect or facilitation on the critical verb, with the exception of Franck et al., (2006) and Villata et al. (2018). In Experiment 1, we found no similarity-based effects on the verb, but, as we comment, the match inhibition effects on the noun in VS word order could be at least partially ascribed to the retrieval mechanisms, given that the verb is located before the noun. In Experiment 2, match inhibition on the verb was found, but that effect might be a spillover from the noun. Therefore, we could say that our results for the similarity-based interference at retrieval go in line either with the studies that find no effect of matching, or with those that find match inhibition at the verb.

Finally, this chapter also reveals some differences between Spanish and English. The effect of maintenance (i.e. the effect of Manipulation) over the embedded clause was present in both languages, and it was more prominent on the embedded subject noun (NP2) in both cases. This supports our proposal that the content of the maintained representation is noun-like. Although Lago et al. (2015) suggest that number prediction in subject-verb dependency is stronger in Spanish than in English, our findings on number feature maintenance and thus prediction do not allow us to draw clear conclusions. We saw that the (weak) match inhibition in the experimental items, which would evidence number maintenance, is present on NP2, while that effect occurs on the verb in English (possibly a spillover effect). However, in English, we did find the Manipulation effect on NP2, so it seems as if the effects found on the NP2 in Spanish are divided between NP2 and the verb in English. This difference between nouns and verbs in two languages could have occurred due to the fact that nouns in Spanish provide more morphosyntactic cues than the English ones. And, indeed, Spanish nouns are preceded by an article which is also number-marked, unlike English nouns. Therefore, it is possible that the effects related to the number representation (i.e. Matching effect) are limited to nouns in Spanish because the nouns are very informative when it comes to morphosyntax. In English, on the other hand, the nouns are less morphologically (number) marked, which is why the effect might be spread to both subject and the verb.





## **IV. The nature of the maintained representation: Disambiguation**

*“the streets of your glances have no ending”*

Vasko Popa, *Far Within Us*

In Chapter 3, we used similarity-based interference to show that the maintained representation contains the specification of the noun category. Whether the maintained representation is marked for the number feature, though, is still unclear. In the current chapter, we try to tackle this question from a different perspective. Rather than looking at the processing cost or the interference effects that the maintained representation might incur, we test how this maintained representation affects disambiguation of the interpolated material which is morphosyntactically ambiguous.

#### **4.1. Resolving (morpho)syntactic ambiguity**

Numerous studies have shown that the parser uses different kinds of contextual information in order to resolve structural ambiguity, such as the semantics of the preceding words (Ni & Crain, 1990; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994) or the preceding sentence (Marslen-Wilson & Tyler, 1987), referential context (Altman & Steedman, 1988), frequency (MacDonald, Pearlmutter, & Seidenberg, 1994), lexical features of the preceding verbs (MacDonald, 1994; Malaia, Wilbur, & Weber-Fox, 2010; Trueswell, Tanenhaus, & Kello, 1993), as well as their tense (Trueswell & Tanenhaus, 1991). But, although morphological or morphosyntactic ambiguity is pervasive across languages, it has been only scarcely studied.

The ambiguity of the case markers (syncretism) has been studied in German mostly in order to help understand syntactic disambiguation and parsing preference. Weber, Grice, & Crocker (2006) studied temporarily structurally ambiguous sentences in German, in which the initial noun was morphosyntactically ambiguous between a nominative-case subject (and thus pertaining to SVO word order), and an accusative-case object (and thus pertaining to OVS word order). They found that prosody can disambiguate the initial noun towards nominative (subject) interpretation, and SVO word order (see also Knoeferle, Crocker, Scheepers, & Pickering, 2005). Furthermore, Xiang, Harizanov, Polinsky, & Kravtchenko (2011) studied the interpretation of the ambiguously marked nouns in Russian. The nouns were ambiguous between genitive singular and the so-called *paucal* form, occurring with the numerals 2-4. The results of this study show that the preceding numerals affect the

interpretation by biasing towards paucal reading. These studies show that cues such as prosody or a preceding word's meaning can bias the interpretation of an ambiguously marked noun.

In the current chapter, we investigate whether the interpretation of morphosyntactically ambiguous nouns is biased by the representation maintained in subject-verb agreement establishment. Based on this, we can draw inferences about the nature of the maintained representation and, more specifically, test whether the number feature is part of it.

#### 4.2. Basque ambiguous nouns and Basque relative clauses

In the experiments presented in the current chapter, we investigate whether active maintenance affects morphosyntactic disambiguation in a language typologically different from those presented so far - Basque. Since Basque is a head-final language, prediction mechanisms could be stronger or different from those in head-initial languages, as suggested previously (Lago et al., 2015; Vasishth, Suckow, Lewis, & Kern, 2010). Indeed, all the agreement and argument structure building in Basque occurs at the auxiliary verb, which is positioned late in the sentence. This might reinforce maintenance of the morphosyntactic information throughout the course of the sentence and thus enable us to detect the maintained number information more easily.

We take advantage of the Basque noun phrase system, where nouns that are marked with *-ak* are ambiguous between singular ergative and plural absolutive case. Namely, the subjects of transitive verbs in Basque are marked with ergative case (*-(a)k* for singular, *-ek* for plural), while the subjects of intransitive verbs are marked for absolutive case (which is a zero morpheme, thus equals to the determiner, which is *-a* for singular, *-ak* for plural). Thus, the nominal suffixes *-ek* (ergative plural) and *-a* (absolutive singular) are unambiguous, while the *-ak* sequence is ambiguous. It denotes either singular number and ergative case (combination of singular determiner morpheme *-a* and ergative marker *-k*), as shown in (7a), or plural number and absolutive case (plural determiner morpheme *-ak* and zero morpheme), as shown in (7b). Additionally, in transitive constructions, direct objects take absolutive case (plural or singular), as shown in (7c). The sequence *-ak* can therefore be used to mark

singular subjects of transitive verbs, plural subjects of intransitive verbs or plural objects of transitive verbs.

7.a) *Mutilak ogia erosi du*

boy-det-ERG.SG bread-det-ABS.SG buy has

“The boy has bought a bread”

b) *Mutilak etorri dira*

boy-det-ABS.PL arrive are

“The boys have arrived”

c) *Gizonak mutilak ikusi ditu*

man-det-ERG.SG boy-det-ABS.PL see has

“The man has seen the boys”

Several studies have already made use of the ambiguity of the Basque nouns marked with *-ak*. Given its ambiguity regarding the ergative/absolutive construction and thus subject/object interpretation, these nouns have been used to demonstrate the preference for SOV word order. Namely, sentence-initial nouns marked with *-ak* have been shown to be preferably interpreted as ergative subjects in sentence comprehension (Erdocia, Laka, Mestres-Missé, & Rodriguez-Fornells, 2009; Erdocia, Zawiszewski, & Laka, 2014; Yetano, Duñabeitia, & Laka, 2011) and sentence production (Ristic, Mancini, & Molinaro, 2017; under review) although the object, absolutive plural interpretation seems to be preferred when the NPs are isolated (Ristic et al., 2017; under review). Besides implying a SOV, canonical word order preference, this also means that there is a preference to interpret sentence-initial ambiguous arguments as agents (absent outside of the sentential context). Importantly for our experiments, previous research has also shown that nouns ambiguously marked with *-ak* can be disambiguated by the number features of another element within the same NP (Ristic et al., 2017; under review). Here, we follow the same idea and test whether a maintained representation’s number feature can help disambiguate nouns with *-ak*.

In the experiments presented in this chapter, the nouns ambiguously marked with *-ak* are part of the clause that is positioned between matrix subject and matrix verb and they are disambiguated at

the auxiliary located at the end of the embedded clause (*Matrix NP, ....ambiguous NP* <sub>[SG/PL]</sub> ...*disambiguating VP, matrix VP*). It should be noted that both postnominal and prenominal relative clauses exist in Basque, although the latter type is more frequent (De Rijk, 1972; Laka, 1996). In contrast to many head-initial languages, not a lot of studies have been devoted to Basque relative clauses. Carreiras, Duñabeitia, Vergara, De La Cruz-Pavía, & Laka (2010) studied subject and object prenominal relative clauses in Basque and found that the trend opposed the one observed for head-initial languages: subject relative clauses elicited more cost than the object relative clauses. This is however in line with some findings on another head-final language, namely Chinese (e.g. Hsiao & Gibson, 2003; Lin & Garnsey, 2010). However, in a self-paced reading study with postnominal relative clauses, subject relative clause preference was found (Yetano, Duñabeitia, De La Cruz-Pavía, Carreiras, & Laka, 2010), as longer reading times were obtained on the matrix auxiliary verbs disambiguating the previously encountered clause as object relative. Although investigating relative clauses is not the focus of the experiments presented in this chapter, our study design also enables us to provide additional evidence on Basque postnominal relative clauses, albeit with different structures and experimental design.

### ***4.3. Current Chapter***

As suggested in Chapter 1, Box 1.2, and followed in Chapter 3, one of our basic assumptions is that, if a feature is actively maintained, it should interact with the elements over which it is maintained. Here, we investigate whether the number information that is being actively maintained as part of subject-verb dependency computation can disambiguate a number and case-ambiguous noun. Thus, the number feature that is part of active processing should bias the reading of the ambiguously marked noun towards singular ergative (when actively maintaining singular feature) or plural absolutive (when actively maintaining plural feature). We will measure eye movements on the ambiguous noun to see if they vary as a function of the matrix subject number which is maintained. Thus, we expect the ambiguous noun to be interpreted as singular ergative more when the matrix

subject is singular, and as plural absolute more when the matrix subject is plural. Importantly, we measure eye movements on the ambiguous noun, before the disambiguation has taken place. Our design thus allows us to compare reading times on two sentences that, at the point of processing the embedded ambiguous noun, only differ on whether the preceding matrix subject is plural or singular. In line with Chapter 3, we also present the analyses for the verb region, where the integration of the subject-verb dependency takes place, and, in this case, where the ambiguous noun is disambiguated. Also, following Experiments 1 and 2, we introduce additional, control items, in order to make sure that the difference between the conditions can be ascribed to active maintenance within the subject-verb dependency. In the control items, the ambiguous noun is not interpolated between the matrix subject and verb, and thus no maintenance is expected.

Moreover, we employ two different paradigms in this chapter: the eye-tracking during reading and the visual world paradigm. Both of these paradigms have been extensively used in language research and together, they provide a comprehensive representation of sentence processing. Eye tracking during reading has been useful in investigating both word-level effects, as well as sentence-level effects (see Chapter 1, Section 1.5), while the visual world paradigm has been very useful in capturing incremental language processing as it develops. Importantly for the current study, the visual world paradigm has been successfully applied to study prediction in sentence processing (e.g. Gussow, Kapnoula, & Molinaro, 2019; Kamide, Altmann, & Haywood, 2003), due to its ability to reflect immediate processing of spoken language.

#### ***4.4. Experiment 3: Eye-tracking during reading study***

In Experiment 3, we aim at investigating reading times on the ambiguously marked nouns that are interpolated between the matrix subject and verb. More specifically, we are testing whether the morphosyntactic feature of number is actively maintained and thus biases number (and consequently case) disambiguation in reading.

In order to interpret whether the ambiguous noun is read as absolutive plural or ergative singular, we refer to the previous research that has found processing differences between transitive and intransitive constructions. Namely, various experiments showed that processing of transitive constructions is more costly than processing of intransitive constructions, as complexity is shown to increase with the number of arguments (Meltzer-Asscher, Mack, Barbieri, & Thompson, 2015; Thompson et al., 2007; Thompson, Bonakdarpour, & Fix, 2010; Thompson & Meltzer-Asscher, 2014). We apply these findings to our study, given that processing ergative singular implies building a transitive, and processing absolutive plural implies building an intransitive configuration. Thus, an increase in reading times between the conditions will be interpreted as ergative singular (transitive) reading of the ambiguous noun.

As in Chapter 3, we measure active maintenance effects in early reading measures, which are not expected to be affected by the subsequent area processing. Specifically, we expect first pass and go-past reading times, as well as regressions to the previous areas to be increased (i.e. the ambiguous noun to be read as ergative singular, and transitive construction) when the matrix subject is singular, compared to when it is plural. Therefore, increased reading times are expected in singular matrix subject condition due to ergative singular (transitive) reading of the ambiguous noun, caused by singular feature maintenance.

#### **4.4.1. Methods**

##### **4.4.1.1. Participants**

Twenty four participants (7 male, 17 female) aged 19 to 35 ( $SD=4.09$ ) took part in the experiment. They were all native Basque-Spanish bilinguals, with 22 of them being Basque dominant and acquiring Basque from birth, while the remaining 2 were Spanish dominant and acquired Basque at 3 years of age. They all received the highest score in a Basque language interview and marked at least 60 out of 65 on the BEST language test (de Bruin et al., 2017), with one participant scoring 57

(SD=2.06). Twenty one participants had the official language certificate that proves their high proficiency in standard Basque<sup>7</sup>. The experiment was approved by the BCBL Ethics Review Board and complied with the guidelines of the Helsinki Declaration.

#### 4.4.1.2. Stimuli and study design

The experimental stimuli consisted of 60 experimental items. The critical (ambiguous) noun was located within an embedded relative clause, which was interpolated between a matrix subject and a matrix verb. There was no relative pronoun, but the morpheme cluster *-en+a(k)* on the auxiliary marked the relative clause (this differs from the postnominal relative clauses in Yetano et al., 2010). The number of the matrix subject/verb was manipulated (unambiguously singular or unambiguously plural), in order to test if it affects the interpretation of the ambiguously marked critical noun (absolute plural/ergative singular). The relative clause was disambiguated at the auxiliary at the end of the relative clause, either as singular ergative and thus object relative, or as absolute plural and thus subject relative clause. As both subject-verb and object-verb agreement are marked in Basque, this resulted in four different markings on the auxiliary. Thus, we created a 2 x 2 study design, with Matrix number (singular, plural) and Disambiguation (ergative singular, absolute plural) factors (see Table 4.1).

Besides the experimental items, 60 additional control items were created to attest that the potential effects are coming from the maintenance of singular/plural feature. In these items, the critical ambiguous noun was not located between the matrix subject and the matrix verb and thus no subject-verb agreement information is expected to be maintained over it. Rather, the nouns were preceded by a clause ending with an adjunct, whose number (singular/plural) was manipulated (see Table 4.1). Again, the second clause containing the ambiguous critical noun was disambiguated as ergative singular or absolute plural, and the clause was constructed accordingly. This also generated

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<sup>7</sup> Twenty participants obtained EGA certificate, which is awarded by the Department of Education of the Basque Government and is equivalent to level C1 of the Common European Framework of Reference for Languages. In order to obtain this certificate, candidates must demonstrate both oral and written skills that are in accordance with the rules established by the Royal Academy of the Basque Language concerning spelling and unified Basque. One participant obtained other type of language certificate that corresponds to C1 level.



a 2x2 design for the control items, with Adjunct number (singular, plural) and Disambiguation (ergative singular, absolutive plural) factors. Unlike in Experiments 1 and 2, the control items were a separate set of items and were thus analyzed separately (due to the nature of the Basque sentences).

The experimental items were Latin Squared into 4 lists, in such a way that each item occurred only once per list. The same was done for the control items. Eighty fillers were added to each list, whose structure, length and lexical content were varied. Both in experimental and control items, the critical ambiguous noun was animate, and nouns that are not usually used in either singular or plural form were avoided (e.g. parent or wives)<sup>8</sup>. The full list of stimuli is provided in the Appendix A3.

item	matrix number	disambiguation	Example
Experimental	Sg	ergative singular (OR)	Nere <b>ahizpa</b> <sub>[Sg]</sub> , dirudienez <b>mutilak</b> asko maite <u>duena</u> <sub>[S-Sg, O-Sg]</sub> , desagertu <b>egin zen</b> . “My sister, whom a boy apparently loves a lot, disappeared.”
		absolutive plural (SR)	Nere <b>ahizpa</b> <sub>[Sg]</sub> , dirudienez <b>mutilak</b> asko maite <u>dituena</u> <sub>[S-Sg, O-Pl]</sub> , desagertu <b>egin zen</b> . “My sister, who apparently loves the boys a lot, disappeared.”
	Pl	ergative singular (OR)	Nere <b>ahizpek</b> <sub>[Pl]</sub> , dirudienez <b>mutilak</b> asko maite <u>dituenak</u> <sub>[S-Pl, O-Sg]</sub> , kotxe bat <b>erosi zuten</b> . “My sisters, whom a boy apparently loves a lot, bought a car.”
		absolutive plural (SR)	Nere <b>ahizpek</b> <sub>[Pl]</sub> , dirudienez <b>mutilak</b> asko maite <u>dituztenak</u> <sub>[S-Pl, O-Pl]</sub> , kotxe bat <b>erosi zuten</b> . “My sisters, who apparently love the boys a lot, bought a car.”
Control	Sg	ergative singular (OR)	Nere ahizpa pozik zegoen <b>azterketagatik</b> <sub>[Sg]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zuen</u> . “My sister was happy about the exam, so the boy invited her for a drink.”
		absolutive plural (SR)	Nere ahizpa pozik zegoen <b>azterketagatik</b> <sub>[Sg]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zituen</u> . “My sister was happy about the exam, so she invited the boys for a drink.”
	Pl	ergative singular (OR)	Nere ahizpa pozik zegoen <b>azterketengatik</b> <sub>[Pl]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zuen</u> . “My sister was happy about the exams, so the boy invited her for a drink.”
		absolutive plural (SR)	Nere ahizpa pozik zegoen <b>azterketengatik</b> <sub>[Pl]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zituen</u> . “My sister was happy about the exams, so she invited the boys for a drink.”

Table 4.1. Example of an experimental item used in Experiments 3 and 4. The squared brackets subscripts on the nouns mark the number of the noun (Sg= singular, Pl=plural), while the squared brackets subscripts on the auxiliaries mark the agreement with the subject (S) and object (O); SR= subject relative clause, OR= object relative clause

<sup>8</sup> Twenty ambiguous nouns overlapped in experimental and control condition.

Yes/no comprehension questions appeared after 50% items, equally distributed over experimental, control and filler items (100 questions in total). For both the experimental and control items, the questions were focused on the content of the clause containing the ambiguous noun, to make sure the participants processed the ambiguous noun correctly, i.e. that the disambiguation was successful (e.g. for the example in Table 4.1, the question would be *Does the boy like the girl?* for experimental, and *Did the girl invite her friends for a dinner?* for the control items).

Both in control and experimental items, there was only one word (an adverbial) between the ambiguous critical noun and the manipulated word (adjunct in the control items and the matrix subject noun in the experimental items). Therefore, if number information maintenance is triggered at the matrix subject and kept active until the matrix verb is reached, i.e. over the relative clause, this information should bias the reading of the number-ambiguous noun within the relative clause. However, if the disambiguation also takes place in the control condition as a function of the adjunct number, that would imply that the disambiguation effects are not occurring due to the subject-verb agreement maintenance.

### Naturalness judgment task

As the stimuli in the current experiment are characterized by structurally complex sentences with postnominal relative clauses, which are not as frequent as the prenominal ones (De Rijk, 1972; Laka, 1996), we carried out a naturalness judgment task before the experiment. Twelve native Basque speakers who didn't take part in the experiment rated the sentences on a scale from 1 (= very unnatural, unusual) to 7 (= very natural, usual). The rating revealed a medium naturalness, whose average value was 3.85 (SD= 1.64) for the experimental items and 4.16 (SD= 1.68) for the control items. We fitted linear mixed effects models, with Matrix number (singular, plural) and Disambiguation (ergative singular, absolutive plural) conditions as fixed effects and random by-subject and by-item intercepts, separately for the experimental and the control items.

The analysis on the experimental items showed a main effect of Matrix number, such that sentences with singular matrix number were rated as more natural [Intercept: 3.66, Estimate: 0.28, SE: 0.14,  $t= 2.02$ ]. The analysis on the control items showed no significant effects (all  $ts < 1.13$ ).

#### **4.4.1.3. Procedure**

The session consisted of a practice block (5 items), followed by two experimental blocks (100 items each). The rest of the procedure and apparatus was the same as described in Experiment 1.

#### **4.4.1.4. Data Analysis**

Due to the nature of our study design, experimental and control items were analyzed separately. Both for the control and the experimental items, the critical region in this experiment was the ambiguous noun marked with *-ak*. At this region, the clause is still ambiguous between object relative and subject relative clause. We performed analyses separately for first pass, go-past and, as well as the regressions out of the noun to the previous interest area, and separately for the control and for the experimental items.

Additionally, for the experimental items, we analyzed the reading times on the embedded verb, i.e. the disambiguating region. Although the main focus of the current experiment was to look at the effects on the ambiguous noun before the disambiguation (i.e. before reaching the auxiliary verb), analyzing the verb can be potentially informative about how maintenance and retrieval processes interact (see Chapter 3). Furthermore, analyzing the verb allows us to test for possible differences between object relative and subject relative clauses in Basque. Previous research on prenominal relative clauses in Basque (Carreiras et al., 2010) has found that subject relative clauses are harder to process than object relative clauses, while research on the postnominal relative clauses (Yetano et al., 2010) suggests the opposite. Thus, our expected transitivity-based pattern of results, where processing

absolute plural is expected to incur shorter reading times compared to ergative singular, might be either boosted or reversed by the subject/object relative preference. This additional analysis was not performed on the control items, as their aim was to control for the possible maintenance effects only, i.e. those occurring at the ambiguous noun.

For the ambiguous noun region in both experimental and control items, we fitted linear mixed-effect models (for reading times) or generalized linear mixed-effect models (for proportion of regressions) with Matrix Number (singular, plural) as a fixed effect. By-item and by-subject random intercepts and slopes (when resulting in a converging model) were also added. For the disambiguating verb region in the experimental items, we also included the Disambiguation factor, so the fixed effects included the interaction of Matrix Number (singular, plural) and Disambiguation (absolute plural, ergative singular), while the random effects were the same. Additionally, word length was added to the model analyzing the verb region (as the length of the auxiliary verb varied across the conditions, see Table 4.1), whereby the model containing the centered Word Length factor was always compared to the model without that factor but with the same random effects structure (the models with this factor were kept if significantly improving the model fit). The rest of data preprocessing, analysis and model selection was performed following the steps described in Experiment 1.

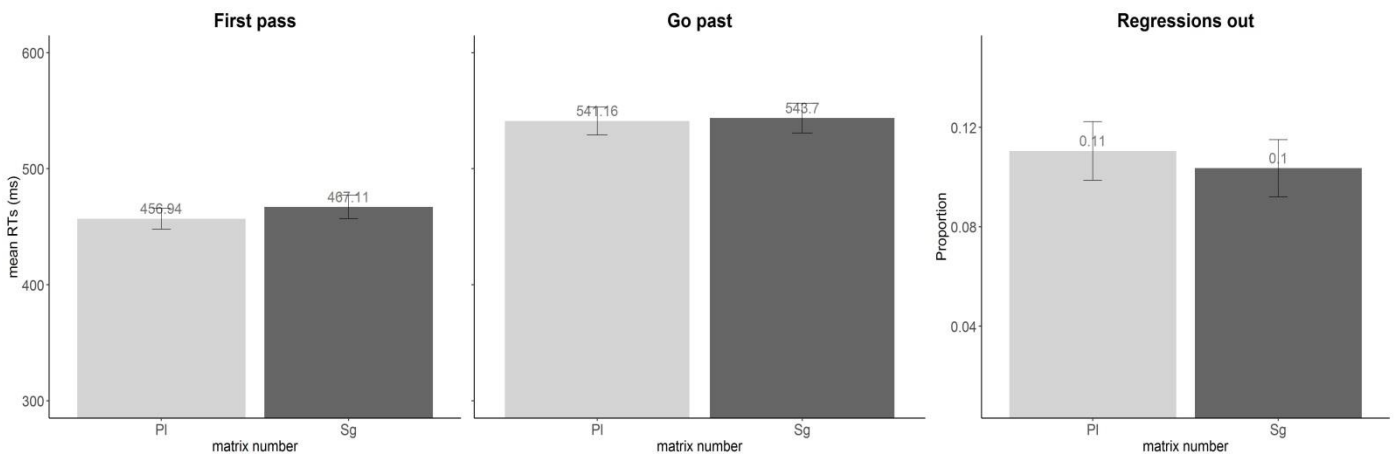
#### **4.4.2. Results**

Due to a technical error, accuracy data was lost for 2 participants. The rest of the participants scored above 87% on the comprehension questions, with a mean of 91.59% (SD=0.28). The average accuracy for the experimental items was 87.12%, (SD=0.33), 88.48% (SD=0.32) for the control items, and 97.16% (SD=0.16) for the filler items. One experimental item was removed from the analysis due to a spelling error.

**4.4.2.1. Experimental items**

**4.4.2.1.1. Ambiguous noun analysis**

We found no significant effects for the first pass reading times, go-past reading times, or the regressions out of the ambiguous noun to the previous regions (see Table 4.2 and Figure 4.1).



**Figure 4.1.** First pass reading times, go-past reading times and regressions out of the ambiguous noun for the experimental items in Experiment 3. The numbers on the top of the bars represent the mean values for that level of the factor. PI= plural matrix number, Sg= singular matrix number

**Ambiguous noun region – experimental items****First pass****model: firstpass~ matrixnumber + (1|participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	461.55	26.52	17.40	409.57	513.52
<b>matrixnumber1</b>	4.73	5.41	0.87	-5.87	15.34

**Go-past****model: gopast~ matrixnumber + (1+matrixnumber |participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	541.81	30.93	17.51	481.18	602.44
<b>matrixnumber1</b>	0.98	10.18	0.10	-18.96	20.92

**Regressions out****model: regout~ matrixnumber + (1|participant)**

	estimate	se	z.value	p.value	conf.low	conf.high
<b>(Intercept)</b>	-2.12	0.09	-23.92	2.03E-126	-2.30	-1.95
<b>matrixnumber1</b>	-0.04	0.09	-0.42	0.67	-0.21	0.13

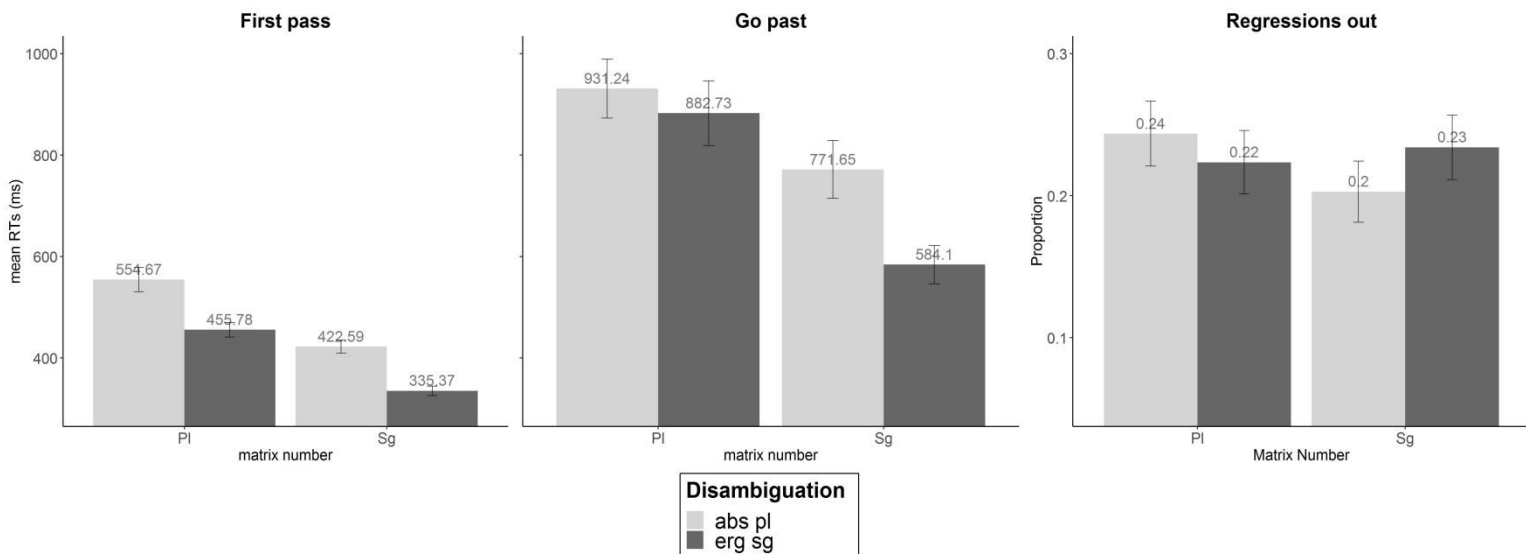
Table 4.2. Analyses for the ambiguous noun region for the experimental items in Experiment 3. Coding: for the Matrix Number factor, -1=plural, 1= singular; for the Disambiguation factor, -1=absolute plural, 1=ergative singular.

***4.4.2.1.2. Disambiguating (embedded verb) region analysis***

In the first pass reading time analysis, we found a significant Matrix Number effect, such that first pass reading times increased in the presence of a plural matrix subject, compared to the singular matrix subject. We also found a significant Disambiguation effect, as reading times increased when the verb disambiguated the ambiguous noun as absolute plural (see Table 4.3 and Figure 4.2). Adding Word Length did not result in a better model fit.

The same Matrix Number and Disambiguation effects emerged in go-past reading times (see Table 4.3 and Figure 4.2). Also, adding Word Length factor did not significantly improve the model fit.

For the regressions out of the verb, we found marginal effects of Word Length and Disambiguation, as ergative singular condition elicited more regressions than absolutive plural condition (see Table 4.3 and Figure 4.2).



**Figure 4.2.** First pass reading times, go-past reading times and regressions out of the disambiguation verb region for the experimental items in Experiment 3. The numbers on the top of the bars represent the mean values for that level of the factor. Pl= plural matrix number, Sg= singular matrix number; abs pl= absolutive plural disambiguation; erg sg= ergative singular disambiguation

**Disambiguating (embedded verb) region – Experimental items****First pass****model: firstpass~ matrixnumber\* disambiguation+ (1|participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	440.82	29.46	14.96	383.08	498.57
<b>matrixnumber1</b>	-63.25	7.16	<b>-8.83</b>	-77.29	-49.21
<b>disambiguation1</b>	-47.06	7.16	<b>-6.57</b>	-61.10	-33.02
<b>matrixnumber1:disambiguation1</b>	2.99	7.16	0.42	-11.05	17.03

**Go-past****model: gopast~ matrixnumber\* disambiguation+ (1+ matrixnumber|participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	788.88	90.50	8.72	611.51	966.25
<b>matrixnumber1</b>	-113.27	33.54	<b>-3.38</b>	-179.01	-47.53
<b>disambiguation1</b>	-61.12	24.94	<b>-2.45</b>	-110.01	-12.23
<b>matrixnumber1:disambiguation1</b>	-34.07	24.95	-1.36	-82.96	14.83

**Regressions out****model: regout~ matrixnumber\* disambiguation+ length + (1+ matrixnumber|participant) + (1|item)**

	estimate	se	z.value	p.value	conf.low	conf.high
<b>(Intercept)</b>	-1.55	0.23	-6.80	0.00	-1.99	-1.10
<b>matrixnumber1</b>	0.30	0.23	1.30	0.19	-0.15	0.762
<b>disambiguation1</b>	0.26	0.15	<u>1.73</u>	0.08	-0.03	0.55
<b>length</b>	0.45	0.26	<u>1.75</u>	0.08	-0.05	0.95
<b>matrixnumber1:disambiguation1</b>	0.11	0.07	1.52	0.13	-0.03	0.24

Table 4.3. Analyses for the disambiguating region for the experimental items in Experiment 3. Coding: for the Matrix Number factor, -1=plural, 1= singular; for the Disambiguation factor, -1=absolute plural, 1=ergative singular. Significant effects are in bold, and marginal effects are underlined.

**4.4.2.2. Control items****4.4.2.2.1. Ambiguous noun analysis**

We found no significant effects in first pass reading times, go-past reading times, or in regressions to the previous regions (see Table 4.4 and Figure 4.3).



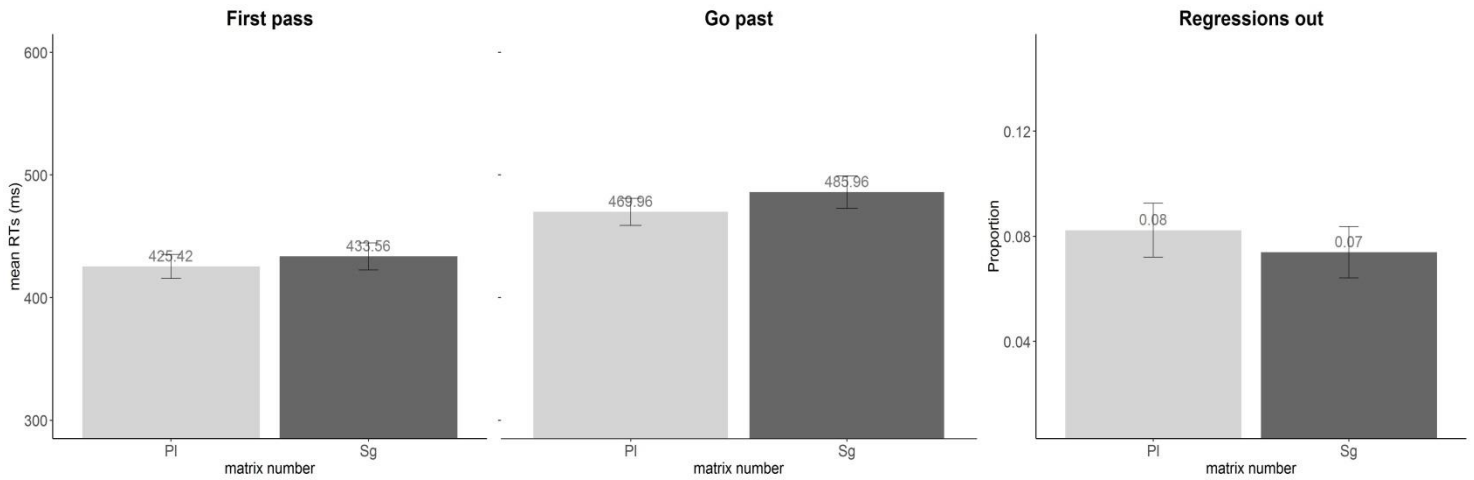


Figure 4.3. First pass reading times, go-past reading times and regressions out of the ambiguous noun for the control items in Experiment 3. The numbers on the top of the bars represent the mean values for that level of the factor. Pl= plural matrix number, Sg= singular matrix number

**Ambiguous noun region– control items**

**First pass**

**model: firstpass~ matrixnumber + (1|participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	429.39	28.56	15.03	373.41	485.37
<b>matrixnumber1</b>	3.86	5.99	0.64	-7.88	15.60

**Go-past**

**model: gopast~ matrixnumber + (1|participant) + (1|item)**

	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	477.71	31.44	15.19	416.08	539.34
<b>matrixnumber1</b>	7.83	7.23	1.08	-6.35	22.00

**Regressions out**

**model: regout~ matrixnumber + (1|participant) + (1|item)**

	estimate	se	z.value	p.value	conf.low	conf.high
<b>(Intercept)</b>	-2.77	0.21	-13.47	0.00	-3.18	-2.37
<b>matrixnumber1</b>	-0.06	0.10	-0.59	0.55	-0.26	0.14

Table 4.4. Analyses for the ambiguous noun region for the control items in Experiment 3. Coding: for the Matrix Number factor, -1=plural, 1= singular; for the Disambiguation factor, -1=absolute plural, 1=ergative singular.

### 4.4.3. Interim Discussion

Our main region of interest in this study was the ambiguously marked noun (*-ak*) functioning as the subject/object of the embedded clause. We expected that this noun would be read as singular in the singular matrix subject condition due to the presence of the singular maintained feature, and as plural in the plural matrix subject condition due to the presence of the plural maintained feature. Since reading a noun as singular ergative would mean interpreting it as an argument of a transitive verb, and as transitive constructions were shown to be costlier than the intransitive ones (e.g. Thompson et al., 2007, 2010; Thompson & Meltzer-Asscher, 2014), we expected that the reading times would be longer in the singular condition. However, the results showed no statistically reliable difference between the two conditions. No difference was found in the control conditions either.

When it comes to the results for the disambiguating verb time window, we found a significant main effect of Matrix Number, as plural matrix subjects triggered longer reading times. We also found a significant effect of Disambiguation, triggered by longer reading times on the verb when it disambiguated the ambiguous noun as absolutive plural (subject relative clause). This result goes in line with the previous research on prenominal relative clauses in Basque (Carreiras et al., 2010), where increased processing cost was found for the subject relative clauses. In contrast to this, the marginal effect of Disambiguation on the regressions out suggests that disambiguating nouns as ergative singular, i.e. realizing the clause is an object relative clause, triggers more regressions out. This effect goes in line with the previous findings on postnominal relative clauses (Yetano et al., 2010), but it did not reach statistical significance. We discuss these findings in the General Discussion of the current chapter.

Nevertheless, the lack of a strong Matrix Number effect in the early measures on the ambiguous noun is preventing us from making any strong claims about number feature maintenance. It is thus possible that measuring maintenance of the number feature by drawing inferences about transitive or intransitive reading might simply not be the most efficient paradigm to test our research question. For that reason, we designed Experiment 4.

## 4.5. Experiment 4: Visual world paradigm study

In Experiment 3, the lack of significant effects on the ambiguous noun prevented us from drawing strong conclusions about active maintenance of the number feature. In Experiment 4, we hope to get a more direct measure of singular/plural reading of the ambiguous noun. Namely, instead of looking at whether reading times change as a function of transitive/intransitive reading, which in turn should tell us about singular/plural interpretation, we opt for a more straightforward design. We employ a visual world paradigm and simply test whether the participants are looking at plural or singular pictures at the point of ambiguity.

The visual world paradigm has already been used to study if number information is used predictively in subject-verb agreement. Lukyanenko & Fisher (2016) studied whether toddlers and adults use the number marking on the verb to anticipate the referent. They compared the looks during the beginnings of the sentences which either contained a number-marked verb or not (*Where are/is the... or Do you see the...*). They found that both toddlers and adults are shifting their looks towards the image that represents the number of the referents that corresponds to the marking on the verb, even before that referent (...*cookie/cookies?*) has been heard. Thus, the authors conclude that morphosyntactic number information is used predictively in online language comprehension. Accordingly, we expect more looks on the plural image in the plural matrix subject condition, indicating plural interpretation of the ambiguous noun, and, conversely, more looks on the singular image in the singular matrix subject condition, indicating singular interpretation of the ambiguous noun.

### 4.5.1. Methods

#### 4.5.1.1. Participants

Twenty-eight participants (12 male, 16 female) aged 18 to 40 ( $SD=5.92$ ) took part in the experiment. They were all native Basque-Spanish bilinguals whose dominant language was Basque,

and who acquired Basque from birth. They all received the highest score in a Basque language interview and marked at least 62 out of 65 on the BEST language test (de Bruin, Carreiras, & Duñabeitia, 2017), with one participant scoring 59 (SD=1.49). Twenty-five participants had an official language certificate that proves their high proficiency in standard Basque<sup>9</sup>. The experiment was approved by the BCBL Ethics Review Board and complied with the guidelines of the Helsinki Declaration.

#### **4.5.1.2. Stimuli and study design**

The linguistic stimuli in Experiment 4 were the same as those in Experiment 3. In eight experimental items, ambiguous nouns were substituted by higher imageability nouns, to achieve a better visual representation. The same was done for control items, where several items were also changed to avoid ambiguous noun repetition. The changes are marked in Appendix A3. The sentences were recorded in standard Basque by a native speaker in a soundproof cabin, using a Sennheiser microphone, and were preprocessed with Praat software.

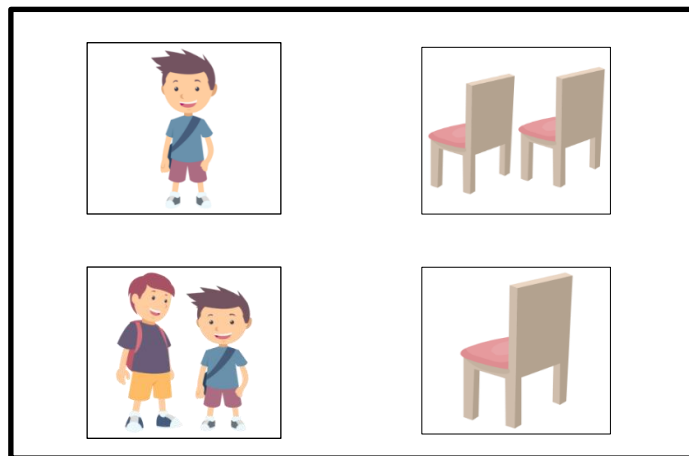
For each of the 60 experimental items, a visual representation of the critical noun was created both in its singular version (one token of the entity that the noun represents, e.g. one boy for the noun *mutilak*), and its plural version (two tokens of the entity that the noun represents, e.g. two boys for the noun *mutilak*). Since the critical nouns in experimental and control items were animate, the plural image was created by adding a different token of the same entity (e.g. two different boys), rather than duplicating the singular one. This was done in order to achieve naturalness. For the 20 nouns that were the same in control and experimental items, the same images were used. For the filler items, one of the nouns from the sentence was depicted and represented in singular and plural version. These nouns were always inanimate and served (in their singular and plural version) as distractors for the experimental and control items. By using the images for the experimental and control items as

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<sup>9</sup> Twenty two participants obtained EGA certificate, two participants had other types of official certificates that correspond to C1 level, while one participant obtained a C2 level certificate.

distractors for the filler items, the number of occurrences of each image across the experiment was balanced.

Each item was related to one 4-image screen (see Figure 4.7). The 4 images represented: the critical noun in its singular version, the critical noun in its plural version, the distractor image in its singular version (taken from the filler items, and thus inanimate), and the distractor image in its plural version. The position of each image type in each of the positions (upper left, upper right, lower left and lower right) was counterbalanced. Images for both singular and plural versions were of the same size (15 x 15 cm) and were limited by a half-inch border. This was done in order to make sure that the singular and plural image are taking the same surface on the screen. All the pictures were taken from a free online source ([www.freepik.com](http://www.freepik.com)) and were modified using the InkSpace software.



**Figure 4.7. Illustration of the visual display used in Experiment 4**

#### **4.5.1.3. Procedure**

We used a modified version of the visual world paradigm used in sentence processing (Altmann & Kamide, 1999; Tanenhaus et al., 1995). The participants listened to the sentences using the headphones, while looking at the images on the screen. However, unlike the typical visual world paradigm, the images did not appear from the beginning of the auditory presentation of the sentence. Namely, since we were not interested in participants' looking behavior prior to hearing the critical

ambiguous noun, we presented the visual stimuli only 500 ms before the critical word onset. That way, we also hoped to eliminate the looking behavior related to the words in the sentence prior to the critical one. This was especially important because both experimental and control items contain animate nouns prior to the critical nouns. Therefore, from the auditory onset of the sentence, the participants were presented with a fixation cross. They were asked to listen to the sentences and look at the fixation cross, until the images appear. They were told to look wherever they wanted upon the appearance of the images. They were also instructed to listen to the sentences carefully and to answer the comprehension questions.

The session consisted of a practice block (5 items), followed by two experimental blocks (100 items each). The yes/no comprehension questions appeared after 50% items, equally distributed over experimental, control and filler items. For the experimental and control items, the questions were focused on the content of the clause containing the ambiguous noun, to make sure the participants processed the ambiguous noun correctly, i.e. that the disambiguation was successful. On the rest of the items (50%), a picture selection task was performed. In this task, the participants were asked to listen to the ambiguous noun from the just heard sentence once again and click on the image that corresponds to the noun in that particular sentence. For that purpose, the 4-image screen that appeared during the presentation of the sentence appeared once again, and the ambiguous noun was played. The ambiguous noun audio was extracted from the same sentence audios that the participants had listened using Praat software. This task was added in order to make sure that the participants pay attention to the visual stimuli, as well as to ensure the correct disambiguation and thus comprehension. The sentences were presented auditorily through headphones. Before each trial, participants had to fixate a red point positioned on the left side of the screen, where the first word of each item appeared. The experiment was performed using the SR EyeLink 1000 (SR Research, Toronto, ON, Canada) eyetracker with a sampling rate of 500 Hz. The rest of the procedure and apparatus was the same as in Experiments 1 and 3.

#### **4.5.1.4. Data analysis**

We performed the initial steps of data preprocessing using the Data Viewer software (SR Research). Firstly, the short fixations ( $\leq 80$  ms) were merged with the preceding/following fixation that was within 0.5 degrees of visual angle (Duñabeitia, Avilés, Afonso, Scheepers, & Carreiras, 2009). Otherwise, fixations shorter than 80 ms were removed. To analyze the potential effects during the ambiguous word presentation period, we analyzed the time period that starts 500 ms before the onset of the ambiguous word, until the end of it<sup>10</sup>. As the critical words were of different lengths, the duration on the ambiguous noun window ranged from 416 to 980 ms for the experimental, and from 203 to 1066 ms for the control items. We generated the sample report for the ambiguous noun window, which provides the eye movement data for each eye sample in a trial. Then, the ambiguous word time window was divided into 20 ms time bins, which with the current sampling rate provided 10 samples per bin, and the proportion of looks (samples) in each interest area for each bin was calculated. Fixations were automatically calculated as falling inside the squared interest area that surrounded each object on the screen in a given sample or not.

We tested the proportion of the looks to singular and plural image. Both the proportion of looks to the singular and the plural images were baselined by subtracting the mean proportion of looks to the two distractors. Formatting, binning, and calculation of proportions was done using the package *VWPre* (Porretta, Kyröläinen, van Rij, & Järvikivi, 2018), while the analyses were performed using the same software as in Experiments 1, 2 and 3. We fitted linear mixed-effect models for the proportion of looks, following the model selection procedure described in Experiment 1. The dependent variable was the proportion of looks, while the independent variables were the Matrix Number (singular, plural) and Image Number (singular, plural). Thus, we were able to test whether the proportion of looks changes as a function of interest area, and, importantly, whether that is modulated by the number of the matrix subject. Effect coding was used for all the independent variables. We report the intercept, the estimate, standard error, and the *t* values in tables.

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<sup>10</sup> We have also analyzed the interest period including only the ambiguous noun presentation in experimental items (i.e. excluding the 500 ms prior to the stimulus onset), and obtained the same results.

Additionally, as in Experiment 3, we also analyzed the time window during the presentation of the auxiliary verb which disambiguates the clause (disambiguating verb window). The duration of the auxiliary ranged from 326 to 829 ms, and we analyzed the proportion of looks in the 830 ms window, in order to make sure that all the phonemes from the longest auxiliaries entered the analysis<sup>11</sup>. The dependent variable was the proportion of looks, while the independent variables were the Matrix Number (singular, plural), Disambiguation (ergative singular, absolutive plural) and Image Number (singular, plural). The rest of the data preprocessing and analysis was the same as the one for the ambiguous region analysis. As in Experiment 3, this additional analysis was not performed on the control items, as their aim was to control for the possible maintenance effects only, i.e. those occurring at the ambiguous noun.

## 4.5.2. Results

### 4.5.2.1. Comprehension tasks

The overall accuracy for both tasks was 83.57% (SD=0.37), with participants scoring from 68.5% to 93%. The average accuracy for experimental condition was 70.35% (SD=0.46), 80.77% (SD=0.39) for the control items, and 95.58% (SD=0.21) for the fillers. When it comes to the comprehension questions, all the participants scored from 71% to 96%, with an average score of 86.11% (SD=0.49). More precisely, the mean accuracy for the experimental items was 77.02% (SD=0.42), 79.52% (SD=0.40) for the control items, and 97.86% (SD=0.15) for the filler items. When it comes to the picture selection task, the participants scored from 66% to 91%, with an average score of 81.03% (SD=0.39). The accuracy for the experimental items on the picture selection task was 63.69% (SD=0.48), 82.02% (SD=0.38) on the control items, and 93.30% (SD=0.25) on the fillers.

As we can see, the overall mean accuracy for the experimental items is by 10.42% lower than the accuracy for the control items, but this difference seems to be emerging from the picture selection

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<sup>11</sup> It was not possible to adjust the time window for every item, as for ambiguous noun window. We have also performed the analysis using the average length of the verb, which was 530 ms, and obtained the same results.

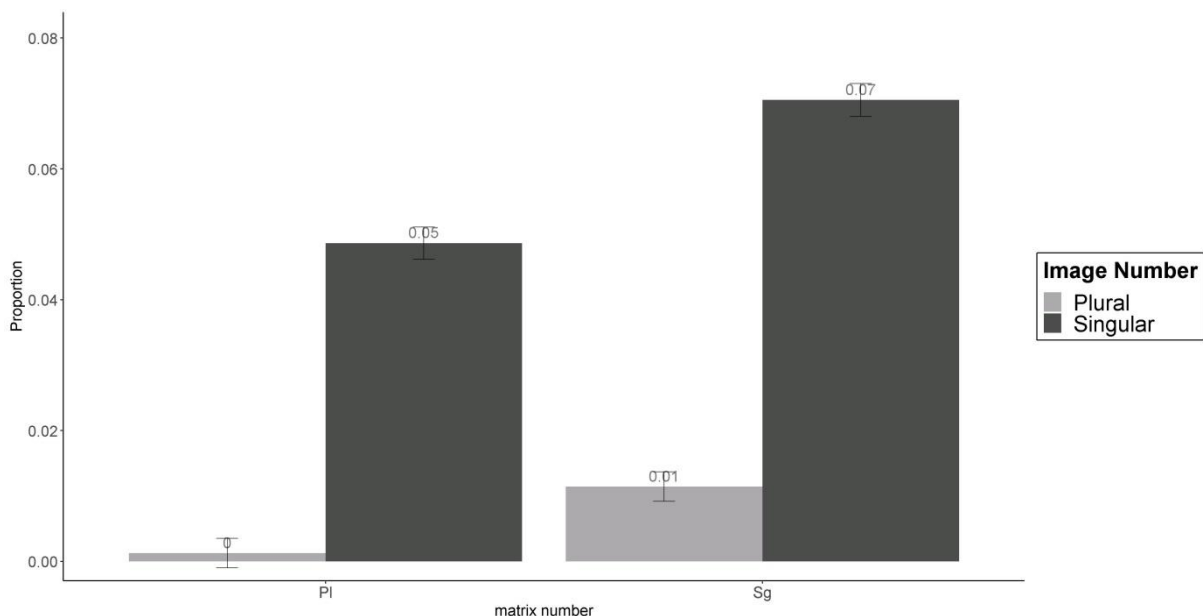


task; for the comprehension questions, the accuracy on experimental and control conditions was comparable. We believe that this low accuracy for the picture selection task comes from misunderstanding of the task, i.e. the participants not understanding they are supposed to select the picture that corresponds to the ambiguous noun as used in the sentence they previously heard. Nevertheless, the comparable means for the experimental and control items on the comprehension questions suggests that the participant understood the experimental sentences equally well.

#### 4.5.2.2. Experimental items

##### 4.5.2.2.1. *Ambiguous noun window*

We found a significant Image Number effect, driven by higher proportion of looks for the singular image, as well as a significant Image Number x Matrix Number interaction, as the proportion of looks to singular image increased in singular matrix subject condition significantly more than in plural matrix subject condition (see Table 4. 5 and Figure 4.4).



**Figure 4.4. Proportion of looks (baselined to the average for the distractors) for the ambiguous noun time window, in singular and plural matrix subject condition for experimental items in Experiment 4. The numbers on the top of the bars represent the mean values for that level of the factor. Pl= plural matrix number, Sg= singular matrix number**

**Ambiguous noun – experimental items**

<b>model: model: looks ~ matrixnum *imagenum + (1+matrixnum participant) + (1 item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	0.03	0.03	1.22	-0.02	0.08
<b>matrixnum1</b>	0.01	0.00	1.53	0.00	0.02
<b>imagenum1</b>	0.03	0.00	<b>24.13</b>	0.02	0.03
<b>matrixnum1: imagenum1</b>	0.00	0.00	<b>2.66</b>	0.00	0.00

**Ambiguous noun – control items**

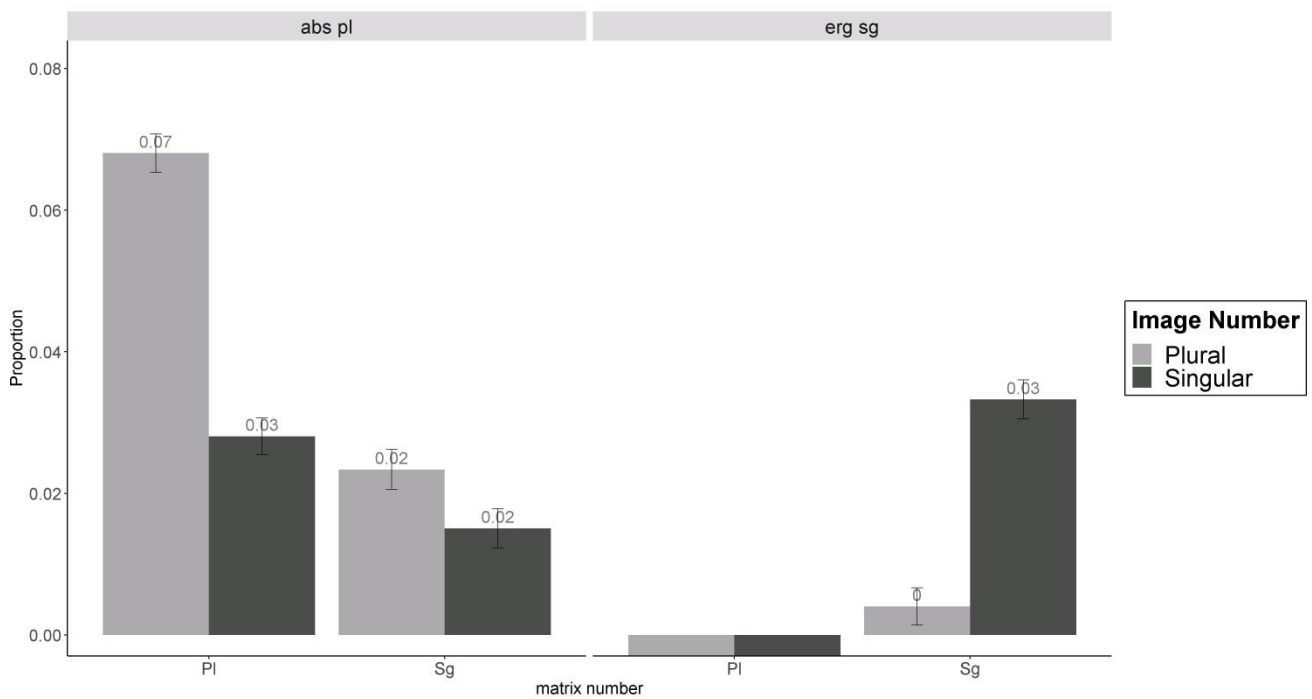
<b>model: model: looks ~ matrixnum *imagenum + (1+matrixnum participant) + (1+matrixnum item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	0.02	0.03	0.55	-0.04	0.07
<b>matrixnum1</b>	-0.01	0.00	-0.95	-0.01	0.00
<b>imagenum1</b>	0.02	0.01	<b>19.25</b>	0.01	0.04
<b>matrixnum1: imagenum1</b>	0.00	0.00	1.22	0.00	0.00

Table 4.5. Analyses for the ambiguous noun region for the experimental and control items in Experiment 4. Coding: for the Matrix Number factor, -1=plural, 1= singular; for the Disambiguation factor, -1=absolute plural, 1=ergative singular, for the Image Number factor, -1= plural image, 1= singular image. Significant effects are in bold.

#### 4.5.2.2.2. *Disambiguating verb time window*

The disambiguating verb time window in experimental items showed a significant Image Number effect, such that the proportion of looks to the plural image was higher. Furthermore, there was a significant Disambiguation effect, as absolute plural condition triggered more looks, as well as Image Number x Disambiguation interaction, as the proportion of looks increased for the singular image with singular ergative disambiguation. Furthermore, a significant Disambiguation x Matrix Number interaction was found, as the proportion of overall looks increased significantly more when the matrix subject was singular and the disambiguation was towards ergative singular, as well as a significant Matrix Number x Image Number interaction, as more looks to the singular image were generated in the singular matrix subject condition. Finally, we also found a significant Image Number x Matrix Number x Disambiguation interaction.

Separate analyses for singular and plural matrix subject showed that the Image Number effect (more looks to the singular image) was present only with singular matrix subject, that Disambiguation effect (more looks in absolute plural condition) was present only with plural matrix subject, but that the interaction is present for both matrix subject numbers. While the interaction in the singular matrix number condition was driven by a significantly bigger increase in the proportion of looks to the singular image when disambiguating the noun as ergative singular, its direction was different in the plural matrix number condition: the proportion of looks to the plural image was higher disambiguating the noun as absolute plural (see Table 4.6 and Figure 4.5).

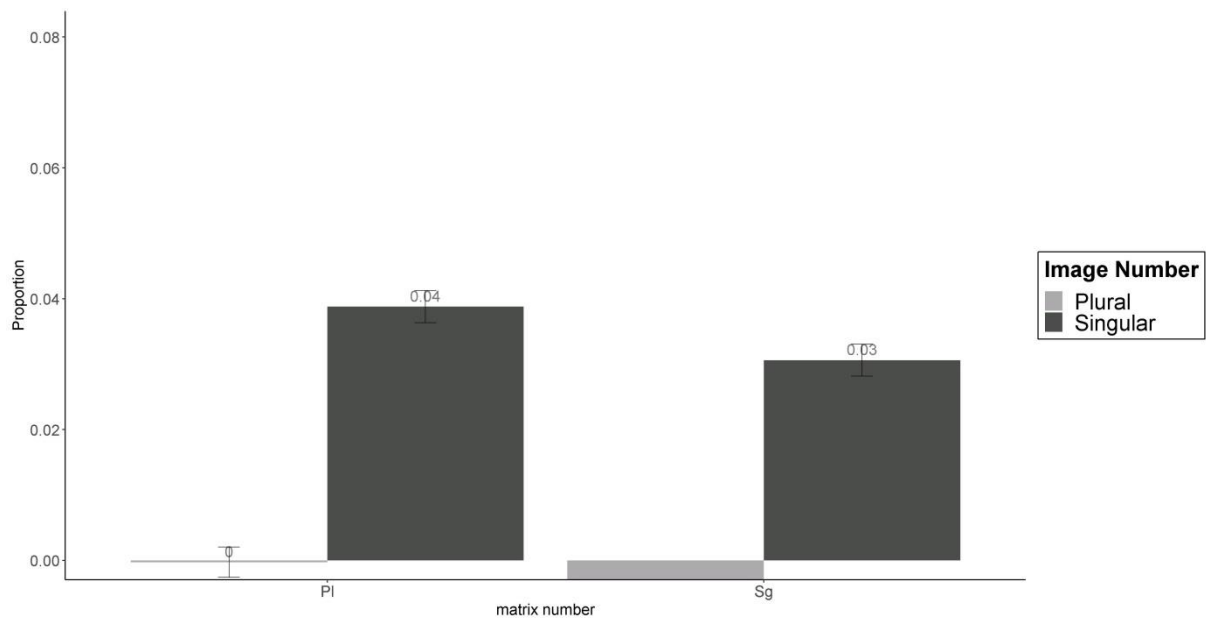


**Figure 4.5. Proportion of looks (baselined to the average for the distractors) for the disambiguating verb time window in the experimental items of Experiment 4. The numbers on the top of the bars represent the mean values for that level of the factor. Sg= singular matrix number, Pl= plural matrix number; abs pl= absolute plural disambiguation, erg sg= singular ergative disambiguation**

#### 4.5.2.3. Control items

##### 4.5.2.3.1. *Ambiguous noun window*

For the control items, we found a significant Matrix Number effect, as the proportion of looks increased with the plural matrix number (plural adjunct), as well as Image Number effect, such the proportion of looks to the singular image was higher. The interaction wasn't significant (see Table 4.5 and Figure 4.6).



**Figure 4. 6. Proportion of looks (baselined to the average for the distractors) on the ambiguous noun in singular and plural matrix subject condition, for the control items in Experiment 4. The numbers on the top of the bars represent the mean values for that level of the factor. Pl= plural matrix number, Sg= singular matrix number**

<b>Disambiguating verb</b>					
<b>model: looks~ matrixnum*disambiguation*imagenum +( 1+ matrixnum  participant) + (1+matrixnum  item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	0.00	0.03	0.07	-0.05	0.06
<b>matrixnum1</b>	0.00	0.01	0.16	-0.02	0.02
<b>imagenum1</b>	-0.01	0.00	<b>-6.95</b>	-0.01	0.00
<b>disambiguation1</b>	-0.01	0.00	<b>-4.30</b>	-0.01	0.00
<b>matrixnum1: imagenum1</b>	0.01	0.00	<b>12.70</b>	0.01	0.01
<b>matrixnum1: disambiguation1</b>	0.01	0.00	<b>4.35</b>	0.00	0.01
<b>imagenum1: disambiguation1</b>	0.01	0.00	<b>6.33</b>	0.00	0.01
<b>matrixnum1: imagenum1: disambiguation1</b>	0.00	0.00	<b>3.99</b>	0.00	0.01
<b>Disambiguating verb - Singular Matrix Number</b>					
<b>model: looks~disambiguation*imagenum+ (1+disambiguation participant)+(1+disambiguation item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	0.01	0.03	0.33	-0.05	0.07
<b>imagenum1</b>	0.01	0.00	<b>4.10</b>	0.00	0.01
<b>disambiguation1</b>	0.00	0.02	0.32	-0.03	0.04
<b>imagenum1: disambiguation1</b>	0.01	0.00	<b>7.35</b>	0.01	0.01
<b>Disambiguating verb - Plural Matrix Number</b>					
<b>model: looks~ disambiguation*imagenum+ (1+ imagenum  participant) + (1+ imagenum  item)</b>					
	estimate	se	t.value	conf.low	conf.high
<b>(Intercept)</b>	0.00	0.03	0.03	-0.06	0,06
<b>imagenum1</b>	-0.01	0.02	-0.32	-0.04	0.03
<b>disambiguation1</b>	-0.01	0.00	<b>-2.81</b>	-0.01	0.00
<b>imagenum1: disambiguation1</b>	0.00	0.00	<b>2.47</b>	0.00	0.01

Table 4.6. Analyses for the disambiguating verb in Experiment 4. Coding: for the Matrix Number factor, -1=plural, 1= singular; for the Disambiguation factor, -1=absolute plural, 1=ergative singular, for the Image Number factor, -1= plural image, 1= singular image. Significant effects are in bold.

### 4.5.3. Interim Discussion

In Experiment 4, we used the visual world paradigm to measure more straightforwardly whether the number feature is maintained, i.e. predicted. This paradigm allowed us to directly measure whether the participants are resolving morphosyntactic ambiguity, before the rest of the sentence does, by testing whether they look at a singular (and thus interpreting the noun as singular) or a plural image (and thus interpreting the noun as plural). Importantly, we isolated the time window when the participants were listening to the still ambiguous noun, thus making sure that the effects are not affected by the following words in the sentence.

The ambiguous noun window analysis (i.e. the analysis of the period during the presentation of the ambiguous noun) revealed that, overall, the singular image attracted more looks than the plural image. Finding the overall preference for the singular image in both the control and experimental items suggests that this particular effect is probably not mediated by the prediction mechanisms, but occurs due to some other factors. Although plural preference might be more expected due to the visual saliency of plural images (Yetano et al., 2011), it is possible that the looks to the singular entities in experimental items reflect the search for an object of the sentence, after hearing the matrix subject (as the SOV word order is the preferred one in Basque, see Section 4.2). This would also be supported by the previous work on anticipation of the sentential arguments using visual world paradigm (e.g. Altmann & Kamide, 2007; Kamide et al., 2003). However, it is unclear why this would occur in the control items too.

Importantly, the singular image preference was modulated by the number of the matrix subject in the experimental items, as the looks to the singular image increased when the matrix subject number was singular. This implies that the ambiguous noun was interpreted as singular more often in the singular matrix subject condition. On the control items, importantly, this interaction was absent. Thus, the increase in the proportion of looks to the singular image in the singular matrix subject condition can be ascribed to the maintenance of the singular feature in online subject-verb agreement. Namely, maintaining the singular feature in order to establish subject-verb agreement made that

feature active in the moment of processing the ambiguous noun, and biased the disambiguation of the noun towards singular. This is also in line with the results by Ristic et al. (2017; under review) that show that the Basque nouns ambiguously marked with *-ak* are disambiguated in sentence production by using the number information available from the context.

We also considered the possibility that the looks to the singular/plural image during the ambiguous word time window might be affected by the semantic properties of the previously heard matrix subject noun in the experimental items. One way in which we tried to control for this was the modification of the paradigm – the visual display did not appear until after the matrix subject noun presentation (see the Section 4.5.1.3 for the description of the procedure). Furthermore, random by-item intercepts were included in the analyses to account for the possible differences across the items regarding the semantic similarities of the two nouns. Also, an additional connector or an adverbial was inserted to separate the two nouns, so that enough time is provided between their processing. Additionally, we assessed the semantic match between the image and the matrix subject noun, i.e. how well the image represents the matrix subject noun. For that purpose, we categorized the items using 0 (=not matching), 1(=partially matching) and 2 (=matching) rating. According to this rating, 24 items were categorized as 0 match, 24 as 1 partial match, and 12 as complete match. The matching variable was also added to the analysis, but this didn't improve the model fit. The analysis showed that the effect of the match was not significant ( $t=-0.21$ ). Nonetheless, a more careful manipulation is necessary, as the possibility that the semantic information is maintained in matrix subject-verb agreement together with the number information is very plausible.

When it comes to the embedded auxiliary verb, i.e. the disambiguating window, plural images attracted more looks overall, and more looks overall were generated in the absolute plural disambiguation condition. This goes in line with the findings in Experiment 3, where the first pass and go-past reading times on the auxiliary verb increased when it disambiguated the noun as plural absolute (subject relative clause). Furthermore, it supports previously reported increase in the processing cost with subject relative clauses, compared to the object relative clauses (Carreiras et al., 2010). Overall, the results on the disambiguating verb window show that more looks towards plural

image were generated in the plural matrix number condition (although this result was not statistically significant), and more looks to the singular image were generated in the singular matrix number condition. This effect was boosted by the number of the verb, i.e. by whether it disambiguated the ambiguous noun as singular ergative or plural absolutive. Therefore, more looks to the singular image were generated in the singular matrix number condition when disambiguating the noun as ergative singular (e.g. *Nere ahizpa*<sub>[Sg]</sub>... *duena*<sub>[S-Sg]</sub>), and more looks to the plural image were generated in the plural matrix number condition when disambiguating the noun as plural absolutive (e.g. *Nere ahizpek*<sub>[Pl]</sub>... *dituztenak*<sub>[S-Pl]</sub>). Based on this, we can conclude that the looks on the verb are *confirmatory*, i.e. they are directed towards the image whose number corresponds to the number of the verb being heard. The only non-confirmatory looks are found in the plural matrix number condition with ergative singular disambiguation, where the number of looks towards singular image does not increase (see Figure 4.9), which could be ascribed to the generally low percentage of looks in the ergative singular disambiguation condition. In general, this interpretation aligns with the view that the integration of the subject-verb dependency takes place at the verb, while the predictive processes are activated before reaching the verb. We discuss this prediction-integration symbiosis in Chapter 5.

#### 4.6. *General Discussion*

The aim of the current chapter was to test whether the number feature is actively maintained during subject-verb dependency establishment as a way of syntactic prediction. We wanted to find evidence for maintenance by interpolating an embedded relative clause between the matrix subject and the matrix verb and placing a number-ambiguous noun within it. We hypothesized that the maintained singular/plural feature would bias the reading of the number-ambiguous noun. While the results of the reading study were inconclusive, the visual world paradigm experiment showed that the ambiguous noun was read as singular when the matrix subject-verb dependency established over it was singular. We believe that the effects emerged in the visual world paradigm experiment and not



during reading because the former paradigm provided a more direct measure of incremental language processing. Rather than expecting a decrease in reading times due to transitive (and thus singular) construction processing, as in Experiment 3, the visual world paradigm provides us with a more direct indicator of singular or plural interpretation.

Furthermore, the reason why we find maintenance effects in Experiment 4, but not 3, might be ascribed to the different task demands. As Ferreira & Chantavarin (2018) and Kim, Brehm, Sturt, & Yoshida (2019) suggest, the motivation for prediction is very important, and different comprehension goals and settings can influence comprehenders' performance. Thus, in a naturalistic reading study, where the entire sentence is available on the screen and readers can decide when to move on to the next one, the need to maintain the number feature might not be so strong – the ambiguous noun stays on the screen and the reader can regress to it from the verb, if necessary. In contrast, sentences are presented auditorily in the visual world paradigm. This might have more strongly motivated comprehenders to maintain all the necessary information, as the previously heard elements cannot be rewound later in the sentence. The difference in tasks might have also revealed the form in which the number information is maintained, which we further discuss in Chapter 5.

The current results thus suggest that the establishment of a subject-verb agreement dependency is characterized by active maintenance of the number feature. This is in line with sentence processing studies that claim that the number of the verb in subject-verb agreement is predicted (Lago et al., 2015; Tanner, Nicol, & Brehm, 2014). Interestingly, our visual world paradigm study suggests that the singular, but not the plural feature is predictively maintained. Although the opposite might be expected due to the marked status of the plural feature, there might be a few possible reasons for this. Firstly, the singular feature might be maintained in order to ensure its availability at the verb, precisely due to its unmarked status. While the marked plural feature is more salient and more likely to be active over the course of the sentence (as demonstrated by its prominence in different subject-verb agreement phenomena, such as number attraction), the singular feature might need an additional reinforcement in order to be preserved. Another option might be that the singular feature is simply less costly for the system due to its unmarkedness. This way, the parser

might be saving its resources. However, further investigation is necessary to tell these different options apart, as well as to determine whether this finding is specific to the Basque language.

In addition, the use of the disambiguation paradigm is informative about the ambiguity resolution mechanisms that the parser employs. Ristic et al. (2017; under review) and Bader & Meng (1999) demonstrate that the parser uses morphosyntactic information available at the moment of processing ambiguously marked words in order to disambiguate them. The reason for this is that the ambiguities are demanding for the system as the parser has to deal with two possible interpretations. Given the reduced processing resources, the parser is eager to resolve the ambiguities, and it might be more prone to use any cues available at the moment. The experiments presented in the current chapter show that number information (available due to maintenance) can be one of the cues used by the parser to help resolve this temporary ambiguity and facilitate processing. This adds to the existing evidence showing that different types of cues are used to resolve temporary structural ambiguity (e.g. Knoeferle et al., 2005; Ni & Crain, 1990; Trueswell & Tanenhaus, 1991; Weber et al., 2006).

There are certainly some limitations to the two studies presented in this chapter. Namely, experimental and control items in this experiment do not just differ in their structures. Besides contrasting sentences with the clauses that either interrupt a subject-verb agreement or not, the semantics of the manipulated nouns also varies – the manipulated noun is inanimate in the control items and animate in the experimental items. Therefore, it is possible that animacy information is also maintained, given its relevance for subject-verb agreement. The potential evidence for animacy maintenance would not be incompatible with our conclusions, though, as this feature was kept constant in our experimental items, i.e. it did not vary across the conditions. Certainly, a design where control and experimental items are more similar and analyzed together is necessary to better understand how these different features interact in subject-verb agreement.

### **4.5.1. Processing of the relative clauses in Basque**

Although investigating Basque relative clauses was not the primary aim of the current chapter, our choice of the experimental design surely allowed us test processing of the relative clauses in Basque. Both the reading and the visual world experiment showed that the absolute plural condition, and thus subject relative clauses, elicit longer reading times and more looks at the disambiguating auxiliary. This goes in line with the results on the prenominal relative clauses in Basque, where object relative preference was found (Carreiras et al., 2010). Carreiras et al. (2010) suggest that object relative preference in Basque, which contradicts subject relative preference found in many Indo-European languages (Frazier, 1987; Schriefers, Friederici, & Kuhn, 1995), arises out of the typological differences in markedness of transitive/intransitive arguments.

However, we suggest that there might be another, rather simple reason for the increased cost on subject relative clauses in our study. Due to subject and object agreement on Basque auxiliaries (see Table 4.1), the auxiliaries are more morphologically complex and thus longer in plural subject conditions, as well as in absolute plural (subject relative) conditions. We thus believe that the effects on the relative clause auxiliary can be ascribed to morphological complexity. This is further supported by the marginal effect of Word Length on the regressions out in Experiment 3, showing more regressions with the increase in word length. It should be noted, though, that the study by Carreiras et al. (2010) employs a different paradigm. Their effects from Carreiras et al. (2010) cannot be ascribed to morphological complexity of the relative clause auxiliaries, as the disambiguation in their study occurs and is measured at the matrix clause auxiliary, which does not differ in length across the conditions. In any case, although the relative clauses in our experiment were different from the previous studies, our results mostly align with those found in Carreiras et al. (2010).



## **V. General Discussion and Conclusions**

*“It is not a word indeed until it is part of a sentence.”*

Virginia Woolf, *On Craftsmanship*

One of the guiding assumptions of the current dissertation was that subject-verb agreement is established in online sentence comprehension through a *psychologically real* operation. Rather than looking at the end of this operation process, i.e. at the verb (as the previous behavioral and neuroimaging evidence has), we set out to look at the subject verb-agreement *while* it is being established.

To this end, we investigated whether the parser keeps the information relevant for subject-verb agreement active over the course of the sentence. More specifically, we asked two questions:

1. whether a subject-verb dependency involves active information maintenance, causing increased processing cost over the interpolated elements, and, if it does,
2. what the composition of the maintained representation is.

As linguistic theory describes subject-verb agreement as covariance between subjects and verbs in morphosyntactic features, we tested whether the parser actively maintains morphosyntactic features such as word's grammatical category and number in order to perform agreement operation in real time.

We tested our questions in three morphologically and typologically distinct languages (Spanish, English and Basque), through two different morphosyntactic effects (similarity-based interference and disambiguation); we used two different eye-tracking paradigms (reading and visual world paradigm), which allowed us to test two different language modalities (written and spoken language). We found that establishment of a subject-verb dependency certainly involves active maintenance and that at least some morphosyntactic features involved in subject-verb agreement are actively maintained in real-time sentence processing. In the remaining of the chapter, we expand the implications of our findings to the psycholinguistic literature. Specifically, we elaborate on their significance for current sentence processing models (SPLT/DLT and cue-based retrieval models), for the testing of the psychological reality of subject-verb agreement, as well as for the role of prediction in syntactic processing. Finally, we comment on our findings from a cross-linguistic perspective.

### ***5.1. Maintenance of subject-verb dependency***

As noted in Chapter 2, the previous literature investigating processing cost related to subject-verb dependency establishment is scarce and offers rather inconclusive evidence. While a few studies using embedded relative clauses found no effects that could be interpreted as increased processing cost caused by subject-verb dependency establishment (Hakes et al., 1976; Van Dyke & Lewis, 2003), using embedded clauses of different type showed opposing results. Namely, Chen et al. (2005) show that the processing cost over embedded complement clauses increased with the number of the matrix verb predictions that the clause interrupts. All these studies, however, used tasks which do not investigate language comprehension in the most natural and ecological way, such as the phoneme monitoring task or the self-paced reading task. The current dissertation filled that gap by using eye-tracking. Additionally, in our English and Spanish experiments, we used adverbial embedded clauses, making sure that no syntactic expectations or relations are established between the matrix and embedded clause.

We demonstrated that reading times, as measured by first pass and go-past reading times, as well as the regressions out, do increase when an adverbial clause interrupts a subject-verb dependency, relative to when it does not. This was shown in both Spanish and English. Together with the findings by Chen et al. (2005), this seemingly questions some assumptions of the sentence comprehension models: the assumption that matrix verb prediction doesn't increase processing cost, as claimed within SPLT/DLT model, as well as the assumption that the representations involved in subject-verb agreement establishment are not kept active, as postulated by the cue-based retrieval models.

However, one should carefully consider what exactly these models assume. Gibson's SPLT/DLT model (Gibson, 1998, 2000) presupposes that the maintained (and costless) representation belongs to the matrix verb. The cue-based retrieval accounts presuppose that both the subject and the verb representation are encoded at the subject, and then retrieved at the verb, with no active maintenance before the retrieval. First of all, neither the models nor the studies that investigate this

issue clearly state the difference between *prediction*, *expectation*, *maintenance* and *anticipation*. We deal with this seemingly trivial terminological issue in Section 5.5. More importantly, there is inconsistency in what exactly is believed to be predicted during the establishment of a subject-verb dependency, and we first address this issue. We stand that a logical solution would be to look at the content of the predicted representation and try to break it down to its component features. The current dissertation aimed at taking the first step towards that goal.

## ***5.2. The nature of the maintained representation***

Although the previous studies have tried to answer whether subject-verb agreement employs active maintenance (Chen et al., 2005; Van Dyke & McElree, 2006), and although other research has looked for evidence for encoding interference in subject-verb dependency (Villata et al., 2018), to our knowledge, there is no study that has put these two questions together in order to study the nature of the maintained representation.

We manipulated number and category feature and studied encoding interference on an element prior to the retrieval site (as well as the retrieval-triggering element), and found that the category feature is actively maintained, causing encoding interference on the element of the same category. In contrast to the proposal that what is being predicted/maintained in subject-verb dependency is verb representation (Chen et al., 2005; Gibson, 1998), we found that the maintained representation belongs to the subject noun. However, important differences between these and past studies must be pointed out. Indeed, previous studies have not looked at the potential effects that the maintained representation triggers, which would be informative about its nature. Thus, the results by Chen et al. (2005), could be explained either way: the processing cost over the embedded clause reported in their study might be ascribed to the number of the predicted verbs, or to the number of the maintained subjects.



Our results, nevertheless, support the findings from research in filler-gap dependencies, where the maintained representation is believed to correspond to the filler (the *predictor*), rather than to the gap (the *predictee*). Wagers & Phillips (2014) also looked at the content of the maintained representation in filler gaps, and found that the maintained filler representation includes category information, while Chow & Zhou (2019) and Ness & Meltzer-Asscher (2019) found that semantic information might also be maintained. Similarly, we tested whether the maintained subject representation includes other features besides category – the number feature.

As the experiments using similarity-based interference paradigm were not clear with regards to the question of number feature maintenance, we expanded our investigation (still focusing on the element prior to the retrieval site) and tested whether the potentially maintained number feature could disambiguate number-ambiguous nouns. To the best of our knowledge, no study so far has used the disambiguation paradigm to investigate maintenance in long-distance dependencies. Our visual world paradigm experiment showed that the maintained number feature can disambiguate, as the number-ambiguous nouns were interpreted in accordance with the maintained (singular) feature. Therefore, a more conclusive proof that the number information is maintained was found in the visual world paradigm, but not in the reading studies. It is thus possible that number is maintained in its abstract, notional form, and that the morphological form itself is not maintained. That is, what might be maintained active is the information about how many entities there are in the given sentential context, rather than the form of the word (together with the singular/plural morpheme). This would explain why a strong evidence for encoding interference was not found across the reading measures in Experiments 1 and 2. Namely, similarity-based interference occurs in the presence of a representation that matches the retrieval cues at the verb, which are the features such as number, case, gender etc. What informs the system about the features of a potentially similar element (or its representation) might be exactly its morphology. If there is no morphological information about number, the interference does not occur.

This explanation would be in line with a more general view of prediction, where the exact (phonological or orthographical) form of the words is not preactivated. For example, Ferreira &

Chantavarin (2018) differentiate prediction and *preparedness*. Preparedness implies that comprehenders form a rich representation of preceding discourse, which allows them to be more receptive to certain features of the upcoming words, and which only sometimes leads to preactivation. So, they suggest that word form is predicted only when the context is highly constraining, but that the categories are generally predicted. Our results support this idea, demonstrating that numerosity (i.e. how many entities there are) and word category are part of the maintained representation, while the exact morphological form might not be. However, some studies have found proof that the phonological or phonetic form is also preactivated (DeLong et al., 2014; Monsalve et al., 2018). It is therefore possible that the specificity of the preactivated element depends on the experimental setting, on the manipulated feature, or on the task demands.

The effect of the latter variable can also be observed in the current dissertation. As suggested in the discussion to Chapter 4, there was a difference in the task demands between the two paradigms. During reading, the participants know that all the elements will be available on the screen for as long as they want, whereas the visual world paradigm utilizes spoken language, where the elements are available only as long as their presentation lasts. Therefore, the availability of the sentential elements determined by different paradigms might have affected the strength and the specificity of predictions across the experiments in the current dissertation.

### ***5.3. Prediction/maintenance mechanisms in sentence comprehension***

As previously discussed, SPLT/DLT model assumes that matrix subject-verb prediction is maintained, but causes no processing cost (Gibson, 1998, 2000). However, according to this model, prediction refers to the matrix verb, and no clear statements are made on potential matrix subject maintenance. On the other hand, cue-based retrieval models stand that both the matrix subject and the matrix noun representation are encoded, but then displaced from the focus of attention, to be retrieved

and thus reactivated later at the verb (Lewis et al., 2006, see Figure 1.2 in Chapter 1). So, how do our findings fit within these two sentence processing models?

First of all, we do not claim that the noun category and number are the only features that are maintained in subject-verb agreement computation. There might be other features, possibly related to the verb representation, that are kept active. From the perspective of cue-based retrieval accounts, upon encoding the subject and the verb representation at the subject, it is possible that some information about both of these representations is left in the focus of attention over the storage interval (see Figure 1.2 in Chapter 1). But, as suggested by these accounts (Jäger et al., 2017; Lewis & Vasishth, 2005; McElree et al., 2003), the focus of attention is rather limited and it would probably not be plausible to maintain the full, rich representations of both elements. We thus believe that some sort of simplification is taking place, whereby only the relevant features are kept in this privileged, active state.

Therefore, here we do not claim that there is no verb prediction *per se*, but rather that prediction might be put into practice by maintaining the relevant information concerning the subject. It is important to note that in that sense, our results do not speak directly against the SPLT/DLT model (Gibson, 1998, 2000), which suggests that the prediction of the matrix verb is effortless – indeed, there might be some features of the maintained representation related to the verb that are really not actively maintained and thus posit no cost. However, this model does not recognize that the subject representation is kept active either.

In light of our results, we believe both SPLT/DLT and cue-based retrieval models should be revised in order to accommodate for these and similar findings. When it comes to the SPLT/DLT model, an additional storage cost (reflecting maintenance cost) could be added to each element that interpolates between the subject and the verb (e.g. on each element in the relative clause *who the senator attacked* in Figure 1.1, Section 1.3). Also, based on the results of the experiments presented in the current dissertation, more additional cost should be added to the intervening nouns (e.g. on *the senator*), compared to other intervening elements.

Cue-based retrieval accounts, on the other hand, suggest that the representations encoded upon encountering the matrix subject noun are not part of active processing until the matrix verb is reached (Lewis et al., 2006), but our results suggest that at least some parts of those representations are maintained active over the interpolated material. How is this representation kept active within the memory architectures proposed by the cue-based retrieval models? We believe that there are two possibilities.

The first one is that parts of the maintained representation are within the focus of attention. Importantly, both the working memory and sentence comprehension literature propose that focus of attention is extremely limited (around four items), and the items outside of it must be retrieved (Cowan, 2001; McElree et al., 2003; Oberauer, 2002). In their model, Lewis & Vasishth (2005) also propose that the working memory focus is extremely limited, and that it is reduced to single-chunk (i.e. single-representation) buffers that contain the results of lexical access, the constituent just retrieved from working memory, and the local control state. The control state includes the *syntactic goal category*, which they describe as syntactic expectation. Therefore, it might be possible that the maintained representation or parts of the maintained representation in a subject-verb dependency are kept within the control state buffer; arguably, they stay within that buffer while the other elements are processed, until the verb is reached. This is also supported by Wagers & Phillips (2014), who propose that certain information in filler-gap dependency establishment is maintained in the focus of attention, while the rest of the information is retrieved (see also Fiebach et al., 2002).

Alternatively, the maintained representation could be out of the attention focus. While, according to Oberauer (2002), only one representation is usually in the focus of attention, more representations can be in the region of direct access, and the rest of them are in the activated part of long-term memory (see Box 1.1 in Chapter 1). Retrieval brings representations belonging to the last two types into the focus of attention. However, Oberauer (2002) claims that the representations outside of the focus of attention can still affect the processing of focused elements. He reports intrusion effect in a recognition task, coming from the residual activation of the elements in long-term memory. Furthermore, he claims that the elements from the region of direct access are susceptible to

competition, causing a slowdown effect. Thus, the other possibility is that the representation maintained in subject-verb dependency is kept within the region of direct access, from where it interferes with the encoding of new elements, and from where it can be easily accessed as soon as a verb is encountered. By all means, further research that would be able to distinguish between these two proposals is necessary, to ascertain whether the maintained representation is in the focus of attention or not (see also Schoknecht, Roehm, Schlesewsky, & Bornkessel-Schlesewsky, 2019 for a proposal that combines predictive coding and retrieval interference).

#### ***5.4. Encoding and retrieval***

To our knowledge, our Chapter 3 provides the first attempt to measure encoding interference in subject-verb dependency on the region before encountering a verb, i.e. as soon as an element similar to the maintained element is encountered (as suggested by Van Dyke & McElree, 2006; Villata et al., 2018). Although some studies have provided analyses for the pre-retrieval region (see Table 3.1 in Chapter 3), none of them has manipulated this region to study maintenance. Namely, by measuring interference on the region where the effects can undoubtedly be ascribed to the encoding stage of processing, we were able to detect the effects that are occurring due to active maintenance of the representations in sentence comprehension. We were also able to provide analyses for the region where retrieval and thus integration takes place (the verb), showing that the effects found in that region differ from those found on the preceding, maintenance-related region. This was confirmed in Chapter 4, where the verb processing reflected integration-related mechanisms, which prediction-related effects were found prior to the verb. This highlights the necessity to expand the analyses in the subject-verb processing research beyond the verb region.

While the retrieval exemplifies bottom-up integration mechanisms in sentence comprehension, we believe that maintenance is a top-down mechanism utilized to keep the information preactivated or predicted. And indeed, sentence processing has already been described as

a mixture of prediction and integration mechanisms by some psycholinguists. Wagers & Phillips (2014) claim that sentence comprehension is a combination of predictive, leading processes, and retrospective, lagging processes; rather than opting for one model or another, a hybrid one should be adopted, including both maintenance and reactivation mechanisms. This hybrid model, which was suggested by Fiebach et al. (2002), has become more and more accepted in sentence comprehension (Kim et al., 2019; Ness & Meltzer-Asscher, 2017, 2019; Wagers & Phillips, 2014), and aligns with the working memory models that introduce active maintenance mechanisms, besides retrieval mechanisms, as an integral part of the working memory architecture (see Section 1.3 and Box 1.1). Wagers et al. (2009) also claim that the top-down maintenance or prediction, and the bottom-up integration can be viewed on a continuum, and that the precise characteristics of the sentential configurations might determine the relative dominance of each mechanism.

Moreover, the idea that the parser incorporates predictive mechanisms in building subject-verb agreement has already been suggested in psycholinguistic research (Lago et al., 2015; Tanner et al., 2014). Finally, both SPLT/DLT and cue-based retrieval models propose that syntactic prediction or expectation forms part of natural sentence comprehension. What seems to be questionable then is *how* this prediction is implemented and how maintenance manifests. We elaborate on this in the following section.

### ***5.5. Maintenance, expectation and prediction***

In order to decipher what *syntactic prediction* means, we believe that research in this field needs to be clear on how different terms are used and whether some of them relate to different cognitive mechanisms. In order to achieve that, it is important to state what is meant by syntactic prediction in each particular configuration and to understand the differences between prediction in syntax and other language levels. In accordance with that, we state our conclusions regarding prediction in syntax and subject-verb agreement below.

Firstly, in syntax, prediction has its clear limits, as both the *predictor* and the *predictee* are clearly detectable elements (compared to, for example, lexical prediction, where an element is predicted based on various accumulating evidence from the context). Furthermore, syntactic prediction is manifested through either morphology/phonology (e.g. number morphemes), or by using a certain lexeme (e.g. in the case of *either...or*, Staub & Clifton, 2006). Syntactic prediction can be thus seen as anticipation of an open dependency/relation to be closed. This anticipation, we believe, is conducted through active maintenance of a representation that will help close this relation. As syntax is “invisible” and, as mentioned above, operates through different linguistic levels, a way to investigate this representation is to manipulate the features that it might contain and see whether they cause certain effects on different elements. The current dissertation adopted this approach and found that the actively maintained representation indeed triggers certain effects on the interpolated elements: it causes either interference (Chapter 3) or disambiguation (Chapter 4). Eliciting these and possibly other effects allows us to measure the active status of the features within a maintained representation. Thus, in order to study syntactic prediction, focusing on the effects that the preactivated representations generates in conjunction with other elements might be more informative than describing the architecture of the working memory structures with which the syntactic processing operates.

Since the maintained representation in subject-verb agreement was found to contain parts of the subject representation, we believe that active maintenance of the subject representation and the prediction of the matrix verb could be seen as two sides of the same coin. Prediction in subject-verb agreement is conducted through active maintenance of the representation that contains subject-like features, but possibly also verb-related features. Therefore, we show that the subject-verb agreement related information causes increased processing cost over the elements *before* its conclusion, i.e. before the verb. As already mentioned in the introduction, claiming that an element is predicted in language processing requires showing that it is preactivated before it is encountered. That way, the processes of prediction cannot be mistaken for the processes of integration (Ferreira & Chantavarin,

2018; Ilkin & Sturt, 2011; Kuperberg & Jaeger, 2016), and we can claim that establishing a subject-verb dependency relies on syntactic prediction mechanisms.

Indeed, prediction in language processing is believed to facilitate processing downstream. Keeping active the information that will for sure be necessary for later integration therefore seems plausible. Moreover, subject-verb agreement is one of the core syntactic operations and it is understandable for the parser to make sure that it is established correctly.

## 5.6. *Online syntax*

The current dissertation provides evidence that the subject-verb agreement operation employs certain mechanisms to establish the relation between the subject and the noun. We have found that the features related to this dependency are predictively maintained active, until the verb is reached. This way, the system might be keeping the information needed for the later integration active, making sure that one of the core syntactic operations is established correctly. This interpretation reflects descriptions of the subject-verb agreement within generative syntax, especially minimalism, and below we underline the parallels between this program and our findings<sup>12</sup>.

In minimalism, the existence of the features that need to be valued (uninterpretable features) makes the elements that carry them “active” and causes them to look for an element which could value them. The “active” element in subject-verb agreement would be the verb, as the one carrying uninterpretable features, and the prediction mechanisms that we propose in the current dissertation (conducted through subject maintenance, see Section 5.5) might reflect this “activity”. Keeping the subject representation active could represent a mechanism in sentence comprehension that brings the subject (or at least the parts of it) within the verbal domain, so that the verb’s uninterpretable features

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<sup>12</sup> It should be noted, however, that the general view of sentence derivation in minimalism (and, more generally, generativism) is devoid of any temporal factors or real-time language processing. Rather, structure building is seen as an encapsulated series of operations. Thus, talking about agreement as a partially top-down mechanism would not be in line with the generativist tradition *per se*. Nevertheless, the aim of the current section is to try to highlight the common ideas and principles in language theory and language processing, rather than to find the mental equivalents of the specific operations proposed by specific theoretical frameworks.



can be valued. We showed that the subject's category and number features are one of those actively maintained features.

It is interesting to note that the category feature seems to be more strongly maintained than the number feature, according to our findings. In minimalist syntax, satisfying the uninterpretable category feature occurs earlier in sentence derivation. Moreover, this valuation has to do with the lexical requirements of the verb, which are recorded in people's mental lexicon. Therefore, valuing the uninterpretable feature of category could be considered more essential for the structure building, which is why the prediction of it might be stronger. Also, as we claim in Section 5.2, number feature might be maintained in its non-morphological form. Interestingly, this also goes in line with the minimalist tradition, where syntax operates on the representations that still don't have their morphophonological form.

Finally, it is important to note that our results comply with the idea that subject-verb agreement is *psychologically real* even when agreement is defined outside of any theoretical framework. In other words, we show that the transfer of features from the noun to the verb – regardless of the formal operations it implies – occurs in in real time sentence comprehension.

### ***5.7. Cross-linguistic perspective***

The current dissertation reveals some similarities and differences between Spanish, English and Basque. The effect of maintenance (the difference between experimental and control items) over the embedded clause was undoubtedly present in both English and Spanish (Experiments 1 and 2). It should also be noted that an observable difference between control and experimental items occurred in the Basque reading experiment. Although this experiment doesn't provide a direct comparison between the two types of items, the differences in the RTs between them are noticeable (see Figures 4.1 and 4.3 in Chapter 4).

Furthermore, the difference between control and experimental items was more prominent on the embedded subject noun in both Spanish and English. This supports our proposal that the content of the maintained representation is noun-like. When it comes to the number feature maintenance, we saw that the Matching effect on the noun is present in Spanish, while it is not statistically significant and occurs on the verb in English. This is in line with the proposal that number prediction in subject-verb agreement is stronger in Spanish (Lago et al., 2015). As explained in Chapter 3, the reason for this might be the difference in the morphosyntactic information on the NPs between the languages, i.e. the fact that NPs in Spanish provide more morphosyntactic cues than the English ones.

Nevertheless, the clearest evidence for number prediction comes from Basque and, more specifically, from the visual world paradigm study. The strong number prediction effects in Basque study could be expected, given its head-final property. Namely, previous research has suggested that head-final languages might employ stronger prediction mechanisms, as a significant part of the morphosyntactic processing is occurring at or close to the end of the sentence, and thus a lot of information is expected to appear later (Lago et al., 2015; Vasishth et al., 2010). At the same time, this means that in head-final languages, a lot of information is left “on hold” and might not be processed in depth. In reading, where the entire sentence is present from the beginning of the processing of the sentence, this might be even more apparent. This proposal would also explain the lack of prediction effects in Experiment 3. Nevertheless, the most successful methodology in proving that number information is maintained seems to be the visual world paradigm. We will address this, and other methodological issues in the following section.

## ***5.8. Methodological notes, open questions and future directions***

In order to investigate word category and number maintenance in subject-verb agreement, we used different paradigms, languages and study designs. In this section, we discuss some observations

related to the differences between them, as well as some implications for the research in sentence comprehension in general.

First of all, the eye-tracking technique has proven to be a very ecological method to study language comprehension, and particularly subject-verb maintenance. While previous studies used the self-paced reading technique and found mixed evidence regarding the maintenance of subject-verb dependency (Chen et al., 2005; Hakes et al., 1976), eye-tracking provided us with a more realistic setting and allowed us to observe maintenance effects across experiments and languages. Furthermore, our Experiments 1 and 2 confirmed that using adverbial, rather than relative clauses, might be a better way to study matrix subject-verb maintenance in reading, as it doesn't imply additional predictions of arguments related to the embedded clause itself.

Our Basque experiments, however, did include embedded relative clauses, but this was dictated by our study design: as we were focused on the morphologically ambiguous nouns marked with *-ak*, the only way to have them interpolated between the matrix subject and verb was within a relative clause. Furthermore, the design of the Basque experiments was not adapted to measure maintenance effects over the entire embedded clause (as we already investigated that effect in Experiments 1 and 2), but rather on one element within them – the ambiguous noun. At the same time, using relative clauses allowed us to study differences between object and subject relative clauses in Basque, adding to the previous scarce evidence.

Nevertheless, it is possible that the lack of maintenance and prediction effects in the Basque reading experiment (Experiment 3) can be ascribed to the combination of the design that includes relative clause processing, the fact that Basque is a head-final language where the processing is left “on hold” (see the Section 5.7), and the choice of the paradigm. As discussed in section 5.2, the strength and specificity of prediction might be determined by the task demands. We thus believe that, in order to investigate a sentence processing phenomenon, it is important to choose a paradigm that will maximize the possibility of the effects showing up. The effects such as similarity-based interference are not expected to be very strong in natural language comprehension. Indeed, if they

were, our everyday language performance would be seriously endangered. Using a paradigm that reflects immediate language comprehension is thus highly valuable in these situations. Unlike single word comprehension, sentence processing is a complex bundle of different relations and effects, and isolating and capturing one might often require searching for a suitable paradigm.

Altogether, our findings imply that subject-verb agreement does occur online. By all means, category and number features are only a subset of information that could possibly be maintained in subject-verb dependency establishment, causing the processing cost that we report on the embedded clause in Chapter 2. Relating the subject and the verb in a sentence requires keeping track of structural, semantic, and other types of information. It is thus possible that other types of information have partially contributed to the processing cost. One possible candidate for this is animacy, whose importance in determining the argument structure (which plays an important role in establishing subject-verb dependencies) is undeniable. Moreover, Ness & Meltzer-Asscher (2019) suggest that animacy is maintained in the filler-gap dependency, and it is therefore possible that the same applies for other dependencies where this information is important. It is thus necessary to investigate other cues that are actively maintained in subject-verb dependency, in order to understand their relative importance for the complex operation such as agreement.

Research in filler-gap dependencies has opened another interesting topic in the field of long-distance dependency maintenance. Namely, Kim et al. (2019) have found that maintenance is motivated by the *wh*-element in the filler-gap dependency. The *wh*-element signals that the dependency is being opened, which triggers maintenance. When it comes to definite NPs, however, the authors claim that maintenance does not apply. But what motivates maintenance in the subject-verb dependency? Looking at the stimuli used across our experiments, one could say that the matrix noun phrases at the beginning of the experimental sentences (which we claim to be maintained) are topicalized. Potentially, this could have been an additional motivation for the prediction. However, topicalization here would probably have to be achieved through prosody, and only Experiment 4 utilizes spoken language modality. By all means, there might be different types of NPs with respect to

how strongly they signal to the parser that the subject-verb dependency is opened, and we hope that future studies will be dedicated to deciphering them.

Related to that is the question of the specificity of prediction (Section 5.2). Do certain cues or configurations determine how specific a syntactic prediction will be? Different experimental designs, tasks and sentential configurations might imply prediction errors of different scales, and thus bias the parser to maintain the representations of different levels and specificities.

Finally, we cannot ignore the possibility that the prediction in subject-verb dependency does not occur always. Undoubtedly, evidence on prediction in long-distance dependencies in general is still scarce and further investigation is necessary in order to understand the extent of automaticity of the prediction mechanisms in subject-verb agreement computation.

## ***5.9. Conclusions***

The current dissertation showed that active maintenance occurs in long-distance subject-verb dependency, manifested as processing cost over the interpolated elements. We showed that the maintained representation contains noun category features, and, probably in its abstract form, the number feature too. We proved this feature's activity through the effects it triggers: it causes encoding interference, but it also biases morphosyntactic interpretations upon temporary ambiguity. Contrary to the previous studies on subject-verb dependencies maintenance and sentence comprehension models, but in line with research on other long-distance dependencies, we propose that the representation of the subject noun, rather than the verb, is actively maintained.

We conclude that the parser keeps the essential morphosyntactic features active over the course of the sentence in comprehension. This way, the subject-verb agreement – seen as the transfer

of features from one element to another – is established *in real time*. We describe this as a predictive process, in which the parser maintains syntactically relevant information preactivated in order to facilitate later integration. The current dissertation represents the first steps into the investigation of prediction in subject-verb dependency, and we hope that the future research will unravel the full complexity of these mechanisms in sentence comprehension.

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# Appendices

## A1. Stimuli sentences used in Experiment 1

The sentences are given in the experimental conditions and control conditions, with the approximate translations to English below (in grey), in VS word order of the embedded clause (the SV word order was achieved by permuting the embedded subject and verb). Different conditions are separated by slash.

- 1) *La chica/Las chicas, cuando se divierte/divierten la amiga/las amigas los fines, graba/graban todo con su móvil.*  
*“The girl/The girls, when the friend/friends is/are having fun on the weekends, records/record everything with her phone.”*  
*Para la chica/las chicas, cuando se divierte/divierten la amiga/las amigas los fines, la noche se pasa volando.*  
*“For the girl/the girls, when the friend/friends is/are having fun on the weekends, the night passes by quickly.”*
- 2) *La embarazada/Las embarazadas, cuando empieza/empiezan la matrona/las matronas con las preparaciones, piensa/piensan sobre cosas positivas.*  
*“The pregnant woman/women, when the midwife/midwives starts/start with the preparations, thinks/think positively.”*  
*Para la embarazada/las embarazadas, cuando empieza/empiezan la matrona/las matronas con las preparaciones, mantener la calma es útil.*  
*“For the pregnant woman/women, when the midwife/midwives starts/start with the preparations, staying calm is useful.”*
- 3) *La sirvienta/Las sirvientas, cada vez que viene/vienen una chica/unas chicas a la casa, sirve/sirven unos zumos.*  
*“The servant/servants, every time a girl/girls comes/come to the house, serves/serve juices.”*  
*Para la sirvienta/las sirvientas, cada vez que viene/vienen una chica/unas chicas a la casa, su trabajo disminuye.*  
*“For the servant/servants, every time a girl/girls comes/come to the house, the workload decreases.”*
- 4) *La nieta/Las nietas, cuando se entera/enteran la abuela/las abuelas de sus notas, huye/huyen a su habitación.*  
*“The granddaughter/granddaughters, when the grandmother/grandmothers finds/find out about her/their grades, escapes/escape to her/their room.”*  
*Para la nieta/las nietas, cuando se entera/enteran la abuela/las abuelas de sus notas, mentir es lo más fácil.*  
*“For the granddaughter/granddaughters, when the grandmother/grandmothers finds/find out about her/their grades, the easiest thing is to lie.”*
- 5) *La enfermera/Las enfermeras, si se mueve/mueven la enferma/las enfermas a pesar de los avisos, quita/quitan la jeringa inmediatamente.*  
*“The nurse/nurses, if the patient/patients moves/move in spite of the warnings, takes/take out the syringe immediately.”*  
*Para la enfermera/las enfermeras, si se mueve/mueven la enferma/las enfermas a pesar de los avisos, pinchar sin dolor es difícil.*  
*“For the nurse/nurses, if the patient/patients moves/move in spite of the warnings, pinching painlessly is hard.”*
- 6) *La trabajadora/las trabajadoras, si progresa/progresan la operadora/las operadoras con los formularios, termina/terminan antes.*  
*“The worker/workers, if the operator/operators makes/make progress with the forms, finishes/finish early.”*  
*Para las trabajadoras/las trabajadoras, si progresa/progresan la operadora/las operadoras con los formularios, la productividad es mayor.*  
*“For the worker/workers, if the operator/operators makes/make progress with the forms, the productivity increases.”*
- 7) *La diputada/Las diputadas, si declara/declaran la acusada/las acusadas ante el tribunal, participa/participan en el juicio.*  
*“The deputy/deputies, if a defendant/defendants speaks/speak in court, takes/take part in the trial.”*  
*Para la diputada/las diputadas, si declara/declaran la acusada/las acusadas ante el tribunal, el protocolo es interminable.*  
*“For the deputy/deputies, if a defendant/defendants speaks/speak in court, the protocol is never-ending.”*
- 8) *La campeona/Las campeonas, si se anima/animan la compañera/las compañeras después del entrenamiento, ensaya/ensayan unos nuevos saltos.*  
*“The winner/winners, if the team mate/teammates is/are up for it after the training, shows/show some new jumps.”*  
*Para la campeona/las campeonas, si se anima/animan la compañera/las compañeras después del entrenamiento, tomar algo es relajante.*  
*“For the winner/winners, if the team mate/teammates is/are up for it after the training, having a drink is relaxing.”*

- 9) *La matrona/Las matronas, si ingresa/ingresan una extranjera/unas extranjeras en su clínica, traduce/traducen todo al inglés.*  
“The midwife/midwives, if a foreigner/foreigners comes/come to the clinic, translates/translate everything to English.”  
*Para la matrona/las matronas, si ingresa/ingresan una extranjera/unas extranjeras en su clínica, gestionar sus documentos es relevante.*  
“For the midwife/midwives, if a foreigner/foreigners comes/come to the clinic, taking care of her/their documents is important.”
- 10) *La experta/Las expertas, cada vez que expone/exponen la escritora/las escritoras en el auditorio, recuerda/recuerdan frases interesantes.*  
“The expert/experts, every time an author/authors present in the auditorium, remembers/remember interesting quotes.”  
*Para la experta/las expertas, cada vez que expone/exponen la escritora/las escritoras en el auditorio, sus frases son inspiradoras.*  
“For the expert/experts, every time an author/authors present in the auditorium, the quotes are inspiring.”
- 11) *La marquesa/Las marquesas, cada vez que come/comen la ministra/las ministras en su chalé, arregla/arreglan el comedor.*  
“The marchioness/marchionesses, every time a minister/ministers dines/dine in her/their house, puts/put the dining room in order.”  
*Para la marquesa/las marquesas, cada vez que come/comen la ministra/las ministras en su chalé, el recibimiento es caluroso.*  
“For the marchioness/marchionesses, every time a minister/ministers dines/dine in her/their house, the reception is very warm.”
- 12) *La novia/Las novias, si se conmueve/conmueven una invitada/unas invitadas en la boda, pide/piden un pañuelo.*  
“The bride/brides, if a guest/guests get/gets emotional at the wedding, looks/look for a tissue.”  
*Para la novia/las novias, si se conmueve/conmueven una invitada/unas invitadas en la boda, la emoción es grande.*  
“For the bride/brides, if a guest/guests get/gets emotional at the wedding, the feelings get really intense.”
- 13) *La presentadora/Las presentadoras, si miente/mienten la sospechosa/las sospechosas sobre los crímenes, lo nota/notan enseguida.*  
“The presenter/presenters, if a suspect/suspects lies/lie about the crimes, notices/notice right away.”  
*Para la presentadora/las presentadoras, si miente/mienten la sospechosa/las sospechosas sobre los crímenes, los gestos son reveladores.*  
“For the presenter/presenters, if a suspect/suspects lies/lie about the crimes, the gestures are very revealing.”
- 14) *La peregrina/Las peregrinas, cada vez que se debilita/debilitan una monja/unas monjas en el convento, trae/traen té y galletas.*  
“The pilgrim/pilgrims, every time a nun/nuns get/gets weak, bring/brings tea and cookies.”  
*Para la peregrina/las peregrinas, cada vez que se debilita/debilitan una monja/unas monjas en el convento, cuidarla es gratificante.*  
“For the pilgrim/pilgrims, every time a nun/nuns get/gets weak, taking care of her/them is a pleasure.”
- 15) *La refugiada/Las refugiadas, si insiste/insisten una peregrina/unas peregrinas en la cola, retrocede/retroceden para dejar paso.*  
“The refugee/refugees, if a pilgrim/pilgrims in the queue insists/insist, go/goes back to let her/them pass.”  
*Para la refugiada/las refugiadas, si insiste/insisten una peregrina/unas peregrinas en la cola, dejarla/dejarlas pasar no es molestia.*  
“For the refugee/refugees, if a pilgrim/pilgrims in the queue insists/insist, letting her/them pass is not a problem.”
- 16) *La compañera/Las compañeras, cuando aconseja/aconsejan la terapeuta/las terapeutas sobre alguna crema, obedece/obedecen en todo.*  
“The workmate/workmates, when the therapist/therapists recommends/recommend a cream, does/do everything as told.”  
*Para la compañera/ las compañeras, cuando aconseja/aconsejan la terapeuta/las terapeutas sobre alguna crema, su trabajo es más efectivo.*  
“For the workmate/workmates, when the therapist/therapists recommends/recommend a cream, her/their work is more efficient.”
- 17) *La ama/Las amas, cada vez que acude/acuden una refugiada/unas refugiadas a la posada, proporciona/proporcionan alojamiento.*  
“The owner/owners, every time a refugee/refugees comes/come to the inn, provides/provide accommodation.”  
*Para la ama/las amas, cada vez que acude/acuden una refugiada/unas refugiadas a la posada, los pequeños gestos son fundamentales.*  
“For the owner/owners, every time a refugee/refugees comes/come to the inn, the small gestures are very important.”

- 18) *La dueña/Las dueñas, si trabaja/trabajan la criada/las criadas en los dormitorios, ordena/ordenan el salón.*  
*“The housekeeper/housekeepers, if the maid/maids is/are working in the bedrooms, arranges/arrange the living room.”*  
*Para la dueña/las dueñas, si trabaja/trabajan la criada/las criadas en los dormitorios, las camas quedan mal hechas.*  
*“For the housekeeper/housekeepers, if the maid/maids is/are working in the bedrooms, the beds are not well done.”*
- 19) *La empleada/ Las empleadas, si se retrasa/retrasan la dueña/las dueñas con las pagas, utiliza/utilizan sus ahorros.*  
*“The employee/employees, if the boss/bosses is/are late with the paycheck, uses/use her/their savings.”*  
*Para las empleadas/las empleadas, si se retrasa/retrasan la dueña/las dueñas con las pagas, eso es una falta de respeto.*  
*“For the employee/employees, if the boss/bosses is/are late with the paycheck, that is disrespectful.”*
- 20) *La psiquiatra/Las psiquiatras, cuando se apunta/apuntan una anciana/unas ancianas a las terapias, modifica/modifican sus planes.*  
*“The psychiatrist/psychiatrists, when an old lady/ladies signs/sign up for the therapies, changes/change the plan.”*  
*Para las psiquiatras/las psiquiatras, cuando se apunta/apuntan una anciana/unas ancianas a las terapias, la sesión no es monótona.*  
*“For the psychiatrist/psychiatrists, when an old lady/ladies signs/sign up for the therapies, the session is not boring.”*
- 21) *La abuela/Las abuelas, si se rebela/rebelan la nieta/las nietas ante los recortes, apoya/apoyan las protestas.*  
*“The granny/grannies, if the granddaughter/granddaughters rebels/rebel about the budget cuts, supports/support the protests.”*  
*Para la abuela/las abuelas, si se rebela/rebelan la nieta/las nietas ante los recortes, apoyar su causa es primordial.*  
*“For the granny/grannies, if the granddaughter/granddaughters rebels/rebel about the budget cuts, supporting her/their cause is essential.”*
- 22) *La lechera/Las lecheras, cuando se compromete/comprometen la sirvienta/las sirvientas con las tareas, descansa/descansan un poco.*  
*“The milkmaid/milkmaids, when a servant/servants takes/take over the chores, rests/rest a bit.”*  
*Para la lechera/las lecheras, cuando se compromete/comprometen la sirvienta/las sirvientas con las tareas, el alivio es enorme.*  
*“For the milkmaid/milkmaids, when a servant/servants takes/take over the chores, it is a great relief.”*
- 23) *La extranjera/ Las extranjeras, cada vez que interviene/intervienen una directiva/unas directivas en las fronteras, muestra/muestran sus documentos.*  
*“The foreigner/foreigners, every time a manager/managers intervenes/intervene at the border, shows/show her/their documents”*  
*Para la extranjera/las extranjeras, cada vez que interviene/intervienen una directiva/unas directivas en las fronteras, el viaje se complica.*  
*“For the foreigner/foreigners, every time a manager/managers intervenes/intervene at the border, the trip gets more complicated”*
- 24) *La asesina/Las asesinas, cada vez que avanza/avanzan la investigadora/las investigadoras con el caso, comete/cometen errores.*  
*“The assassin/assassins, every time an investigator/investigators makes/make progress on the case, makes/make errors.”*  
*Para la asesina/las asesinas, cada vez que avanza/avanzan la investigadora/las investigadoras con el caso, la esperanza se va perdiendo.*  
*“For the assassin/assassins, every time an investigator/investigators makes/make progress on the case, the hope starts disappearing.”*
- 25) *La profesora/Las profesoras, cuando se involucra/involucran la experta/las expertas en la programación, renueva/renuevan su temario.*  
*“The professor/professors, when an expert/experts gets/get involved in the program, renews/renew her/their syllabus.”*  
*Para la profesora/las profesoras, cuando se involucra/involucran la experta/las expertas en la programación, el currículo se moderniza.*  
*“For the professor/professors, when an expert/experts gets/get involved in the program, the curriculum gets updated.”*
- 26) *La investigadora/Las investigadoras, si se opone/oponen la diputada/las diputadas a sus peticiones, se manifiesta/manifiestan otra vez.*  
*“The researcher/researchers, if a member/members of the parliament opposes/oppose her/their petitions, protests/protest again.”*  
*Para la investigadora/las investigadoras, si se opone/oponen la diputada/las diputadas a sus peticiones, protestar es la reacción instintiva.*  
*“For the researcher/researchers, if a member/members of the parliament opposes/oppose her/their petitions, protesting is an instinctive reaction.”*
- 27) *La terapeuta/Las terapeutas, cuando habla/hablan una profesora/unas profesoras sobre medicamentos, duda/dudan sobre sus conclusiones.*

*“The therapist/therapists, when the professor/professors talks/talk about the medication, doubts/doubts her/their conclusions.”*

*Para la terapeuta/las terapeutas, cuando habla/hablan una profesora/unas profesoras sobre medicamentos, sus productos son atractivos.*

*“For the therapist/therapists, when the professor/professors talks/talk about the medication, her/their products are appealing.”*

28) *La editora/Las editoras, cada vez que colabora/colaboran la supervisora/las supervisoras en la traducción, percibe/perciben tensión en el equipo.*

*“The editor/editors, every time a supervisor/supervisors collaborate on a translation, notices/notice the tension in the team.”*

*Para las editoras/las editoras, cada vez que colabora/colaboran la supervisora/las supervisoras en la traducción, el resultado es óptimo.*

*“For the editor/editors, every time a supervisor/supervisors collaborate on a translation, the results are optimal.”*

29) *La amiga/Las amigas, cada vez que se ríe/ríen un chico/unos chicos sobre chorradas, desvía/desvían la mirada.*

*“The friend/friends, every time a guy/guys laughs/laugh about nonsense, looks/look away.”*

*Para la amiga/las amigas, cada vez que se ríe/ríen un chico/unos chicos sobre chorradas, todos los chistes son estúpidos.*

*“For the friend/friends, every time a guy/guys laughs/laugh about nonsense, all the jokes are stupid.”*

30) *La alumna/Las alumnas, cuando enseña/enseñan el profesor/los profesores con mucha pasión, aprende/aprenden más fácil.*

*“The student/students, when the professor/professors teaches/teach with passion, learns/learn more easily.”*

*Para la alumna/las alumnas, cuando enseña/enseñan el profesor/los con mucha pasión, escuchar atentamente es fácil.*

*“For the student/students, when the professor/professors teaches/teach with passion, listening carefully is easy.”*

31) *La niña/Las niñas, si corre/corren el entrenador/los entrenadores en los partidos, se pone/ponen nerviosas.*

*“The girl/girls, if the coach/coaches runs/run at the match, becomes/become nervous.”*

*Para la niña/las niñas, si corre/corren el entrenador/los entrenadores en los partidos, la situación se pone tensa.*

*“For the girl/girls, if the coach/coaches runs/run at the match, the situation gets tense.”*

32) *La autora/Las autoras, cuando se motiva/motivan el pintor/los pintores durante el verano, organiza/organizan un festival de arte.*

*“The author/authors, when a painter/painters feels/feel motivated in the summer, organizes/organize an art festival.”*

*Para la autora/las autoras, cuando se motiva/motivan el pintor/los pintores durante el verano, la exposición es un éxito.*

*“For the author/authors, when a painter/painters feels/feel motivated in the summer, the exhibition is a success.”*

33) *La monja/Las monjas, cada vez que predica/predican el cura/los curas en una misa, reza/rezan un avemaría.*

*“The nun/nuns, every time a priest/priests preaches/preach at the mass, says/say the Hail Mary.”*

*Para la monja/las monjas, cada vez que predica/predican el cura/los curas en una misa, la parte final es la más bonita.*

*“For the nun/nuns, every time a priest/priests preaches/preach at the mass, the final part is the nicest one.”*

34) *La operadora/las operadoras, cuando fracasa/fracasan el actor/los actores en las pruebas, agita/agitan los brazos.*

*“The operator/operators, when an actor/actors fails/fail at the rehearsals, waves/wave his/their arms.”*

*Para la operadora/las operadoras, cuando fracasa/fracasan el actor/los actores, los otros actores parecen mejores.*

*“For the operator/operators, when an actor/actors fails/fail at the rehearsals, the other actors seem better.”*

35) *La camarera/Las camareras, si tropieza/tropezan un borracho/unos borrachos con los azulejos, advierte/ advierten a otros clientes.*

*“The waitress/waitresses, if a drunkard/drunks falls/fall down on the tiles, advises/advise the other clients.”*

*Para la camarera/las camareras, si tropieza/tropezan un borracho/unos borrachos con los azulejos, pedir ayuda es lo primero.*

*“For the waitress/waitresses, if a drunkard/drunks falls/fall down on the tiles, the first thing is to look for help.”*

36) *La actriz/Las actrices, cuando se prepara/preparan un pasajero/los pasajeros para una foto, se perfila/perfilan los labios en el avión.*

*“The actress/actresses, when a passenger/passengers get/gets ready for a photo, paints/paint her/their lips.”*

*Para la actriz/las actrices, cuando se prepara/preparan un pasajero/los pasajeros para una foto, posar para la cámara es automático.*

*“For the actress/actresses, when a passenger/passengers get/gets ready for a photo, posing for the camera is automatic.”*

37) *La azafata/Las azafatas, cada vez que vuela/vuelan un gobernante/unos gobernantes en su turno, saca/sacan mejor comida.*

*“The flight attendant/attendants, every time a governor/governors flies/fly in her/their shift, serves/serve the best food.”*

*Para la azafata/las azafatas, cada vez que vuela/vuelan un gobernante/unos gobernantes en su turno, la calidad del servicio es mejor.*

*“For the flight attendant/attendants, every time a governor/governors flies/fly in her/their shift, the service is better.”*

38) *La encargada/Las encargadas, cada vez que revisa/revisan el vendedor/los vendedores por las tardes, supervisa/supervisan el proceso.*

*"The manager/managers, every time the seller/sellers revises/revise in the afternoon, supervises/supervise the process."*

*Para la encargada/las encargadas, cada vez que revisa/revisan el vendedor/los vendedores por las tardes, la caja no cuadra.*

*"For the manager/managers, every time the seller/sellers revises/revise in the afternoon, the register doesn't balance."*

39) *La dama/Las damas, cuando presume/presumen el conquistador/los conquistadores en las fiestas, recurre/recurren a sus amigas.*

*"The lady/ladies, when a seducer/seducers shows/show off at the parties, resorts/resort to her/their friends."*

*Para la dama/las damas, cuando presume/presumen el conquistador/los conquistadores en las fiestas, las conversaciones son aburridas.*

*"For the lady/ladies, when a seducer/seducers shows/show off at the parties, the conversations are boring."*

40) *La criada/Las criadas, cada vez que se pierde/pierden el muchacho/los muchachos en el campo, se alarma/alarman enseguida.*

*"The servant/servants, every time a boy/boys gets/get lost in the field, gets/gets alarmed right away."*

*Para la criada/las criadas, cada vez que se pierde/pierden el muchacho/los muchachos en el campo, llamar a sus padres es lo primero.*

*"For the servant/servants, every time a boy/boys gets/get lost in the field, calling his/their parents is the first thing to do."*

41) *La estrella/Las estrellas, cuando se responsabiliza/responsabilizan el aprendiz/los aprendices de los vestidos, exige/exigen mucho.*

*"The star/stars, when an apprentice/apprentices takes/take over the dresses, is/are very demanding."*

*Para la estrella, cuando se responsabiliza/responsabilizan el aprendiz/los aprendices de los vestidos, todo debe ser glamuroso.*

*"For the star/stars, when an apprentice/apprentices takes/take over the dresses, everything has to look glamorous."*

42) *La cría/Las crías, si compone/componen el maestro/los maestros en el piano, practica/practican el canto.*

*"The girl/girls, if the teacher/teachers composes/compose on the piano, practices/practice singing."*

*Para la cría/las crías, si compone/componen el maestro/los maestros en el piano, estudiar para el examen es más fácil.*

*"For the girl/girls, if the teacher/teachers composes/compose on the piano, studying for the exam is easier."*

43) *La financiera/Las financieras, cuando encaja/encajan el ingeniero/los ingenieros en los planes, desarrolla/desarrollan proyectos muy interesantes.*

*"The financier/financiers, when the engineer/engineers agrees/agree with the plans, develops/develop very interesting projects."*

*Para la financiera/las financieras, cuando encaja/encajan el ingeniero/los ingenieros en los planes, empezar enseguida es fácil.*

*"For the financier/financiers, when the engineer/engineers agrees/agree with the plans, starting right away is easy."*

44) *La jugadora/Las jugadoras, cada vez que vence/vencen el contrincante/los contrincantes en el campo, se muerde/muerden las uñas.*

*"The player/players, every time the opponent/opponents wins/win, bites/bite her/their nails."*

*Para la jugadora/las jugadoras, cada vez que vence/vencen el contrincante/los contrincantes en el campo, mantener la cabeza fría es vital.*

*"For the player/players, every time the opponent/opponents wins/win, staying calm is vital."*

45) *La enferma/Las enfermas, si se rinde/rinden el cirujano/los cirujanos durante la operación, requiere/ requieren un informe detallado.*

*"The patient/patients, if the surgeon/surgeons gives/give up during the operation, wants/want a detailed report."*

*Para la enferma/las enfermas, si se rinde/rinden el cirujano/los cirujanos durante la operación, la fe es vital.*

*"For the patient/patients, if the surgeon/surgeons gives/give up during the operation, having faith is vital."*

46) *La ciudadana/Las ciudadanas, si sonríe/sonríen un refugiado/los refugiados a pesar de sus problemas, reflexiona/reflexionan sobre su vida.*

*"The citizen/citizens, if a refugee/refugees smiles/smile despite his/their problems, reflects/reflect on his/their life."*

*Para la ciudadana/las ciudadanas, si sonríe/sonríen un refugiado/los refugiados a pesar de sus problemas, el día se vuelve más alegre.*

*"For the citizen/citizens, if a refugee/refugees smiles/smile despite his/their problems, the day gets happier."*

47) *La ministra/Las ministras, si se atreve/atreven el senador/los senadores a un careo, inicia/inician un debate.*

*"The minister/ministers, if a senator/senators dares/dare to confront her/them, starts/start a debate."*

*Para la ministra/las ministras, si se atreve/atreven el senador/los senadores a un careo, cambiar de tema es lo mejor.*

*"For the minister/ministers, if a senator/senators dares/dare to confront her/them, changing the topic is the best solution."*

48) La invitada/Las invitadas, cada vez que circula/circulan el fotógrafo/los fotógrafos con su cámara, rectifica/rectifican su postura.

*"The guest/guests, every time the photographer/photographers walks/walk by with his/their cameras, fixes/fix her/their posture."*

Para la invitada/las invitadas, cada vez que circula/circulan el fotógrafo/los fotógrafos con su cámara, salir bien en las fotos es lo habitual.

*"For the guest/guests, every time the photographer/photographers walks/walk by with his/their cameras, looking good on the photos always works."*

49) La acusada/Las acusadas, si se levanta/levantan el testigo/los testigos de su banco, tiembla/tiemblan de miedo.

*"The defendant/defendants, if the witness/witnesses gets/get up from the bench, trembles/tremble with fear."*

Para la acusada/las acusadas, si se levanta/levantan el testigo/los testigos de su banco, la sentencia está más cerca.

*"For the defendant/defendants, if the witness/witnesses gets/get up from the bench, the sentence seems closer."*

50) La proveedora/Las proveedoras, cada vez que abre/abren el tendero/los tenderos por las mañanas, reparten/reparte los pedidos.

*"The supplier/suppliers, when the shopkeeper/shopkeepers open in the morning, distributes/distribute the orders."*

Para la proveedora/las proveedoras, cada vez que abre/abren el tendero/los tenderos por las mañanas, la entrega es rápida.

*"For the supplier/suppliers, when the shopkeeper/shopkeepers open in the morning, the delivery is very fast."*

51) La escritora/Las escritoras, cuando critica/critican el editor/los editores con duras palabras, se inventa/inventan una excusa.

*"The writer/writers, when the editor/editors criticizes/criticize her/them harshly, thinks/think of an excuse."*

Para la escritora/las escritoras, cuando critica/critican el editor/los editores con duras palabras, su ánimo decae.

*"For the writer/writers, when the editor/editors criticizes/criticize her/them harshly, the enthusiasm decreases."*

52) La secretaria/Las secretarias, si se confunde/confunden el cartero/los carteros con las cartas, devuelve/devuelven el envío.

*"The secretary/secretaries, if the postman/postmen mixes/mix up the letters, returns/return the delivery."*

Para la secretaria/las secretarias, si se confunde/confunden el cartero/los carteros con las cartas, el seguimiento online lo resuelve todo.

*"For the secretary/secretaries, if the postman/postmen mixes/mix up the letters, the online tracking system solves everything."*

53) La vendedora/Las vendedoras, cada vez que se interesa/interesan un alumno/unos alumnos por sus productos, se explica/explican con paciencia.

*"The merchant/merchants, every time a student/students asks/ask about his/their products, explains/explain everything patiently."*

Para la vendedora/las vendedoras, cada vez que se interesa/interesan un alumno/unos alumnos por sus productos, su trabajo merece la pena.

*"For the merchant/merchants, every time a student/students asks/ask about his/their products, his/their job is worth it."*

54) La señora/Las señoras, cuando entrena/entrenan un nadador/los nadadores en la piscina, se traslada/trasladan a la otra piscina.

*"The lady/ladies, when a swimmer/swimmers trains/train in the pool, moves/move to the other pool."*

Para la señora/las señoras, cuando entrena/entrenan un nadador/los nadadores en la piscina, cambiar de carril es más sencillo.

*"For the lady/ladies, when a swimmer/swimmers trains/train in the pool, changing the lane is the easiest."*

55) La señorita/Las señoritas, si molesta/molestan un mensajero/los mensajeros con sus llamadas, prefiere/prefieren avisar a su padre.

*"The young lady/ladies, if a messenger/messengers is/are bothering with his/their calls, prefers/prefer to inform her father."*

Para las señoritas/las señoritas, si molesta/molestan un mensajero/los mensajeros con sus llamadas, no contestar es mejor.

*"For the young lady/ladies, if a messenger/messengers is/are bothering with his/their calls, it's better not to answer."*

56) La supervisora/las supervisoras, cuando engaña/engañan el rector/los rectores con sus mentiras, sospecha/sospechan de todo lo que hace.

*"The supervisor/supervisors, when the dean/deans misleads/mislead with her/their lies, suspects/suspect everything he/they does/do."*

Para la supervisora/las supervisoras, cuando engaña/engañan el rector/los rectores con sus mentiras, la sinceridad es vital.

*"For the supervisor/supervisors, when the dean/deans misleads/mislead with her/their lies, honesty is very important."*

57) El médico/los médicos, cuando sufre/sufren una señora/unas señoras por la regla, prescribe/prescriben ibuprofeno.

*"The doctor/doctors, when a lady/ladies suffers/suffer because of her/their period, prescribes/prescribe ibuprofen."*

Para el médico/los médicos, cuando sufre/sufren una señora/unas señoras por la regla, prescribir ibuprofeno es lo más fácil.



*“For the doctor/doctors, when a lady/ladies suffers/suffer because of her/their period, prescribing ibuprofen is the easiest solution.”*

58) *El chico/Los chicos, cada vez que canta/cantan la estrella/las estrellas en los festivales, disfruta/disfrutan de la actuación.*

*“The boy/boys, every time a star/stars sings/sing at the festivals, enjoys/enjoy the performance.”*

*Para el chico/los chicos, cada vez que canta/cantan la estrella/las estrellas en los festivales, el viaje merece la pena.*

*“For the boy/boys, every time a star/stars sings/sing at the festivals, it is worth the trip.”*

59) *El compañero/Los compañeros, si entra/entran una ciudadana/unas ciudadanas a la tienda, ofrece/ofrecen los mejores productos.*

*“The co-worker/co-workers, if a citizen/citizens enters/enter the shop, offers/offer the best products.”*

*Para el compañero/los compañeros, si entra/entran una ciudadana/unas ciudadanas a la tienda, su opinión es fundamental.*

*“For the co-worker/co-workers, if a citizen/citizens enters/enter the shop, his/their opinion is fundamental.”*

60) *El inspector/Los inspectores, si se escapa/escapan la asesina/las asesinas de la cárcel, espera/esperan a los refuerzos.*

*“The inspector/inspectors, if the assassin/assassins escapes/escape from the prison, waits/wait for the backup.”*

*Para el inspector/los inspectores, si se escapa/escapan la asesina/las asesinas de la cárcel, la investigación se complica.*

*“For the inspector/inspectors, if the assassin/assassins escapes/escape from the prison, the investigation gets complicated.”*

61) *El conductor/Los conductores, si sube/suben una embarazada/unas embarazadas al autobús, señala/señalan dónde hay un asiento libre.*

*“The driver/drivers, if a pregnant woman/women gets/get on the bus, points/point to a free seat.”*

*Para el conductor/los conductores, si sube/suben una embarazada/unas embarazadas al autobús, esperar un poco no supone un problema.*

*“For the driver/drivers, if a pregnant woman/women gets/get on the bus, waiting a bit is not a problem.”*

62) *El profesor/Los profesores, si analiza/analizan la trabajadora/las trabajadoras en el laboratorio, observa/observan atentamente.*

*“The professor/professors, if the worker/workers does/do the analysis in the laboratory, observes/observe attentively.”*

*Para el profesor/los profesores, si analiza/analizan la trabajadora/las trabajadoras en el laboratorio, su trabajo resulta complicado.*

*“For the professor/professors, if the worker/workers does/do the analysis in the laboratory, his/their work ends up being complicated.”*

63) *El dueño/los dueños, cuando aparece/aparecen la proveedora/las proveedoras los miércoles, cierra/cierran la tienda.*

*“The owner/owners, if the supplier/suppliers shows/show up on Wednesdays, closes/close the shop.”*

*Para el dueño/los dueños, cuando aparece/aparecen la proveedora/las proveedoras los miércoles, la calidad del servicio es peor.*

*“For the owner/owners, if the supplier/suppliers shows/show up on Wednesdays, the service quality gets worse.”*

64) *El controlador/Los controladores, cuando grita/gritan la encargada/las encargadas por la radio, respeta/respetan sus órdenes.*

*“The controller/controllers, when the manager/managers yells/yell on the radio, obeys/obey his/their orders.”*

*Para el controlador/los controladores, cuando grita/gritan la encargada/las encargadas por la radio, la cooperación no fluye correctamente.*

*“For the controller/controllers, when the manager/managers yells/yell on the radio, the collaboration doesn't flow smoothly.”*

65) *El reportero/Los reporteros, cuando desfila/desfilan una actriz/unas actrices en televisión, enciende/encienden la cámara.*

*“The reporter/reporters, when an actress/actresses marches/march on TV, turns/turn on the camera.”*

*Para el reportero/los reporteros, cuando desfila/desfilan una actriz/unas actrices en televisión, la risa es inevitable.*

*“For the reporter/reporters, when an actress/actresses marches/march on TV, laughing is inevitable.”*

66) *El traductor/Los traductores, si corrige/corrijen la editora/las editoras después de la entrega, actualiza/actualizan el documento.*

*“The translator/translators, if the editor/editors corrects/correct after handing in, updates/update the document.”*

*Para el traductor/los traductores, si corrige/corrijen la editora/las editoras después de la entrega, perder los nervios es normal.*

*“For the translator/translators, if the editor/editors corrects/correct after handing in, losing his/their nerve is normal.”*

67) *El niño/Los niños, cuando se exalta/exaltan la maestra/las maestras por sus travesuras, llora/lloran sin parar.*

*“The boy/boys, if the teacher/teachers gets/get upset, cries/cry without stopping.”*

*Para el niño/los niños, cuando se exalta/exaltan la maestra/las maestras por sus travesuras, llorar es su vía de escape.*

*“For the boy/boys, if the teacher/teachers gets/get upset, crying is his/their way out.”*

68) El carpintero/Los carpinteros, cuando se encarga/encargan la empleada/las empleadas de su taller, se toma/toman un café.

*"The carpenter/carpenters, when an employee/employees takes/take care of the shop, takes/take a coffee."*

Para el carpintero/los carpinteros, cuando se encarga/encargan la empleada/las empleadas de su taller, su jornada laboral es más amena.

*"For the carpenter/carpenters, when an employee/employees takes/take care of the shop, the shift is more pleasant."*

69) El cartero/Los carteros, cada vez que paga/pagan la vendedora/las vendedoras por los paquetes, confirma/afirman el albarán.

*"The postman/postmen, every time a seller/sellers pays/pay for the packages, confirms/confirm the delivery note."*

Para el cartero/los carteros, cada vez que paga/pagan la vendedora/las vendedoras por los paquetes, cobrar con tarjeta es más sencillo.

*"For the postman/postmen, every time a seller/sellers pays/pay for the packages, it is simpler to charge with a card."*

70) El maestro/Los maestros, cada vez que toca/tocan la alumna/las alumnas en los concursos, aplaude/aplauden con orgullo.

*"The teacher/teachers, every time a student/students plays/play at competitions, applauds/applaud proudly."*

Para el maestro/los maestros, cada vez que toca/tocan la alumna/las alumnas en los concursos, el comité es injusto.

*"For the teacher/teachers, every time a student/students plays/play at competitions, the judges are not fair."*

71) El monitor/Los monitores, cada vez que se cae/caen una niña/unas niñas en el circuito, aplica/aplican agua oxigenada.

*"The instructor/instructors, every time a girl/girls falls/fall during the route, applies/apply oxygenated water."*

Para el monitor/los monitores, cada vez que se cae/caen una niña/unas niñas en el circuito, todo lo demás es secundario.

*"For the instructor/instructors, every time a girl/girls falls/fall during the route, everything else is less important."*

72) El caballero/Los caballeros, si se sienta/sientan la princesa/las princesas después del discurso, se relaciona/relacionan con los invitados.

*"The gentleman/the gentlemen, if the princess/princesses sits/sit down after the speech, mingles/mingle with the guests."*

Para el caballero/los caballeros, si se sienta/sientan la princesa/las princesas después del discurso, la fiesta se vuelve más aburrida.

*"For the gentleman/the gentlemen, if the princess/princesses sits/sit down after the speech, the party gets more boring."*

73) El pintor/Los pintores, si se agota/agotan la marquesa/las marquesas en esa postura, interrumpe/interrumpen la sesión.

*"The painter/painters, if the marchioness/marchionesses gets/get tired of the same posture, stops/stop the session."*

Para el pintor/los pintores, si se agota/agotan la marquesa/las marquesas en esa postura, pintar relajado es más difícil.

*"For the painter/painters, if the marchioness/marchionesses gets/get tired of the same posture, painting with no pressure is hard."*

74) El vendedor/Los vendedores, si se presenta/presentan la autora/las autoras en la exposición, aumenta/aumentan el precio de los libros.

*"The agent/agents, if an author shows/show up at the presentation, increases/increase the book prices."*

Para el vendedor/los vendedores, si se presenta/presentan la autora/las autoras en la exposición, los libros se venden mejor.

*"For the agent/agents, if an author shows/show up at the presentation, the books sell better."*

75) El organizador/Los organizadores, si se equivoca/equivocan la bailarina/las bailarinas en su actuación, pierde/pierden los nervios.

*"The organizer/organizers, if a ballerina/ballerinas makes/make a mistake during the performance, loses/lose his/their nerve."*

Para el organizador/los organizadores, si se equivoca/equivocan la bailarina/las bailarinas en su actuación, el espectáculo se vuelve ridículo.

*"For the organizer/organizers, if a ballerina/ballerinas makes/make a mistake during the performance, the show becomes ridiculous."*

76) El alcalde/Los alcaldes, si accede/aceden la financiera/las financieras a los presupuestos, propone/proponen proyectos nuevos.

*"The mayor/mayors, if a financier/financiers agrees/agree to the proposals, suggests/suggest new projects."*

Para el alcalde/los alcaldes, si accede/aceden la financiera/las financieras a los presupuestos, los nuevos proyectos son emocionantes.

*"For the mayor/mayors, if a financier/financiers agrees/agree to the proposals, the new projects are exciting."*

77) El fotógrafo/Los fotógrafos, cada vez que llama/llaman una novia/unas novias por teléfono, lanza/lanzan una oferta especial.

*"The photographer/photographers, every time a bride/brides calls/call on the phone, gives/give a special offer."*

Para el fotógrafo/los fotógrafos, cada vez que llama/llaman una novia/unas novias por teléfono, los precios pueden cambiar.

*"For the photographer/photographers, every time a bride/brides calls/call on the phone, the prices are subject to change."*

78) El chaval/Los chavales, cada vez que se esconde/esconden la cría/las crías en el bosque, mira/miran en la casita del árbol.

*"The kid/kids, every time the little girl/girls hides/hide in the forest, looks/look at the treehouse."*

Para el chaval/los chavales, cada vez que se esconde/esconden la cría/las crías en el bosque, la preocupación aumenta.

*"For the kid/kids, every time the little girl/girls hides/hide in the forest, his/their worry increases."*

79) El muchacho/Los muchachos, cuando regresa/regresan la camarera/las camareras con las bebidas, abona/abonan la cuenta.

*"The boy/boys, when the waitress/waitresses comes/come back with the drinks, pays/pay the bill."*

Para el muchacho/los muchachos, cuando regresa/regresan la camarera/las camareras con las bebidas, el importe es muy elevado.

*"For the boy/boys, when the waitress/waitresses comes/come back with the drinks, the price is really increased."*

80) El entrenador/Los entrenadores, si se inscribe/inscriben una vieja/unas viejas a sus actividades, adapta/adaptan el programa un poco.

*"The coach/coaches, if an old lady/ladies signs/sign up for the activities, adapts/adapt the program a bit."*

Para el entrenador/los entrenadores, si se inscribe/inscriben una vieja/unas viejas a sus actividades, ganar una medalla es lo de menos.

*"For the coach/coaches, if an old lady/ladies signs/sign up for the activities, winning a medal is not important."*

81) El doctor/Los doctores, cuando persiste/persisten la psiquiatra/las psiquiatras con los antidepresivos, intenta/intentan ayudar con medicina alternativa.

*"The doctor/doctors, when the psychiatrist/psychiatrists is/are insistent on the antidepressants, tries/try to help with the alternative medicine."*

Para el doctor/los doctores, cuando persiste/persisten la psiquiatra/las psiquiatras con los antidepresivos, oponerse es inútil.

*"For the doctor/doctors, when the psychiatrist/psychiatrists is/are insistent on the antidepressants, opposing him/them makes no sense."*

82) El gerente/los gerentes, si se despide/despiden una secretaria/unas secretarias de su departamento, publica/publican una oferta de trabajo.

*"The manager/managers, if a secretary/secretaries leaves/leave the department, publishes/publish a job offer."*

Para el gerente/los gerentes, si se despide/despiden una secretaria/unas secretarias de su departamento, su trabajo se ve afectado.

*"For the manager/managers, if a secretary/secretaries leaves/leave the department, his/their work is affected."*

83) El chófer/Los chóferes, cuando se aleja/alejan la reina/reinas de su villa, permanece/permanecen delante de la puerta.

*"The driver/drivers, when the queen/queens moves/move away from the villa, stays/stay in front of the door."*

Para el chófer/los chóferes, cuando se aleja/alejan la reina/reinas de su villa, el día es más relajante.

*"For the driver/drivers, when the queen/queens moves/move away from the villa, the day is more relaxing."*

84) El mensajero/Los mensajeros, cada vez que contesta/contestan la señorita/las señoritas al teléfono, entrega/entregan con rapidez.

*"The messenger/messengers, every time a young lady/ladies answers/answer the phone, delivers/deliver promptly."*

Para el mensajero/los mensajeros, cada vez que contesta/contestan la señorita/las señoritas al teléfono, ser profesional es necesario.

*"For the messenger/messengers, every time a young lady/ladies answers/answer the phone, staying professional is necessary."*

85) El albañil/Los albañiles, si se detiene/detienen el carpintero/los carpinteros por fuertes dolores, prosigue/prosiguen solo.

*"The construction worker/workers, if the carpenter/carpenters stops/stop strong because of pain, continues/continue working alone."*

Para el albañil/los albañiles, si se detiene/detienen el carpintero/los carpinteros por fuertes dolores, acabar su trabajo es lo lógico.

*"For the construction worker/workers, if the carpenter/carpenters stops/stop because of pain, finishing his/their work is logical."*

86) El cura/Los curas, cuando asiste/asisten un duque/unos duques a su misa, agradece/agradecen su presencia.

*"The priest/priests, when a duke/dukes assists/assist his/their mass, appreciates/appreciate him/them showing up."*

Para el cura/los curas, cuando asiste/asisten un duque/unos duques a su misa, mostrar respeto es fundamental.

*"For the priest/priests, when a duke/dukes assists/assist his/their mass, showing respect is really important."*

87) El financiero/Los financieros, si llega/llegan un novato/unos novatos al equipo, evalúa/evalúan los gastos.

*"The financier/financiers, if a novice/novices arrives/arrive to the team, evaluates/evaluate the expenses."*

Para el financiero/los financieros, si llega/llegan un novato/unos novatos al equipo, los costes son considerables.

*"For the financier/financiers, if a novice/novices arrives/arrive to the team, the expenses are considerable."*

88) El piloto/Los pilotos, cuando se comunica/comunican el controlador/los controladores antes de los vuelos, presta/prestan atención.

*"The pilot/pilots, when the controller/controllers communicates/communicate with him/them before the flight, pays/pay attention."*

Para el piloto/los pilotos, cuando se comunica/comunican el controlador/controladores antes de los vuelos, la atención es máxima.

*"For the pilot/pilots, when the controller/controllers communicates/communicate with him/them before the flight, the attention is very high."*

89) El ingeniero/Los ingenieros, si se convence/convencen el gerente/los gerentes sobre las negociaciones, comienza/comienzan el proyecto.

*"The engineer/engineers, if the director/directors gets/get persuaded with the negotiations, initiates/initiate the project."*

Para el ingeniero/los ingenieros, si se convence/convencen el gerente/los gerentes sobre las negociaciones, acelerar las obras es lo primero.

*"For the engineer/engineers, if the director/directors gets/get persuaded with the negotiations, speeding up with work is the priority."*

90) El camionero/Los camioneros, si se preocupa/preocupan el técnico/los técnicos por su seguridad, repara/reparan los frenos.

*"The truck driver/drivers, if the technician/technicians worry/worries about his/their safety, fixes/fix the breaks."*

Para el camionero/los camioneros, si se preocupa/preocupan el técnico/los técnicos por su seguridad, revisar el vehículo es importante.

*"For the truck driver/drivers, if the technician/technicians worry/worries about his/their safety, checking up the vehicle is important."*

91) El indio/Los indios, cada vez que dispara/disparan un vaquero/unos vaqueros con su pistola, evita/evitan las balas.

*"The Native American/Americans, every time a cowboy/cowboys shoots/shoot, avoids/avoid the bullet."*

Para el indio/los indios, cada vez que dispara/disparan un vaquero/unos vaqueros con su pistola, huir rápidamente es crucial.

*"For the Native American/Americans, every time a cowboy/cowboys shoots/shoot, running away quickly is crucial."*

92) El tendero/Los tenderos, cuando murmura/murmuran el vecino/los vecinos en el mercado, oye/oyen todo desde su tienda.

*"The shopkeeper/shopkeepers, when the neighbour/neighbours whispers/whisper at the market, hears/hear everything from his/their shop."*

Para el tendero/ los tenderos, cuando murmura/murmuran el vecino/los vecinos en el mercado, el cotilleo es interesante.

*"For the shopkeeper/shopkeepers, when the neighbour/neighbours whispers/whisper at the market, the gossip is really interesting."*

93) El enfermo/Los enfermos, cuando vuelve/vuelven el doctor/los doctores a su habitación, se anticipa/anticipan a las noticias.

*"The patient/patients, when the doctor/doctors returns/return to his/their room, anticipates/anticipate the news."*

Para el enfermo/los enfermos, cuando vuelve/vuelven el doctor/los doctores a su habitación, preguntar por su salud es lo primero.

*"For the patient/patients, when the doctor/doctors returns/return to his/their room, asking about health is most important."*

94) El senador/Los senadores, cuando pasa/pasan un empresario/empresarios por las oficinas, aprovecha/aprovechan para hablar sobre trabajo.

*"The senator/senators, when an entrepreneur/entrepreneurs walks/walk around the offices, uses/use the opportunity to talk about business."*

Para el senador/los senadores, cuando pasa/pasan un empresario/empresarios por las oficinas, todo debería estar ordenado.

*"For the senator/senators, when an entrepreneur/entrepreneurs walks/walk around the offices, everything should be in order."*

95) El editor/Los editores, si se ahoga/ahogan el traductor/los traductores con el exceso de documentos, reduce/reducen la carga de trabajo.

*"The editor/editors, if the translator/translators is/are overwhelmed with the number of documents, reduces/reduce the workload."*

Para el editor/los editores si se ahoga/ahogan el traductor/los traductores con el exceso de documentos, la fecha límite es flexible.

*"For the editor/editors, if the translator/translators is/are overwhelmed with the number of documents, the deadline is flexible."*

96) El pasajero/Los pasajeros, cuando frena/frenan el conductor/los conductores de repente, se asusta/asustan un poco.

*“The passenger/passengers, when the driver/drivers hits/hit the brakes all of a sudden, gets/get scared a bit.”*  
*Para el pasajero/los pasajeros, cuando frena/frenan el conductor/los conductores de repente, el viaje se vuelve incómodo.*  
*“For the passenger/passengers, when the driver/drivers hits/hit the brakes all of a sudden, the trip becomes uncomfortable.”*

97) *El boxeador/Los boxeadores, si gana/ganan el chaval/los chavales otra vez, abandona/abandonan el campeonato.*  
*“The boxer/boxers, if a young boy/boys wins/win again, quits/quit the competition.”*  
*Para el boxeador/los boxeadores, si gana/ganan el chaval/los chavales otra vez, su participación no tiene sentido.*  
*“For the boxer/boxers, if a young boy/boys wins/win again, his/their participation makes no sense.”*

98) *El árbitro/Los árbitros, cuando se desvanece/desvanecen el boxeador/los boxeadores por los puñetazos, suspende/suspenden la pelea.*  
*“The referee/referees, when the boxer/boxers passes/pass out from the punches, cancels/cancel the fight.”*  
*Para el árbitro/los árbitros, cuando se desvanece/desvanecen el boxeador/los boxeadores por los puñetazos, el partido se aborta enseguida.*  
*“For the referee/referees, when the boxer/boxers passes/pass out from the punches, the fight is cancelled right away.”*

99) *El conquistador/Los conquistadores, si se aproxima/aproximan el enemigo/los enemigos a pocos metros, agarra/agarran la espada.*  
*“The conqueror/conquerors, if the enemy/enemies approaches/approach more closely, grabs/grab his/their sword.”*  
*Para el conquistador/los conquistadores, si se aproxima/aproximan el enemigo/los enemigos a pocos metros, la espada debe estar preparada.*  
*“For the conqueror/conquerors, if the enemy/enemies approaches/approach more closely, the sword has to be ready.”*

100) *El contrincante/Los contrincantes, cada vez que aspira/aspiran el campeón/los campeones al podio, se esfuerza/esfuerzan al máximo.*  
*“The opponent/opponents, every time the champion/champions aspires/aspire to win, makes/make an extra effort.”*  
*Para el contrincante/los contrincantes, cada vez que aspira/aspiran el campeón/los campeones al podio, el partido es duro.*  
*“For the opponent/opponents, every time the champion/champions aspires/aspire to win, the match is difficult.”*

101) *El aprendiz/Los aprendices, si se ocupa/ocupan el albañil/los albañiles de los techos, gestiona/gestionan todo lo demás.*  
*“The apprentice/the apprentices, if the construction worker/workers takes/take care of the roof, handles/handle everything else.”*  
*Para el aprendiz/los aprendices, si se ocupa/ocupan el albañil/los albañiles de los techos, el trabajo termina enseguida.*  
*“For the apprentice/the apprentices, if the construction worker/workers takes/take care of the roof, the work gets done quickly.”*

102) *El enemigo/Los enemigos, cada vez que ataca/atacan el indio/los indios con los arcos, planea/planean el contraataque.*  
*“The enemy/enemies, every time a Native American/Americans attacks/attack with the arrows, plans/plan the counterattack.”*  
*Para el enemigo/los enemigos, cada vez que ataca/atacan el indio/los indios con los arcos, su vida corre peligro.*  
*“For the enemy/enemies, every time a Native American/Americans attacks/attack with the arrows, his life is in danger.”*

103) *El empresario/Los empresarios, cada vez que negocia/negocian el financiero/los financieros las inversiones, mantiene/mantienen su postura.*  
*“The entrepreneur/entrepreneurs, every time a financier/financiers negotiates/negotiate the investments, maintains/maintain his/their stance.”*  
*Para el empresario/los empresarios, cada vez que negocia/negocian el financiero/los financieros las inversiones, el prestigio del centro es vital.*  
*“For the entrepreneur/entrepreneurs, every time a financier/financiers negotiates/negotiate the investments, the center’s prestige is really important.”*

104) *El técnico/Los técnicos, si viaja/viajan el dueño/los dueños en verano, necesita/necesitan ayuda en la óptica.*  
*“The technician/technicians, if the owner/owners travels/travel during the summer, needs/need help at the optical shop.”*  
*Para el técnico/los técnicos, si viaja/viajan el dueño/los dueños en verano, la carga de trabajo aumenta.*  
*“For the technician/technicians, if the owner/owners travels/travel during the summer, the workload increases.”*

105) *El cirujano/Los cirujanos, cuando muere/mueren el enfermo/los enfermos en el hospital, informa/informan a los familiares.*  
*“The surgeon/surgeons, when a patient/patients dies/die in the hospital, informs/inform the relatives.”*  
*Para el cirujano/los cirujanos, cuando muere/mueren el enfermo/los enfermos en el hospital, no sentirse culpable es difícil.*  
*“For the surgeon/surgeons, when a patient/patients dies/die in the hospital, it is hard not to feel guilty.”*

106) *El refugiado/Los refugiados, si se presta/prestan un camionero/unos camioneros a un viaje gratuito, agradece/agradecen su bondad.*  
*“The refugee/ refugees, if a truck driver/drivers offers/offer a free ride, appreciates/appreciate his/their kindness.”*

Para el refugiado/los refugiados, si se presta/prestan un camionero/unos camioneros a un viaje gratuito, su fe en la humanidad crece.

*"For the refugee/ refugees, if a truck driver/drivers offers/offer a free ride, his/their faith in humanity grows."*

107) El nadador/Los nadadores, cuando sale/salen el árbitro/los árbitros de los vestuarios, se prepara/preparan para el salto.

*"The swimmer/swimmers, when the referee/referees comes/come out of the changing room, prepares/prepare for the jump."*

Para el nadador/los nadadores, cuando sale/salen el árbitro/los árbitros de los vestuarios, hacer contacto visual es favorable.

*"For the swimmer/swimmers, when the referee/referees comes/come out of the changing room, making eye contact is good."*

108) El alumno/los alumnos, cuando se distrae/distraen el monitor/los monitores durante la clase, nada/nadan en la piscina grande.

*"The student/students, when the instructor/instructors gets/get distracted during the class, swims/swim in the big pool."*

Para el alumno/los alumnos, cuando se distrae/distraen el monitor/los monitores durante la clase, probar saltos nuevos es genial.

*"For the student/students, when the instructor/instructors gets/get distracted during the class, trying out new jumps is awesome."*

109) El vaquero/Los vaqueros, cuando atiende/atienden un médico/unos médicos a sus animales, vigila/vigilan la granja.

*"The cowboy/cowboys, when a doctor/doctors takes/take care of his/their animals, monitors/monitor the farm."*

Para el vaquero/los vaqueros, cuando atiende/atienden un médico/unos médicos a sus animales, la meticulosidad es importante.

*"For the cowboy/cowboys, when a doctor/doctors takes/take care of his/their animals, being meticulous is important."*

110) El testigo/Los testigos, si interroga/interrogan el inspector/los inspectores sobre el caso, responde/responden sinceramente.

*"The witness/witnesses, if the inspector/inspectors interrogates/interrogate about the case, answers/answer honestly."*

Para el testigo/los testigos, si interroga/interrogan el inspector/los inspectores sobre el caso, el teléfono debe estar cerca.

*"For the witness/witnesses, if the inspector/inspectors interrogates/interrogate about the case, the phone needs to be at hand."*

111) El borracho/Los borrachos, cuando desaparece/desperecen el compañero/los compañeros del club, avisa/avisan a otros.

*"The drunkard/drunks, when a friend/friends disappears/disappear from the club, lets/let the others know."*

Para el borracho/los borrachos, cuando desaparece/desperecen el compañero/los compañeros del club, la noche sigue siendo divertida.

*"For the drunkard/drunks, when a friend/friends disappears/disappear from the club, the night keeps being fun."*

112) El duque/Los duques, si falla/fallan el mayordomo/los mayordomos en sus responsabilidades, castiga/castigan a todos los empleados.

*"The dukes/dukes, if the butler/butlers makes/make errors with his/their tasks, punishes/punish the entire staff."*

Para el duque/los duques, si falla/fallan el mayordomo/los mayordomos en sus responsabilidades, disculparse no es necesario.

*"For the dukes/dukes, if the butler/butlers makes/make errors with his/their tasks, apologizing is not necessary."*

## A2. Stimuli sentences used in Experiment 2

The sentences are given in the experimental conditions (first line) and control conditions (second line). Different Embedded NP Number and Matrix Number conditions are separated by slash.

- 1) *That kid/Those kids, if a friend/friends invites/invite him/them over, never says/say no.  
I like that kid/those kids, because if a friend/friends invites/invite him/them over, he/they never says/say no.*
- 2) *My cousin/My cousins, whenever an instructor/instructors asks/ask questions, looks/look out the window.  
I am friends with my cousin/cousins, and whenever an instructor/instructors asks/ask questions, she/they looks/look out the window.*
- 3) *My classmate/My classmates, every time a boy/boys joins/join the class, starts/start talking about sports.  
I hate my classmate/my classmates, because every time a boy/boys joins/join the class, he/they starts/start talking about sports.*
- 4) *That professor/Those professors, whenever a student/students cheats/cheat on an exam, stays/stay really calm.  
We like that professor/those professors, because whenever a student/students cheats/cheat on an exam, he/they stays/stay really calm.*
- 5) *That musician/Those musicians, whenever a fan/fans shows/show up in front of his/their house, closes/close the blinds.  
I worked for that musician/those musicians, and whenever a fan/fans shows/show up in front of his/their house, he/they closes/close the blinds.*
- 6) *That actress/Those actresses, as soon as a reporter/reporters turns/turn on the camera, starts/start posing.  
I follow that actress/those actresses, and as soon as a reporter/reporters turns/turn on the camera, she/they starts/start posing.*
- 7) *That joker/Those jokers, when a lecturer/lecturers ends/end on time, starts/start clapping.  
I heard about that joker/those jokers, and when a lecturer/lecturers ends/end on time, he/they starts/start clapping.*
- 8) *That guy/Those guys, whenever a waitress/waitresses passes/pass by his/their table, orders/order another drink.  
I've been watching that guy/those guys, and whenever a waitress/waitresses passes/pass by his/their table, he/they orders/order another drink.*
- 9) *That driver/Those drivers, if a pedestrian/pedestrians approaches/approach the road, stops/stop immediately.  
We respect that driver/those drivers, because if a pedestrian/pedestrians approaches/approach the road, he/they stops/stop immediately.*
- 10) *That teacher/Those teachers, every time a toddler/toddlers cries/cry on the playground, comforts/comfort him/them.  
Mary likes that teacher/those teachers, because every time a toddler/toddlers cries/cry on the playground, she/they comforts/comfort him/them.*
- 11) *My neighbor/My neighbors, every time a child/children spills/spill something on the floor, yells/yell a lot.  
I love my neighbor/neighbors, but every time a child/children spills/spill something on the floor, she/they yells/yell a lot.*
- 12) *That girl/Those girls, whenever a relative/relatives visits/visit on the weekend, throws/throw a party.  
John lives close to that girl/those girls, and whenever a relative/relatives visits/visit on the weekend, she/they throws/throw a party.*
- 13) *Our boss/Our bosses, when an employee/employees arrives/arrive late to work, scolds/scold him/them.  
Everyone hates our boss/bosses, because when an employee/employees arrives/arrive late to work, he/they scolds/scold him/them.*
- 14) *The conductor/ conductors, once the violinist/violinists appears/appear on the stage, signals/signal to start.  
The audience watches the conductor/conductors, because once the violinist/violinists appears/appear on the stage, he/they signals/signal to start.*
- 15) *That director/Those directors, when an actor/actors auditions/audition for a movie, gives/give bad comments.  
Everyone dreads that director/those directors, because when an actor/actors auditions/audition for a movie, he/they gives/give bad comments.*

16) *That bartender/Those bartenders, when a customer/customers orders/order a drink, takes/take forever to bring it. You should avoid that bartender/those bartenders, because when a customer/customers orders/order a drink, he/they takes/take forever to bring it.*

17) *That comedian/Those comedians, whenever a politician/politicians says/say something ridiculous, tells/tell a funny story. I follow that comedian/those comedians, and whenever a politician/politicians says/say something ridiculous, she/they tells/tell a funny story.*

18) *That senator/Those senators, when a citizen/citizens attends/attend his/their press conference, lets/let him/them ask questions. We respect that senator/those senators, because when a citizen/citizens attends/attend his/their press conference, he/they lets/let him/them ask questions.*

19) *That scientist/Those scientists, when a reviewer/reviewers criticizes/criticize his/their article, loses/lose his/their enthusiasm. I relate to that scientist/those scientists, because when a reviewer/reviewers criticizes/criticize his/their article, he/they loses/lose his/their enthusiasm.*

20) *That mechanic/Those mechanics, whenever a lady/ladies comes/come to his/their shop, makes/make stupid comments. My mom hates that mechanic/those mechanics, because whenever a lady/ladies comes/come to his/their shop, he/they makes/make stupid comments.*

21) *This editor/Those editors, when a writer/writers submits/submit a manuscript, reads/read it very thoroughly. I look up to this editor/those editors, because when a writer/writers submits/submit a manuscript, she/they reads/read it very thoroughly.*

22) *That doctor/Those doctors, whenever a patient/patients complains/complain of a headache, prescribes/prescribe strong drugs. Beware of that doctor/those doctors, because whenever a patient/patients complains/complain of a headache, she/they prescribes/prescribe strong drugs.*

23) *That choreographer/Those choreographers, if a dancer/dancers misses/miss the rehearsal, fires/fire him/them right away. I collaborated with that choreographer/those choreographers, and if a dancer/dancers misses/miss the rehearsal, she/they fires/fire him/them right away.*

24) *This researcher/Those researchers, if an undergraduate/undergraduates helps/help him/them in the lab, finishes/finish projects on time. We vouch for this researcher/those researchers, and if an undergraduate/undergraduates helps/help him/them in the lab, he/they finishes/finish projects on time.*

25) *That novelist/Those novelists, when a publisher/publishers offers/offer her/them a contract, jumps/jump for joy. I met that novelist/those novelists, and when a publisher/publishers offers/offer her/them a contract, she/they jumps/jump for joy.*

26) *That worker/Those workers, once the controller/controllers leaves/leave the room, starts/start fooling around. I don't trust that worker/those workers, because once the controller/controllers leaves/leave the room, she/they starts/start fooling around.*

27) *That secretary/Those secretaries, when a coworker/coworkers retires/retire from the company, organizes/organize a picnic. Everyone likes that secretary/those secretaries, because when a coworker/coworkers retires/retire from the company, she/they organizes/organize a picnic.*

28) *That nurse/Those nurses, when a surgeon/surgeons operates/operate for hours, plays/play some relaxing music. I am fond of that nurse/those nurses, because when a surgeon/surgeons operates/operate for hours, she/they plays/play some relaxing music.*

29) *That pilot/Those pilots, if a passenger/passengers feels/feel dizzy on the plane, tries/try to help. I dislike that pilot/those pilots, but if a passenger/passengers feels/feel dizzy on the plane, she/they tries/try to help.*

30) *That protester/Those protesters, whenever the organizer/organizers speaks/speak on the megaphone, supports/support him/them firmly. I admire that protester/those protesters, because whenever the organizer/organizers speaks/speak on the megaphone, he/they supports/support him/them firmly.*



31) *That singer/Those singers, when a songwriter/songwriters wants/want to collaborate, consults/consult her/their manager.*

*Colleagues mock that singer/those singers, because when a songwriter/songwriters wants/want to collaborate, she/they consults/consult her/their manager.*

32) *That cashier/Those cashiers, whenever a manager/managers looks/look around the store, pretends/pretend to be busy.*

*I don't trust that cashier/those cashiers, because whenever a manager/managers looks/look around the store, she/they pretends/pretend to be busy.*

33) *That chef/Those chefs, if a waiter/waiters takes/take too many orders, forgets/forget half of them.*

*I am fond of that chef/those chefs, but if a waiter/waiters takes/take too many orders, he/they forgets/forget half of them.*

34) *That judge/Those judges, if a clerk/clerks messes/mess up the paperwork, threatens/ threaten to fire him/them.*

*Doug fears that judge/those judges, because if a clerk/clerks messes/mess up the paperwork, he/they threatens/threaten to fire him/them.*

35) *That architect/Those architects, when a contractor/contractors sends/send a proposal, discusses/discuss it with the client.*

*I admire that architect/those architects, because when a contractor/contractors sends/send a proposal, she/they discusses/discuss it with the client.*

36) *That author/Those authors, if a proofreader/proofreaders runs/run late with the corrections, talks/talk to the editor.*

*We avoid that author/those authors, because if a proofreader/proofreaders runs/run late with the corrections, she/they talks/talk to the editor.*

37) *Our designer/designers, when a printer/printers changes/change the design, returns/return the printout.*

*I can't stand our designer/designers, because when a printer/printers changes/change the design, he/they returns/return the printout.*

38) *That receptionist/Those receptionists, whenever a guest/guests enters/enter the hotel, smiles/smile cordially.*

*Laura trained that receptionist/those receptionists, so whenever a guest/guests enters/enter the hotel, she/they smiles/smile cordially.*

39) *That guide/Those guides, if a tourist/tourists loses/lose interest, changes/change the tour.*

*I recommend that guide/those guides, because if a tourist/tourists loses/lose interest, she/they changes/change the tour.*

40) *That dentist/Those dentists, when an assistant/assistants works/work slowly, gets/get impatient.*

*We avoid that dentist/those dentists, because when an assistant/assistants works/work slowly, he/they gets/get impatient.*

41) *That photographer/Those photographers, when a celebrity/celebrities goes/go out on the street, prepares/prepare his/their camera.*

*I've heard of that photographer/those photographers, and when a celebrity/celebrities goes/go out on the street, he/they prepares/prepare his/their camera.*

42) *That painter/Those painters, every time a critic/critics attacks/attack his/their work, takes/take it personally.*

*I am tired of that painter/those painters, because every time a critic/critics attacks/attack his/their work, he/they takes/take it personally.*

43) *That psychologist/Those psychologists, when a criminal/criminals seeks/seek help, stays/stay professional.*

*We all admire that psychologist/those psychologists, because when a criminal/criminals seeks/seek help, she/they stays/stay professional.*

44) *That researcher/Those researchers, whenever a statistician/statisticians advises/advise him/them, ignores/ignore the advice.*

*Mike loathes that researcher/those researchers, because whenever a statistician/statisticians advises/advise him/them, he/they ignores/ignore the advice.*

45) *That pharmacist/Those pharmacists, when a clinician/clinicians shares/share some advice, adapts/adapt his research.*

*I endorse that pharmacist/those pharmacists, because when a clinician/clinicians shares/share some advice, he/they adapts/adapt his research.*

46) *That vet/Those vets, whenever a zookeeper/zookeepers drops/drop off an animal, takes/take very good care of it.*

*Joan loves that vet/those vets, because whenever a zookeeper/zookeepers drops/drop off an animal, he/they takes/take very good care of it.*

47) *That engineer/Those engineers, when a programmer/programmers debugs/debug a program, writes/write a positive report.*

*I collaborate with that engineer/those engineers, and when a programmer/programmers debugs/debug a program, he/they writes/write a positive report.*

48) *That landlord/Those landlords, if a tenant/tenants checks/check out very late, makes/make no fuss about it. I don't like that landlord/those landlords, but if a tenant/tenants checks/check out very late, he/they makes/make no fuss about it.*

49) *That prisoner/Those prisoners, if a guard/guards behaves/behave rudely, complains/complain to the warden. I don't believe that prisoner/those prisoners, because if a guard/guards behaves/behave rudely, he/they complains/complain to the warden.*

50) *That referee/Those referees, when a player/players fakes/fake an injury, penalizes/penalize him/them. The fans boo that referee/those referees, because when a player/players fakes/fake an injury, he/they penalizes/penalize him/them.*

51) *That stylist/Those stylists, if a model/models brings/bring someone with her/them, cancels/cancel the photo shoot. Everyone talks about that stylist/those stylists, because if a model/models brings/bring someone with her/them, he/they cancels/cancel the photo shoot.*

52) *That archeologist/Those archeologists, once a visitor/visitors gets/get into the museum, starts/start talking relentlessly. I praise that archeologist/those archeologists, because once a visitor/visitors gets/get into the museum, he/they starts/start talking relentlessly.*

53) *That investor/Those investors, as soon as an economist/economists estimates/estimate the project's costs, makes/make the decision. We rush that investor/those investors, so as soon as an economist/economists estimates/estimate the project's costs, she/they makes/make the decision.*

54) *My buddy/buddies, when the therapist/therapists calls/call off the session, goes/go shopping instead. I can relate to my buddy/buddies, because when the therapist/therapists calls/call off the session, he/they goes/go shopping instead.*

55) *That pianist/Those pianists, whenever the composer/composers listens/listen to his performance, gets/get nervous. I feel bad for that pianist/those pianists, because whenever the composer/composers listens/listen to his performance, he/they gets/get nervous.*

56) *That cook/Those cooks, if a baker/bakers makes/make the kitchen dirty, refuses/refuse to clean it. I worked with that cook/those cooks, and if a baker/bakers makes/make the kitchen dirty, he/they refuses/refuse to clean it.*

57) *That attorney/Those attorneys, if a client/clients worries/worry about money, lowers/lower his/their fees. I recommend that attorney/those attorneys, because if a client/clients worries/worry about money, he/they lowers/lower his/their fees.*

58) *Our executive/executives, every time a collaborator/collaborators proposes/propose a meeting, makes/make up an excuse. I've been watching our executive/executives, and every time a collaborator/collaborators proposes/propose a meeting, he/they makes/make up an excuse.*

59) *Our coach/coaches, when an opponent/opponents wins/win the game, screams/scream at his/their players. I can't stand our coach/coaches, because when an opponent/opponents wins/win the game, he/they screams/scream at his/their players.*

60) *That journalist/those journalists, when a historian/historians takes/take part in her/their show, asks/ask interesting questions. I watch that journalist/those journalists, because when a historian/historians takes/take part in her/their show, she/they asks/ask interesting questions.*

61) *That official/Those officials, whenever an ambassador/ambassadors visits/visit the country, invites/invite TV reporters. They told off that official/those officials, because whenever an ambassador/ambassadors visits/visit the country, she/they invites/invite TV reporters.*

62) *That farmer/Those farmers, if a supplier/suppliers charges/charge a lot for his/their product, loses/lose money. I feel sorry for that farmer/those farmers, because if a supplier/suppliers charges/charge a lot for his/their product, he/they loses/lose money.*

63) *That artist/Those artists, when a spectator/spectators laughs/laugh out loud, pauses/pause the performance.*

*I follow that artist/those artists, and when a spectator/spectators laughs/laugh out loud, he/they pauses/pause the performance.*

64) *Our captain/captains, if a sailor/sailors disobeys/disobey his/their orders, punishes/punish him/them.  
We all fear our captain/captains, because if a sailor/sailors disobeys/disobey his/their orders, he/they punishes/punish him/them.*

65) *That librarian/Those librarians, if a patron/patrons damages/damage a book even a bit, makes/make a scene.  
I usually like that librarian/those librarians, but if a patron/patrons damages/damage a book even a bit, she/they makes/make a scene.*

66) *This hairstylist/Those hairstylists, whenever a barber/barbers opens/open a new shop in town, loses/lose a lot of clients.  
I don't pity this hairstylist/those hairstylists, but whenever a barber/barbers opens/open a new shop in town, she/they loses/lose a lot of clients.*

67) *Our inspector/inspectors, whenever an agent/agents solves/solve a crime, brings/bring a cake.  
We love our inspector/inspectors, because whenever an agent/agents solves/solve a crime, he/they brings/bring a cake.*

68) *That motorcyclist/Those motorcyclists, whenever an officer/officers pulls/pull him/them over, acts/act strange.  
I am familiar with that motorcyclist/those motorcyclists, and whenever an officer/officers pulls/pull him/them over, he/they acts/act strange.*

69) *That nutritionist/Those nutritionists, when a weightlifter/weightlifters pops/pop in for advice, creates/create a special diet.  
He respects that nutritionist/those nutritionists, because when a weightlifter/weightlifters pops/pop in for advice, she/they creates/create a special diet.*

70) *This mom/Those moms, if a nanny/nannies cancels/cancel at the last moment, finds/find a substitute quickly.  
I work with this mom/those moms, and if a nanny/nannies cancels/cancel at the last moment, she/they finds/find a substitute quickly.*

71) *That elder/Those elders, whenever the caregiver/caregivers cooks/cook something nice, keeps/keep smiling.  
I am fond of that elder/those elders, because whenever the caregiver/caregivers cooks/cook something nice, he/they keeps/keep smiling.*

72) *That nun/Those nuns, every time a traveler/travelers sets/set foot in the monastery, offers/offer accommodation.  
We love that nun/those nuns, because every time a traveler/travelers sets/set foot in the monastery, she/they offers/offer accommodation.*

73) *That priest/Those priests, when a follower/followers reaches/reach him/them after the mass, chats/chat with him/them gladly.  
Susan praises that priest/those priests, because when a follower/followers reaches/reach him/them after the mass, he/they chats/chat with him/them gladly.*

74) *That winemaker/Those winemakers, whenever a drinker/drinkers recommends/recommend his/their wine, boasts/boast about it.  
We make fun of that winemaker/those winemakers, because whenever a drinker/drinkers recommends/recommend his/their wine, he/they boasts/boast about it.*

75) *That firefighter/Those firefighters, if a victim/victims breathes/breathe with difficulty, calls/call 911 immediately.  
I respect that firefighter/those firefighters, because if a victim/victims breathes/breathe with difficulty, he/they calls/call 911 immediately.*

76) *That detective/Those detectives, even if a suspect/suspects presents/present an alibi, continues/continue to follow him/them.  
Keep an eye on that detective/those detectives, because even if a suspect/suspects presents/present an alibi, he/they continues/continue to follow him/them.*

77) *That owner/Those owners, whenever an occupant/occupants refurbishes/refurnish her/their house, cancels/cancel the lease.  
I tried to talk to that owner/those owners, but whenever an occupant/occupants refurbishes/refurnish her/their house, she/they cancels/cancel the lease.*

78) *That scholar/Those scholars, as soon as a colleague/colleagues hands/hand in his/their comments, updates/update the manuscript.  
I admire that scholar/those scholars, because as soon as a colleague/colleagues hands/hand in his/their comments, he/they updates/update the manuscript.*

79) *That stockbroker/Those stockbrokers, when an entrepreneur/entrepreneurs mentions/mention selling shares, advises/advise him/them to wait.*

*I am suspicious of that stockbroker/those stockbrokers, because when an entrepreneur/entrepreneurs mentions/mention selling shares, he/they advises/advise him/them to wait.*

80) *That jeweler/Those jewelers, whenever a burglar/burglars breaks/break into her/their store, alerts/alert the authorities.*

*I am familiar with that jeweler/those jewelers, and whenever a burglar/burglars breaks/break into her/their store, she/they alerts/alert the authorities.*

### A3. Stimuli sentences used in Experiments 3 and 4.

The sentences are given in the singular and plural matrix subject version, with approximate English translations below. Different disambiguations are separated by slash.

The differences between the experiments are commented in the footnotes.

#### Experimental items:

- 1) Bere nagusia, antza langileak asko miresten duena/dituena, goibel dago.  
 “His boss, who apparently appreciates employees a lot/whom the employee apparently appreciates a lot, is sad.”  
 Bere nagusiek, antza langileak asko miresten dituenak /dituztenak, errua leporatu zioten.  
 “His bosses, who apparently appreciate employees a lot/whom the employee apparently appreciates a lot, put the blame on him.”
- 2) Etxeko txakurtxoa, ustez lagunak oso gustuko duena/dituena, zaunkaka aritu zen bart.  
 “Our dog, who apparently likes our friends a lot/whom our friend apparently likes a lot, was barking last night.”  
 Etxeko txakurtxoek, ustez lagunak oso gustuko dituenak/dituztenak, hezurra jan zuten.  
 “Our dogs, who apparently like our friends a lot/whom our friend apparently likes a lot, ate the bone.”
- 3) Zure iloba, tamalez bizilagunak negarrez aurkitu zuena/zituena, desagertuta egon zen egun osoa.  
 “Your nephew(niece), who unfortunately found the neighbors crying/whom the neighbor unfortunately found crying, was missing all day.”  
 Zure ilobek, tamalez bizilagunak negarrez aurkitu zituenak/zituztenak, eskarmentua hartu dute.  
 “Your nephews(nieces), who unfortunately found the neighbors crying/whom the neighbor unfortunately found crying, learnt their lesson.”
- 4) Gure irakaslea, ziurrenik zuzendariak asko errespetatzen duena/dituena, etorri zen.  
 “Our teacher, who surely respects the directors a lot/whom the director surely respects a lot, arrived.”  
 Gure irakasleek, ziurrenik zuzendariak asko errespetatzen dituenak/dituztenak, klasea eman ziguten.  
 “Our teachers, who surely respect the directors a lot/whom the director surely respects a lot, gave a lecture.”
- 5) Bere umea, zorionez anaiak izugarri gustuko dueña/dituena, lo geratu zen.  
 “His baby, who luckily likes his brothers very much/whom his brother luckily likes very much, fell asleep.”  
 Bere umeek, zorionez anaiak izugarri gustuko dituenak/dituztenak, bazkaria jan zuten.  
 “His babies, who luckily like their brothers very much/whom their brother luckily likes very much, ate their lunch.”
- 6) Herriko mutila, dirudienek gizonak indartsu jo zuena/zituena, korrikalari ona da.  
 “The boy from the town, who apparently hit the men strongly/whom the man apparently hit strongly, is a good runner.”  
 Herriko mutilek, dirudienek gizonak indartsu jo zituenak/zituztenak, gurasoei dei egin zieten.  
 “The boys from the town, who apparently hit the men strongly/whom the man apparently hit strongly, called their parents.”
- 7) Herriko agurea, agian gazteak asko miresten duena/dituena, ez dago inoiz estresatuta.  
 “The old man from the village, who maybe envies young people a lot/whom the young person maybe envies a lot, is never stressed.”  
 Herriko agureek, agian gazteak asko miresten dituenak/dituztenak, landan egiten dute lan.  
 “The old men from the village, who maybe envy young people /whom the young person maybe envies, work in the field.”
- 8) Zure iloba<sup>13</sup>, ziurrenik ahizpak asko babesten duena/dituena, oso lotsatia da.  
 “Your cousin/nephew/niece, who surely protects his sisters a lot/whom his sister surely protects a lot, seems very shy.”  
 Zure ilobek, ziurrenik ahizpak asko babesten dituenak/dituztenak, eskolan negar egin zuten.  
 “Your cousins/nephews/nieces, who surely protect their sisters a lot/whom their sister surely protects a lot, skipped school yesterday.”
- 9) Atzoko ikaslea, dirudienek irakasleak korrika agurtu zuena/zituena, ez dago jada gure gelan.  
 “The student from yesterday, who apparently saw the teachers running/whom the teacher apparently saw running, is not in our class anymore.”  
 Atzoko ikasleek, dirudienek irakasleak korrika agurtu zituenak/zituztenak, eskola utzi zuten.

<sup>13</sup> *Biloba* (“grandson/granddaughter”) in Experiment 3

“The students from yesterday, who apparently saw the teachers running/whom the teacher apparently saw running, left school.”

10) Bere semea, zoritxarrez gelakideak atzo bultzatu zuena/zituena, zigortuta dago.

“His son, who unfortunately pushed his classmates yesterday/whom his classmate unfortunately pushed yesterday, is grounded.”

Bere semeek, zoritxarrez gelakideak atzo bultzatu zituenak/zituztenak, zuzendariarekin hitz egin zuten.

“His sons, who unfortunately pushed their classmates yesterday/whom their classmate unfortunately pushed yesterday, talked to the principal.”

11) Enpresako zuzendaria, sarri idazkariak kotxean eramaten duena/dituena, lanez gainezka dabil.

“The company's director, who often gives the receptionists a ride/whom the receptionist often gives a ride, is very busy.”

Enpresako zuzendariak, sarri idazkariak kotxean eramaten dituenak/dituztenak, ez dute inoiz autobusa hartzen.

“The company's directors, who often give the receptionists a ride/whom the receptionist often gives a ride, never take the bus.”

12) Ondoko mutikoa, antza lehengusuak izugarri maite duena/dituena, pertsona zoragarria da.

“The boy next door, who apparently loves his cousins a lot/whom his cousin apparently loves a lot, is such a nice person.”

Ondoko mutikoeak, antza lehengusuak izugarri maite dituenak/dituztenak, erabakia hartu zuten.

“The boys next door, who apparently love their cousins a lot/whom their cousin apparently loves a lot, made a decision”

13) Ikastolako zuzendaria, zurrerik irakasleak goizean aurkeztu duena/dituena, oso harro dago.

“The school principal, who introduced the teachers this morning/whom the teacher introduced this morning, is very proud.”

Ikastolako zuzendariak, zurrerik irakasleak goizean aurkeztu dituenak/dituztenak, lan gogorra dute.

“The school principals, who introduced the teachers this morning/whom the teacher introduced this morning, have a hard job.”

14) Herriko futbol jokalaria, jendaurrean entrenatzaileak harro goraipatzen duena/dituena, fama hartzen ari da.

“The football player from our town, who gladly praises the coaches/whom the coach gladly praises, is getting famous.”

Herriko futbol jokalariek, jendaurrean entrenatzaileak harro goraipatzen dituenak/dituztenak, karitatezko ekimena antolatzen zuten.

“The football players from our town, who gladly praise the coaches/whom the coach gladly praises, organized a charity event.”

15) Baserriko atsoa, zorionez bilobak ederki zaindu zuena/zituena, joan egin zen.

“The old woman from the farm, who luckily looked after her granddaughters very well/ whom her granddaughter luckily looked after very well, left.”

Baserriko atsoek, zorionez bilobak ederki zaindu zituenak/zituztenak, lanean jarraitzen dute.

“The old woman from the farm, who luckily looked after their granddaughters very well/ whom their granddaughter luckily looked after very well, continued working.”

16) Tabernako zerbitzaria, akaso bezeroak gogoz goraipatzen duena/dituena, jatun aparta da.

“The waiter of the pub, who probably praises the clients/whom the client probably praises, eats a lot.”

Tabernako zerbitzariak, akaso bezeroak gogoz goraipatzen dituenak/dituztenak, pintxo asko egiten dituzte.

“The waiters of the pub, who probably praise the clients/whom the client probably praises, make a lot of pintxos.”

17) Goiko auzokidea, zorionez pisukideak leihotik ikusten duena/dituena, mutil ederra da.

“Our neighbour, who can luckily see my flatmates from the window/whom my flatmate can luckily see from the window, is pretty handsome.”

Goiko auzokideek, zorionez pisukideak leihotik ikusten dituenak/dituztenak, txakur berria dute.

“Our neighbours, who can luckily see my flatmates from the window/whom my flatmate can luckily see from the window, have a new dog.”

18) Bulegoko atezaina, beti lankideak alai agurtzen duena/dituena, bajaran dago.

“The doorman at the office, who always cheerfully greets the workmates/whom the workmate always cheerfully greets, is on sick leave

Bulegoko atezainek, beti lankideak alai agurtzen dituenak/dituztenak, oporrak hartu dituzte.

“The doormen at the office, who always cheerfully greets the workmates/whom the workmate always cheerfully greets, went on holiday.”

19) Gobernuko ministroa, debatean enbaxadoreak gogor iraindu zuena/zituena, ikaragarri haserretu zen.

“The minister, who disgracefully insulted the ambassadors during the debate/whom the ambassador disgracefully insulted during the debate, got really angry.”

Gobernuko ministroek, debatean enbaxadoreak gogor iraindu zituenak/zituztenak, bileratik alde egin zuten.

“The ministers, who disgracefully insulted the ambassadors during the debate/whom the ambassador disgracefully insulted during the debate, left the meeting.”

- 20) Dendako langilea, egunero bezeroak estu besarkatzen duena/dituena, ez da agertu.  
“The shop assistant, who enthusiastically hugs the clients every day/whom the client enthusiastically hugs every day, didn't show up.”  
Dendako langileek, egunero bezeroak estu besarkatzen dituenak/dituztenak, eztabaidatu dute.  
“The shop assistants, who enthusiastically hug the clients every day/whom the client enthusiastically hugs every day, had an argument.”
- 21) Igerilekuko soroslea, zorionez erabiltzaileak ondo tratatzen duena/dituena, aspertuta dago.  
“The lifeguard at the swimming pool, who luckily treats the users very well/whom the user luckily treats very well, is bored.”  
Igerilekuko sorosleek, zorionez erabiltzaileak ondo tratatzen dituenak/dituztenak, zenbait bizi salbatu dituzte.  
“The lifeguards at the swimming pool, who luckily treat the users very well/whom the user luckily treats very well, saved several lives.”
- 22) Bere izeba, zorionez lehengusinak ondo babesten duena/dituena, zorionsua da.  
“Her aunt, who protects her cousins a lot/whom her cousin protects a lot, is happy.”  
Bere izebek, zorionez lehengusinak ondo babesten dituenak/dituztenak, neba bi dauzkate.  
“Her aunts, who protect their cousins a lot/whom their cousin protects a lot, have two brothers.”
- 23) Herenegungo laguna, antza begiraleak betidanik ezagutzen duena/dituena, Bilboko da.  
“The friend from the other day, who apparently knows his supervisors his entire life/whom his supervisor apparently knows his entire life, is from Bilbao.”  
Herenegungo lagunek, antza begiraleak betidanik ezagutzen dituenak/dituztenak, gitarra jotzen dute.  
“The friends from the other day, who apparently know their supervisors their entire life/whom their supervisor apparently knows his entire life, play the guitar.”
- 24) Leihoko andrea, oraintxe dendariak irribarretsu agurtu duena/dituena, kuxkuxero hutsa da.  
“The woman at the window, who just waved at the shop assistants/whom the shop assistant just waved at, loves gossiping.”  
Leihoko andreak, oraintxe dendariak irribarretsu agurtu dituenak/dituztenak, bikiak dirudite.  
“The women at the window, who just waved at the shop assistants/whom the shop assistant just waved at, look the same.”
- 25) Arrandegiko jabea, sarri osabak ongi aipatzen duena/dituena, beti dago lanean.  
“The fishmonger, who usually speaks well of the uncles/whom the uncle usually speaks well of, is always working.”  
Arrandegiko jabeek, sarri osabak ongi aipatzen dituenak/dituztenak, ondoko lokala alokatu dute.  
“The fishmongers, who usually speak well of the uncles/whom the uncle usually speaks well of, rented the shop next door.”
- 26) Taldeko kidea, zorionez bandako nagusiak epaiketean ondo deskribatu zuena/zituena, atxilotua izan da.  
“The gang member, who luckily described the gang leaders well at the court/whom the gang leader luckily described well at the court, is caught.”  
Taldeko kideek, zorionez bandako nagusiak epaiketean ondo deskribatu zituenak/zituztenak, droga saltzen zuten.  
“The gang members, who luckily described the gang leaders well at the court/whom the gang leader luckily described well at the court, were selling drugs.”
- 27) Autobuseko gidaria, normalean bidaiariak asko errespetatzen zuena/zituena, kafetegian dago.  
“The bus driver, who used to respect the passengers a lot/whom the passenger used to respect a lot, is at the café.”  
Autobuseko gidariek, normalean bidaiariak asko errespetatzen zituenak/zituztenak, lana utzi zuten.  
“The bus drivers, who used to respect the passengers a lot/whom the passenger used to respect a lot, quit the job.”
- 28) Kiroldegiko idazkaria, dirudienez igerilariak asko miresten duena/dituena, ez da emakume atsegina.  
“The sports center's secretary, who appreciates the swimmers so much/whom the swimmer appreciates so much, is not a nice woman.”  
Kiroldegiko idazkariak, dirudienez igerilariak asko miresten dituenak/dituztenak, telefonoz hitz egiten ematen dute eguna.  
“The sports center's secretaries, who appreciate the swimmers so much/whom the swimmer appreciates so much, spend the whole day on the phone.”
- 29) Haren aitona, zorionez ilobak izugarri maite zuena/zituena, kirolari aparta zen.  
“His grandfather, who loved the grannies tremendously/whom the granny loved tremendously, was very good at sports.”  
Haren aitonek, zorionez ilobak izugarri maite zituenak/zituztenak, harreman txarra zuten.  
“His grandfathers, who loved the grannies tremendously/whom the granny loved tremendously, didn't get on really well.”
- 30) Amaiaren laguna, antza bilbotarrak atzo ezkontzara gonbidatu zuena/zituena, eguna iristeko irrikitan dago.  
“Amaia's friend, who apparently invited people from Bilbao to the wedding/whom a person from Bilbao apparently invited to the wedding, is looking forward to that day.”  
Amaiaren lagunek, antza bilbotarrak atzo ezkontzara gonbidatu zituenak/zituztenak, plana egina dute.  
“Amaia's friends, who apparently invited people from Bilbao to the wedding/whom a person from Bilbao apparently invited to the wedding, made the schedule.”

31) Enpresako ingeniaria, inoiz lankideak mespretxatu ez duena/dituena, oso profesional ona da.

“The company’s engineer, who never looks down on his colleagues/whom his colleague never looks down on, is very professional.”

Enpresako ingeniariak, inoiz lankideak mespretxatu ez dituenak/dituztenak, lana beti garaiz bukatzen dute.

“The company’s engineers, who never look down on their colleagues/whom their colleague never looks down on, always finish work on time.”

32) Partaidearen adiskidea, betidanik ikerlariak ondo ezagutzen duena/dituena, sarri etortzen da.

“Participant’s friend, who knows the researchers his whole life/whom the researcher knows his whole life, usually comes.”

Partaidearen adiskideek, betidanik ikerlariak ondo ezagutzen dituenak/dituztenak, esperimentu askotan hartu dute parte.

“Participant’s friends, who know the researchers their whole life/whom the researcher knows his whole life, took part in many experiments.”

33) Emakumearen maitalea, ustez alabak asko errespetatzen duena/dituena, aberatsa da.

“Woman’s lover, who apparently respects the daughters a lot/whom the daughter apparently respects a lot, is rich.”

Emakumearen maitaleek, ustez alabak asko errespetatzen dituenak/dituztenak, ez dute bere berri.

“Woman’s lovers, who apparently respect the daughters a lot/whom the daughter apparently respects a lot, haven’t heard from her.”

34) Festako gonbidatua, seguru anfitrioiak ondo ezagutzen duena/dituena, oso alaia da.

“The guest at the party, who definitely knows the hosts well/whom the host definitely knows well, is very cheerful.”

Festako gonbidatuek, seguru anfitrioiak ondo ezagutzen dituenak/dituztenak, xanpain botila ireki zuten.

“The guests at the party, who definitely know the hosts well/whom the host definitely knows well, opened the champagne.”

35) Bizilagunen katua, zorionez umeak<sup>14</sup> izugarri maite duena/dituena, balkoitik erori zen.

“Neighbours’ cat, who luckily loves the kids/whom the kid luckily loves, fell from the balcony.”

Bizilagunen katuek, zorionez umeak izugarri maite dituenak/dituztenak, esnea edaten dute.

“Neighbours’ cats, who luckily love the kids/whom the kid luckily loves, drink milk.”

36) Sarrerako gizona, beti lagunak<sup>15</sup> presaka agurtzen duena/dituena, gaur ez zegoen bertan.

“The doorman, who always waves quickly at his friends/whom his friend always waves at quickly, wasn’t there today.”

Sarrerako gizonak, beti lagunak presaka agurtzen dituenak/dituztenak, atea konpondu dute.

“The doormen, who always wave quickly at their friends/whom their friend always waves at quickly, fixed the door.”

37) Ordenadorearen jabea, antza dendariak salatu duena/dituena, ez da herrikoa.

“The owner of the computer, who apparently reported the shopkeepers today/whom the shopkeeper apparently reported today, is not from here.”

Ordenadorearen jabeek, antza dendariak salatu dituenak/dituztenak, poliziarengana jo dute.

“The owners of the computer, who apparently reported the shopkeepers today/whom the shopkeeper apparently reported today, went to the police station.”

38) Lantegiko ingeniaria, zorionez zuzendariak<sup>16</sup> gaur etorrarazi duena/dituena, zeharo langilea da.

“The engineer from work, who luckily made the directors come to work today/whom the director luckily made come to work today, is very hard-working.”

Lantegiko ingeniariak, zorionez zuzendariak gaur etorrarazi dituenak/dituztenak, lan aparta gauzatu dute.

“The engineers from work, who luckily made the directors come to work today/whom the director luckily made come to work today, did a good job.”

39) Spinningeko irakaslea, antza ikasleak izugarri miresten duena/dituena, aurtan hasi da polikiroldegian.

“The spinning instructor, who really appreciates the participants/whom the participant really appreciates, started this year at the sports center.”

Spinningeko irakasleek, antza ikasleak izugarri miresten dituenak/dituztenak, kirol asko egiten dute.

“The spinning instructors, who really appreciate the participants/whom the participant really appreciates, look very sporty.”

40) Jatetxeko sukaldaria, zoritxarrez nagusiak ondo mespretxatzen duena/dituena, zerbitzariaren koinata da.

“The cook at the restaurant, who unfortunately looks down on the bosses/whom the boss unfortunately looks down on, is the waitress’s sister-in-law.”

Jatetxeko sukaldariak, zoritxarrez nagusiak ondo mespretxatzen dituenak/dituztenak, bazkari ederra prestatu dute.

“The cooks at the restaurant, who unfortunately look down on the bosses/whom the boss unfortunately looks down on, cooked an amazing dish.”

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<sup>14</sup> Txakurak (“dog”) in Experiment 3

<sup>15</sup> Nagusiak (“boss”) in Experiment 3

<sup>16</sup> Nagusiak (“boss”) in Experiment 3



- 41) Izebaren lankidea, batzuetan semeak eskolara eramaten duena/dituena, irakaslea da.  
 “Aunt’s workmate, who sometimes takes her sons to school/whom her son sometimes takes to school, is a teacher.”  
 Izebaren lankideek, batzuetan semeak eskolara eramaten dituenak/dituztenak, bertan egiten dute lan.  
 “Aunt’s workmates, who sometimes take her sons to school/whom her son sometimes takes to school, work there.”
- 42) Saltzailearen laguna, oporretan lehengusuak iaz ezagutu zuena/zituena, oso neska atsegina da.  
 “The friend of the salesperson, who met our cousins last year on holidays/whom our cousin met last year on holidays, is such a nice girl.”  
 Saltzailearen lagunek, oporretan lehengusuak iaz ezagutu zituenak/zituztenak, kostan erosi dute pisua.  
 “The friends of the salesperson, who met our cousins last year on holidays/whom our cousin met last year on holidays, bought a flat on the coast.”
- 43) Plazako eskalea, antza poliziak <sup>17</sup>goizean salatu duena/dituena, zeharo errebeldea da.  
 “A homeless person from the square, who apparently reported the policemen this morning/whom a policeman apparently reported this morning, is very rebellious.”  
 Plazako eskaleek, antza poliziak goizean salatu dituenak/dituztenak, zeharo justizia eskatzen dute.  
 “Homeless people on the square, who apparently reported the policemen this morning/whom a policeman apparently reported this morning, are demanding justice.”
- 44) Gure lankidea, atzo nagusiak presaka ezagutu zuena/zituena, langile ona da.  
 “Our colleague, who met the bosses briefly yesterday/whom the boss met briefly yesterday, is a good worker.”  
 Gure lankideek, atzo nagusiak presaka ezagutu zituenak/zituztenak, gailetak ekarri zituzten bulegora.  
 “Our colleagues, who met the bosses briefly yesterday/whom the boss met briefly yesterday, brought cookies to work.”
- 45) Igeltseroaren amama, ustez bilobak ederki zaintzen duena/dituena, parkean dago lagunekin kartetan jolasten.  
 “The construction worker’s grandma, who apparently takes care of her granddaughters very well/whom her granddaughter apparently takes care of very well, is playing cards with friends in the park.”  
 Igeltseroaren amamek, ustez bilobak ederki zaintzen dituenak/dituztenak, eginbehar asko dituzte.  
 “The construction worker’s grandmas, who apparently take care of her granddaughters very well/whom her granddaughter apparently takes care of very well, have a lot of work.”
- 46) Dendako jabea, egunero harakinak kotxez ekartzen duena/dituena, bere bizilaguna da.  
 “The shop owner, who gives a ride to the butchers every day/whom the butcher gives a ride every day, is his neighbour.”  
 Dendako jabeek, egunero harakinak kotxez ekartzen dituenak/dituztenak, kutxa asko dituzte sarreran.  
 “The shop owners, who give a ride to the butchers every day/whom the butcher gives a ride every day, have a lot of boxes at the entrance.”
- 47) Ospitaleko psikiatra, maiz pazienteak goizetan bisitatzen duena/dituena, kezkatu dago.  
 “The psychiatrist from the hospital, who regularly visits the patients in the morning/whom the patient regularly visits in the morning, seems very worried.”  
 Ospitaleko psikiatrek, maiz pazienteak goizetan bisitatzen dituenak/dituztenak, botika berria agindu dute.  
 “The psychiatrists from the hospital, who regularly visit the patients in the morning/whom the patient regularly visits in the morning, prescribed a new medicine.”
- 48) Haien nagusia, antza politikariak <sup>18</sup>oraindik babesten duena/dituena, oso ustela da.  
 “Their boss, who apparently still supports the politicians/whom the politician apparently still supports, is very corrupted.”  
 Haien nagusiek, antza politikariak oraindik babesten dituenak/dituztenak, langile berria kontratatu dute.  
 “Their bosses, who apparently still support the politicians/whom the politician apparently still supports, hired a new employee.”
- 49) Musika-eskolako neska, kasualitatez abeslariak behin ikusi zuena/zituena, miresgarria da.  
 “The girl from the music school, who met the rock singers once/whom the rock singer met once, is very talented.”  
 Musika-eskolako neskek, kasualitatez abeslariak behin ikusi zituenak/zituztenak, kontzerturako sarrera erosi zuten.  
 “The girls from the music school, who met the rock singers once/whom the rock singer met once, bought a ticket for the concert.”
- 50) Hango neska, atzo mutilak festara adoretzu gonbidatu zuena/zituena, oso polita da.  
 “The girl, who bravely invited the boys to the party yesterday/whom the boy bravely invited to the party, is very pretty.”  
 Hango neskek, atzo mutilak festara adoretzu gonbidatu zituenak/zituztenak, soinekoa erosi dute.  
 “The girls, who bravely invited the boys to the party yesterday/whom the boy bravely invited to the party, bought a dress.”

<sup>17</sup> *Herritar batek* (“citizen”) in Experiment 3

<sup>18</sup> *Alderdi politikoak* (“political party”) in Experiment 3

51) Bankuko mutila, tamalez lapurrak berehala ezagutu zuena/zituen, arriskuan dago.

“The boy from the bank, who unfortunately instantly recognized the robbers /whom the robber unfortunately instantly recognized, is in danger.”

Bankuko mutilek, tamalez lapurrak berehala ezagutu zituenak/zituztenak, epaiketan hitz egin zuten.

“The boys from the bank, who unfortunately instantly recognized the robbers/whom the robber unfortunately instantly recognized, spoke in the court.”

52) Atzoko manifestatzailea, tamalez poliziak oihuka iraindu zuena/zituen, oso oldarkorra da.

“The protester from yesterday, who shamefully insulted the policemen out loud/whom the policeman shamefully insulted out loud, was very aggressive.”

Atzoko manifestatzaileek, tamalez poliziak oihuka iraindu zituenak/zituztenak, salaketa asko jaso dituzte.

“The protesters from yesterday, who shamefully insulted the policemen out loud/whom the policeman shamefully insulted out loud, started a fight.”

53) Bere aitona, maiz bere bilobak etxean bisitatzen duena/dituen, oso zaharra da.

“His grandfather, who frequently visits his grandchildren at home/whom the grandchild frequently visits at home, is very old.”

Bere aitonek, maiz bere bilobak etxean bisitatzen dituenak/dituztenak, tarta egin zuten.

“His grandfathers, who frequently visit their grandchildren at home/whom their grandchild frequently visits at home, made a cake.”

54) Orkestrako musikagilea, betidanik margolariak asko miresten duena/dituen, oso ezaguna zen.

“The composer from the orchestra, who always admires the painters/whom the painter always admires, was very famous.”

Orkestrako musikagileek, betidanik margolariak asko miresten dituenak/dituztenak, sinfonia asko idatzi zituen.

“The composers from the orchestra, who always admire the painters/whom the painter always admires, was very famous.”

55) Lehengusuaren ikaskidea, sarri mutilak <sup>19</sup>ondo izorratzen duena/dituen, zigortuta dago.

“Our cousin's classmate, who often annoys the boys a lot/whom the boy often annoys a lot, is punished.”

Lehengusuaren ikaskideek, sarri mutilak ondo izorratzen dituenak/dituztenak, kopia jaso dute zigortzat.

“Our cousin's classmates, who often annoys the boys a lot/whom the boy often annoys a lot, have to copy a text as a punishment.”

56) Bere nagusia, astelehenean langileak asko izorratu zuena/zituen, horko etxean bizi da.

“His boss, who annoyed his workmates a lot on Monday/whom his workmate annoyed a lot on Monday, lives in that house over there.”

Bere nagusiek, astelehenean langileak asko izorratu zituenak/zituztenak, enpresako ixteko asmoa dute.

“His bosses, who annoyed his workmates a lot on Monday/whom his workmate annoyed a lot on Monday, plan to close the company.”

57) Herriko zapatagina, tamalez langileak inoiz goraiatzen ez duena/dituen, mito bihurtu zen.

“The shoemaker from the town, who unfortunately never praises his workers/whom his worker unfortunately never praises, became a legend.”

Herriko zapataginek, tamalez langileak inoiz goraiatzen ez dituenak/dituztenak, zapatak eskuz egiten dituzte.

“The shoemakers from the town, who unfortunately never praise their workers/whom their worker unfortunately never praises, make shoes by hand.”

58) Enpresako idazkaria, antza managerrak bileran aurkeztu zuena/zituen, esperientziadun pertsona da.

“The secretary, who happily introduced the managers in the meeting/whom the manager happily introduced in the meeting, is very experienced.”

Enpresako idazkariak, antza managerrak bileran aurkeztu zituenak/zituztenak, agendak ezagutzera eman zituzten.

“The secretaries, who happily introduced the managers in the meeting/whom the manager happily introduced in the meeting, presented the agendas.”

59) Diseinatzaile grafikoa, iaz managerrak <sup>20</sup>internet bidez aukitu zuena/zituen, bere lanean ona da.

“The graphic designer, who found the managers online/whom the manager found online, is good at his work.”

Diseinatzaile grafikoek, iaz managerrak internet bidez aukitu zituenak/zituztenak, lan eskaera egin zuten.

“The graphic designers, who found the managers online/whom the manager found online, applied for the job.”

60) Gelako neska, gutxitan bere lagunak gogoz besarkatzen duena/dituen, oso pertsona hotza da.

“The girl from our class, who strangely never hugs her friends/whom her friend strangely never hugs, is very distant.”

Gelako neskek, gutxitan bere lagunak gogoz besarkatzen dituenak/dituztenak, beste gelara alde egin dute.

“The girls from our class, who strangely never hug their friends/whom their friend strangely never hugs, moved to another class.”

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<sup>19</sup> *Besteak* (“others”) in Experiment 3

<sup>20</sup> *Enpresak* (“the entrepreneur”) in Experiment 3

Control items:

- 1) Ahizpa pozik dago emaitzarekin, eta lehiakideak<sup>21</sup> gaur zoriondu du/ditu.  
 Ahizpa pozik dago emaitzekin, eta lehiakideak gaur zoriondu du/ditu.  
 “My sister is happy with the result(s), and the contestant congratulated her/and she congratulated the contestants today.”
- 2) Mutila uduri dago festagatik, horregatik lagunak indartsu besarkatu du/ditu.  
 Mutila uduri dago festengatik, horregatik lagunak indartsu besarkatu du/ditu.  
 “The boy is nervous about the party(ies), so his friend gave him a strong hug/ so he gave his friends a strong hug.”
- 3) Politikoa sartu zen bilera-gelan, eta jarraitzaileak asko animatu zuen/zituen.  
 Politikoa sartu zen bilera-geletan, eta jarraitzaileak asko animatu zuen/zituen.  
 “The politician entered the meeting room(s), and the supporter greeted him enthusiastically/and greeted his supporters enthusiastically.”
- 4) Neska arrakastatsua izan zen txapelketan, beraz, lagunak afaltzera gonbidatu zuen/zituen.  
 Neska arrakastatsua izan zen txapelketetan, beraz, lagunak afaltzera gonbidatu zuen/zituen.  
 “The girl was successful in the competition(s), so her friend invited her/so she invited her friends for dinner.”
- 5) Maria lanpeturik zegoen umearekin, hortaz, auzokideak ez zuen/zituen ondo ezagutu.  
 Maria lanpeturik zegoen meekin, hortaz, auzokideak ez zuen/zituen ondo ezagutu.  
 “Maria was occupied with the kid(s), so her neighbor didn’t recognize her /so she didn’t recognize her neighbours.”
- 6) Gizona ez zegoen goibel erasoagatik, baina lapurrak gogor jo zuen/zituen.  
 Gizona ez zegoen goibel erasoengatik, baina lapurrak gogor jo zuen/zituen.  
 “The man was not upset about the attack(s), although the robber hit him /he hit the robbers strongly.”
- 7) Zuzendaria kezkatuta zegoen protestagatik, baina orientatzaileak<sup>22</sup> guztiz babestu zuen/zituen.  
 Zuzendaria kezkatuta zegoen protestengatik, baina orientatzaileak guztiz babestu zuen/zituen.  
 “The principal was worried about the protest(s), but the school counsellor protected him/but he protected the school counsellors completely.”
- 8) Langilea kexatzen egon zen batzarrean, bere lankideak asko mespretxatzen baitu/baititu.  
 Langilea kexatzen egon zen batzarretan, bere lankideak asko mespretxatzen baitu/baititu.  
 “The employee was complaining on the meeting(s), because his colleague looks down on him/he looks down on his colleagues a lot.”
- 9) Neska oso lausengari egon zen adierazpenean, bere nagusiak asko gorai patzen baitu/baititu.  
 Neska oso lausengari egon zen adierazpenetan, bere nagusiak asko gorai patzen baitu/baititu.  
 “The girl was very flattering in the report(s), as her boss appreciates her a lot/as she appreciates her bosses a lot.”
- 10) Idazleak familiaren inguruan idatzi zuen liburuan, bere arreba izugarri maite baitzuen/baitzituen.  
 Idazleak familiaren inguruan idatzi zuen liburuetan, bere arreba izugarri maite baitzuen/baitzituen.  
 “The writer wrote about family in his book(s), since his sister loved him/he loved his sisters immensely.”
- 11) Ikaslea ez zegoen pozik mintzaldiarekin, eta antzolatzaileak ere ez zuen/zituen gorai patu.  
 Ikaslea ez zegoen pozik mintzaldiekin, eta antzolatzaileak ere ez zuen/zituen gorai patu.  
 “The student wasn’t content with the conference(s), and the organizer didn’t praise her either/she didn’t praise the organizers either.”
- 12) Neska pozik zegoen dantza eskolarekin, eta irakasleak ere atsegin zuen/zituen.  
 Neska pozik zegoen dantza eskolekin, eta irakasleak ere atsegin zuen/zituen.  
 “The girl was happy with the dance classe(s), and the instructor liked her too/she liked the instructors too.”
- 13) Maria mozkortu zen festan, baina lagunak primeran zaindu zuen/zituen.  
 Maria mozkortu zen festetan, baina lagunak primeran zaindu zuen/zituen.  
 “Maria got drunk at the party(ies), but her friend took care of her/she took care of her friends very well.”
- 14) Zuzendariak asko oihukatu zuen bulegoan, baina lankideak oraindik ere errespetatzen du/ditu.  
 Zuzendariak asko oihukatu zuen bulegoetan, baina lankideak oraindik ere errespetatzen du/ditu.  
 “The director yelled a lot in the office(s), but his colleague still respects him/he still respects his colleagues.”

<sup>21</sup> Lagunak (“friend”) in Experiment 3

<sup>22</sup> Irakasleak (“teacher”) in Experiment 3

- 15) Neskak konpainia nahi du bazkalorduan, baina ikaskideak oso gorroto du/ditu.  
Neskak konpainia nahi du bazkalorduetan, baina ikaskideak oso gorroto du/ditu.  
“The girl wants company during the lunch break(s), but the classmate hates her/she hates the classmates a lot.”
- 16) Presoa ados dago etorkizun planarekin, baina abokatuak gaizki tratatzen du/ditu.  
Presoa ados dago etorkizun planekin, baina abokatuak gaizki tratatzen du/ditu.  
“The prisoner agrees with his future plan(s), but the lawyer treats him/he treats the lawyers badly.”
- 17) Jon ez zegoen oso kontzentratua eskolan, eta ikaskideak karikaturak marrazten ikusi zuen/zituen.  
Jon ez zegoen oso kontzentratua eskoletan, eta ikaskideak karikaturak marrazten ikusi zuen/zituen.  
“Jon was not very focused during the class(es), and his classmate saw him/he saw his classmates drawing caricatures.”
- 18) Futbolzalea oso minduta zegoen partidarekin, eta fanatikoak <sup>23</sup> zelaurrean bultzatu zuen/zituen.  
Futbolzalea oso minduta zegoen partidekin, eta fanatikoak zelaurrean bultzatu zuen/zituen.  
“The football enthusiast was really upset with the match(es), and he punched the fans/the fans punched him in front of the stadium.”
- 19) Gloriak beti gozatzen du familia batzarrean, eta lehengusinak asko estimatzen du/ditu.  
Gloriak beti gozatzen du familia batzarretan, eta lehengusinak asko estimatzen du/ditu.  
“Gloria always enjoys in the family reunion(s), and her cousin appreciates her/she appreciates her cousins a lot.”
- 20) Maria zeharo aspertuta egoten da festan, horregatik ahizpak lagunartean aurkezten du/ditu.  
Maria zeharo aspertuta egoten da festetan, horregatik ahizpak lagunartean aurkezten du/ditu.  
“Maria is bored at the party(ies), so her sister introduced her/she introduced her sisters to some boys.”
- 21) Ama ez zegoen pozik orrazkera berriarekin, nahiz eta ile-apaintzaileak betidanik ezagutzen duen/dituen.  
Ama ez zegoen pozik orrazkera berriekin, nahiz eta ile-apaintzaileak betidanik ezagutzen duen/dituen.  
“My mom was not happy with the hairstyle change(s), although the hairstylist knows her/she knows the hairstylists for years.”
- 22) Pertsona ospetsua distraiturik zegoen kamerarekin, bitartean jarraitzaileak gogo biziz agurtzen zuen/zituen.  
Pertsona ospetsua distraiturik zegoen kamerekin, bitartean jarraitzaileak gogo biziz agurtzen zuen/zituen.  
“The celebrity was distracted by the camera(s), while the fan waves at her/she waved at the fans enthusiastically.”
- 23) Pazientea bakardadean sentitzen da terapian, beraz, jubilatua <sup>24</sup> arratsaldero bisitatzen du/ditu.  
Pazientea bakardadean sentitzen da terapietan, beraz, jubilatua arratsaldero bisitatzen du/ditu.  
“The patient gets lonely at the therapy(ies), so the old person visits him/he visits the old people in the evenings.”
- 24) Abeslaria urduri zegoen entseguan, eta bandako kideak asko eragotzi zuen/zituen.  
Abeslaria urduri zegoen entsegetan, eta bandako kideak asko eragotzi zuen/zituen.  
“The singer was nervous at the rehearsal(s), and a band member annoyed him/he annoyed the band members a lot.”
- 25) Gizona oihuka dabil uneoro laneko arazoagatik, horregatik alabak etxetik bota du/ditu.  
Gizona oihuka dabil uneoro laneko arazoengatik, horregatik alabak etxetik bota du/ditu.  
“The man is yelling all the time because of his work problem(s), so his daughter kicked him/ he kicked his daughters out of the house.”
- 26) Aitor aspertuta egongo da zientziako lanarekin, hortaz, lehengusuak gauean zainduko du/ditu.  
Aitor aspertuta egongo da zientziako lanekin, hortaz, lehengusuak gauean zainduko du/ditu.  
“Aitor will be bored with the science assignment(s), so his cousin will look after him/he will look after his cousins tonight.”
- 27) Emakumea beti dago alai ohean irakurtzen duten istorioarekin, bitartean umeak goxo laztantzen du/ditu.  
Emakumea beti dago alai ohean irakurtzen duten istorioekin, bitartean umeak goxo laztantzen du/ditu.  
“The woman is always happy about the bed time story(ies), when her child caresses her/she caresses her children gently.”
- 28) Iñaki psikologoarekin hitz egitera joan zen bere arazoagatik, bere umeak eskola aurrean jipoitu baitzuen/ baitzuiten.  
Iñaki psikologoarekin hitz egitera joan zen bere arazoengatik, bere umeak eskola aurrean jipoitu baitzuen/ baitzuiten.  
“Iñaki visited a psychologist for his issue(s), as a boy beat him/ he beat some boys in front of the school.”
- 29) Langilea oso haserre zegoen dokumentu problematikoagatik, eta bezeroak berehala salatu zuen/zituen.  
Langilea oso haserre zegoen dokumentu problematikoengatik, eta bezeroak berehala salatu zuen/zituen.  
“The public worker was very angry about the document(s), and the client reported him/he reported the clients instantly.”

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<sup>23</sup> Lagunak (“friend”) in Experiment 3

<sup>24</sup> Lagunak (“friend”) in Experiment 3

- 30) Miguel goibel zegoen andreak esandakoagatik, eta bere seme-alebak<sup>25</sup> hobeto sentiarazi zuen/zituen.  
 Miguel goibel zegoen andreak esandakoengatik, eta bere seme-alabak hobeto sentiarazi zuen/zituen.  
 “Miguel was sorry about his wife’s comment(s), so his kid cheered him up/so he cheered his kids up.”
- 31) Kritikoa kexatu egin zen pelikulagatik, eta produktoreak berriz ere gutxietsi zuen/zituen.  
 Kritikoa kexatu egin zen pelikulengatik, eta produktoreak berriz ere gutxietsi zuen/zituen.  
 “The critic wrote an opinion about the movie(s), and the producer spoke badly about him/he spoke badly about the producers again.”
- 32) Neska hunkituta zegoen pelikulako eszenagatik, eta ikusleak zinema aurrean negarrez aurkitu zuen/zituen.  
 Neska hunkituta zegoen pelikulako eszenengatik, eta ikusleak zinema aurrean negarrez aurkitu zuen/zituen.  
 “The girl was moved by the movie scene(s), and a spectator found her crying/she found the spectators crying in front of the cinema.”
- 33) Zuzendaria oihuka sartu zen ikasgelan, eta irakasleak momentuan kalera bota zuen/zituen.  
 Zuzendaria oihuka sartu zen ikasgeletan, eta irakasleak momentuan kalera bota zuen/zituen.  
 “The principal entered the classroom(s) yelling, and the teacher kicked him out/he kicked the teachers straight away.”
- 34) Andrea goibel sentitzen zen iraganeko harremanagatik, baina maitaleak jada ahaztu zuen/zituen.  
 Andrea goibel sentitzen zen iraganeko harremanengatik, baina maitaleak jada ahaztu zuen/zituen.  
 “The woman was nostalgic about the past relationship(s), although her past lover forgot her/she forgot her past lovers already.”
- 35) Mutila asko hunkitzen da Gabonetako kontzertuan, eta anaiak gogoz besarkatzen du/ditu.  
 Mutila asko hunkitzen da Gabonetako kontzertuetan, eta anaiak gogoz besarkatzen du/ditu.  
 “The boy gets really emotional at the Christmas concert(s), and his brother hugs him/he hugs his brothers strongly.”
- 36) Lehendakaritzarako hautagaia agertu zen prentsaurrekoan, eta aurkariak adeitasunez agurtu zuen/zituen.  
 Lehendakaritzarako hautagaia agertu zen prentsaurrekoetan, eta aurkariak adeitasunez agurtu zuen/zituen.  
 “The presidential candidate showed up at the press conference(s), and his opponent greeted him/he greeted his opponents politely.”
- 37) Emakumeak kontaktuak egin nahi zituen mintzaldiaren aurkezpenean, baina aurkezleak ez zuen/zituen ondo ezagutu.  
 Emakumeak kontaktuak egin nahi zituen mintzaldiaren aurkezpenetan, baina aurkezleak ez zuen/zituen ondo ezagutu.  
 “She wanted to make contacts at the conference presentation(s), but the presenter didn’t recognize her/she didn’t recognize the presenters well.”
- 38) Neska pozik zegoen udalekuan, nahiz eta mutilak askotan jo zuen/zituen.  
 Neska pozik zegoen udalekuetan, nahiz eta mutilak askotan jo zuen/zituen.  
 “The girl was happy about the summer camp(s), although a boy hit her/she hit the boys many times.”
- 39) Unai kezkatuta dago futbolzaleen jarreragatik, beraz, lehengusinak behar bezala babesten du/ditu.  
 Unai kezkatuta dago futbolzaleen jarrerengatik, beraz, lehengusinak behar bezala babesten du/ditu.  
 “Unai is worried about the fans at the football match(es), so his cousin protects him/he protects his cousins.”
- 40) Mutila ez zegoen batere alai kontzerturako entseguan, eta taldekideak ere mespretxatu zuen/zituen.  
 Mutila ez zegoen batere alai kontzerturako entseguetan, eta taldekideak ere mespretxatu zuen/zituen.  
 “The boy was really unhappy at the singing rehearsal(s), and his group member looked down on him/he looked down on his group members too.”
- 41) Managerra nahiko baldarra da mintzaldian, baina zuzendariak asko miresten du/ditu.  
 Managerra nahiko baldarra da mintzaldietan, baina zuzendariak asko miresten du/ditu.  
 “The manager is really clumsy during the talk(s), but the director appreciates him/he appreciates the directors a lot.”
- 42) Pop abeslaria oso pozik zegoen kontzertuarekin, eta ordezkariak ondoren zoriondu zuen/zituen.  
 Pop abeslaria oso pozik zegoen kontzertuekin, eta ordezkariak ondoren zoriondu zuen/zituen.  
 “The pop star was very content with the concert(s), and the booking agent praised her/she praised the booking agents afterwards.”
- 43) Izeba urduri zegoen afariagatik, baina senideak asko poztu zuen/zituen.<sup>26</sup>

<sup>25</sup> Lagunak (“friend”) in Experiment 3

Izeba urduri zegoen afariengatik, baina senideak asko poztu zuen/zituen.

"Aunt was nervous about the dinner(s), but her relative made her happy/she made her relatives happy."

44) Nire ahizpa asko aspertu zen antzerkian, baina lagunak ederki zaindu zuen/zituen.

Nire ahizpa asko aspertu zen antzerkietan, baina lagunak ederki zaindu zuen/zituen.

"My sister got bored on the theatre play(s), but the friend took care of her/she took care of her friends very well."

45) Neska denbora-pasa zegoen tabernan, beraz, anaiak goiz jaso zuen/zituen.

Neska denbora-pasa zegoen tabernetan, beraz, anaiak goiz jaso zuen/zituen.

"The girl was killing time in bar(s), so her brother picked her up/she picked her brothers up early."

46) Langile berria izkutaturik dago bulegoan, bere idazkariak gaizki tratatu baitzuen/baitzituen.

Langile berria izkutaturik dago bulegoetan, bere idazkariak gaizki tratatu baitzuen/baitzituen.

"The new worker is hiding in the office(s), since the secretary treated him/he treated the secretaries badly."

47) Ikaslea urduri zegoen idazlanagatik<sup>27</sup>, hortaz, bizilagunak ez du/ditu joan den ostiraletik ikusi.

Ikaslea urduri zegoen saiakerengatik, hortaz, bizilagunak ez du/ditu joan den ostiraletik ikusi.

"The student was stressed about the essay(s), so her flatmate didn't see her/ so she didn't see her flatmates since last Friday."

48) Elena ez zegoen ikasgelan, eta gelakideak<sup>28</sup> lo aurkitu zuen/zituen.

Elena ez zegoen ikasgeletan, eta gelakideak lo aurkitu zuen/zituen.

"Elena did not attend the class(es), and her her classmate found her sleeping/she found her classmates sleeping."

49) Politikoa lanpetuta zebilen parlamentuko saioarekin, horregatik ministroak azkenean ez zuen/zituen bisitatu.

Politikoa lanpetuta zebilen parlamentuko saioekin, horregatik ministroak azkenean ez zuen/zituen bisitatu.

"The politician was busy with the pairment session(s), so the minister didn't visit him/he didn't visit the ministers in the end."

50) Eneko pozik zegoen berriagatik, eta semeak<sup>29</sup> ospatzera gonbidatu zuen/zituen.

Eneko pozik zegoen berriengatik, eta semeak ospatzera gonbidatu zuen/zituen.

"Eneko was happy about the news<sub>[sg]</sub>( news<sub>[pl]</sub>), and his son invited him/and he invited his sons to celebrate."

51) Mutikoak uste du gaizki dabilela igeriketa-txapelketan, baina irakasleak oso gogoko du/ditu.

Mutikoak uste du gaizki dabilela igeriketa-txapelketetan, baina irakasleak oso gogoko du/ditu.

"The boy thinks he is not good at swimming competition(s), but the teacher really likes him/he really likes the teachers."

52) Mikel agertu da gaur goizean egunkarian, bere auzokideak zaratagatik salatu baitzuen/baitzituen.

Mikel agertu da gaur goizean egunkarietan, bere auzokideak zaratagatik salatu baitzuen/baitzituen.

"Mikel showed up this morning in the newspapers<sub>[sg]</sub>( newspapers<sub>[pl]</sub>), as the neighbour reported him /he reported the neighbours for noise."

53) David ez da inoiz kezkatuta egon bere harremanagatik, bere neska-lagunak izugarri maite baitu/baititu.

David ez da inoiz kezkatuta egon bere harremanengatik, bere neska-lagunak izugarri maite baitu/baititu.

"David is never worried about his relationship(s), because his girlfriend loves him/ he loves his girlfriends unconditionally."

54) Olatz urduri dago familia bazkariagatik, bere mutilak ez baitu/baititu inoiz familian aurkeztu.

Olatz urduri dago familia bazkariengatik, bere mutilak ez baitu/baititu inoiz familian aurkeztu.

"Olatz is nervous about the family lunch(es), as her boyfriend never introduced her/as she never introduced her boyfriends to the family."

55) Paula oso gogotsu egon zen irakurketan, baina ikasleak ergel sentiarazi zuen/zituen.

Paula oso gogotsu egon zen irakurketetan, baina ikasleak ergel sentiarazi zuen/zituen.

"Paula was very active in the lecture(s), but the new student made her feel/she made new students feel stupid."

56) Neskak orduak eman zituen arropa erosten dendan, eta adiskideak<sup>30</sup> azkenean ahaztu zuen/zituen.

Neskak orduak eman zituen arropa erosten dendetan, eta adiskideak azkenean ahaztu zuen/zituen.

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<sup>26</sup> In Experiment 3, the item was different: Amaia urduri zegoen mutila etxean aurkezteagatik, baina senideak berehala onartu zuen/zituen, "Amaia was nervous about the introducing her boyfriend to the family, but the relative accepted him/ but he accepted the relatives immediately."

<sup>27</sup> Saiakeragatik ("about the assignment") in Experiment 3

<sup>28</sup> Lagunak ("friend") in Experiment 3

<sup>29</sup> Lagunak ("friend") in Experiment 3

<sup>30</sup> Lagunak ("friend") in Experiment 3

*“The girl spend hours buying clothes in the shop(s), and her friend forgot about her/she forgot about her friends in the end.”*

57) *Unai ez dago ados gasolinaren prezioarekin, nahiz eta lankideak egunero lanera eramaten duen/dituen.*

*Unai ez dago ados gasolinaren prezioekin, nahiz eta lankideak egunero lanera eramaten duen/dituen.*

*“Unai is not happy with the gasoline price(s), although his colleague takes him to work/he takes his colleagues to work every day.”*

58) *Zikinkeria uzten du beti mahaian, eta pisukideak jada ez du/ditu estimatzen.*

*Zikinkeria uzten du beti mahaietan, eta pisukideak jada ez du/ditu estimatzen.*

*“He always leaves mess on the table(s), and his flatmate doesn’t appreciate him/he doesn’t appreciate his flatmates anymore.”*

59) *Neska pozik zegoen familiarekin sofatan, bereziki ahizpak maitasunez laztantzen zuelako/zituelako.*

*Neska pozik zegoen familiarekin sofatan, bereziki ahizpak maitasunez laztantzen zuelako/zituelako.*

*“The little girl enjoyed with family on the sofa(s), especially because her sister caressed her/she caressed her sisters with love.”*

60) *Saskibaloia jokalaria kexatzen ari zen taldearen buruzagiarekin, eta entrenatzaileak jendaurrean iraindu du/ditu ondoren.*

*Saskibaloia jokalaria kexatzen ari zen taldearen buruzagiarekin, eta entrenatzaileak jendaurrean iraindu du/ditu ondoren.*

*“The basketball player complained about the club leader(s), and his coach insulted him/he insulted his coaches publicly afterwards.”*