USE OF NUMBER AND GENDER FEATURES IN THE INTERPRETATION OF SPANISH NOUN ELLIPSIS

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ABSTRACT

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Various studies have investigated the formal properties of Spanish noun ellipsis (Saab 2010, Depiante & Masullo 2001, among others). The theory developed by Saab (2004, 2010) proposes that noun ellipsis in this language is licensed by matching two components between the elided noun and its antecedent: the gender feature and the lexical root. Crucially, there is no constraint requiring the matching of number features between these two elements. This study presents an experimental approach to investigate if Spanish speakers' online and offline interpretation of noun ellipsis reflects this theoretical distinction. A between subjects, combined eye tracking and picture selection task asks participants to identify the referent of an elided noun. The elided noun phrase matches or mismatches the antecedent in number or gender. While the test phrase is played, participants' gaze patterns are monitored before they point to the referent of the ellipsis at the end of the phrase, thus providing an online and offline measurement. This task was completed with both adult and child participants to see if the interpretation of ellipsis develops over time. The results provide evidence that for adults, gender mismatches are more difficult for participants to process than number mismatches, which is reflected in slower reaction times and fewer looks to target on gender mismatching trials. We also show that this pattern in adults is also reflected in the children's pointing data. Additionally, children's reduced performance on number items involving plural markers is interpreted as a reflection of the delayed acquisition of plural morphology that has been previously documented in Spanish-speaking Chilean Children.

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1. Introduction

One crucial element of an individual's ability to communicate using natural language is the successful comprehension and production of anaphora. Generally speaking, anaphora describes a process in which the interpretation of a linguistic expression Y depends on the presence of a discourse antecedent X to which it is co-indexed. One important aspect of the relationship between the anaphoric element and its antecedent is that this relation is constrained by syntax, semantics, and context. Furthermore, depending on the context, there is more than one potential antecedent for the anaphora.

(1) John bought that one.

(2) John bought the blue car and Mary bought the red one.

(3) John bought this blue car and Mary bought that one

(4) John bought this book and this calendar and Mary bought that one.

For example, it is impossible to interpret (1) out of the blue since we don't have an antecedent that we can use to interpret the anaphoric element *one*. In (2) on the other hand, we effortlessly find an antecedent for *one*, which is interpreted by associating it with *car*. However, in (3) the antecedent for *one* can be represented as either *car* or *blue car*. Furthermore, in (4) we have a problem because there are two potential antecedents and we have no way to determine what is the antecedent.

Although at first glance the task of retrieving some noun phrase antecedent seems to be not very difficult, Lidz et al. (2003) and Pearl (2007) show that a speaker's ability to successfully interpret the antecedent of *one* is not trivial and depends on a complex knowledge of certain syntactic structures and language processing skills that reflect both innate linguistic competence and cognitive development.

Anaphoric expressions such as these, which depend on an antecedent to be interpreted, are very frequent in natural languages. However, they do not always have the same form. For example, not every language uses *one*. The Spanish equivalent of (2) does not have a pronominal element equivalent to *one.* Rather in comparable cases we find instead a gap that needs to be interpreted by linking it to an antecedent, much as one. We can interpret this gap as being a case of ellipsis[1].

(5) Juan compró el coche azul y María compró el rojo.
Juan bought the car blue and María bought the red.
'Juan bought the blue car and María bought the red one'.

In the case of (5), the noun in the DP of the second conjunct is left entirely unpronounced. Much like (1), the interpretation of this sentence requires the retrieval of information provided by the previous discourse. Additionally, we also see cases similar to (3) in which there is ambiguity as to the exact structure of the ellipsis and whether or not it includes the color adjective, showing that the empty category is not an N but an NP of sorts. As we will see, it is an *n*P.

(6) Juan compró el coche azul grande y María compró el pequeño.
Juan bought the car blue big and Mary bought the small.
'Juan bought the big blue car and Mary bought the small (red) one.'

The data in (7) show an interesting contrast with respect to gender and number. While it is possible to recover an antecedent that does not have the same number information (7a), to recover an antecedent with a different gender is for some speakers quite impossible.

(7) a. Juan tiene los gatos blancos y María tiene el negro.
J. has the.M.PL cat.M.PL white.M.PL and M. has the.M.SG black.M.SG

[1] See section 2 for alternative analyses of the Spanish phenomenon.

'Juan has the white male cats and María has the black male one'

b. *Juan tiene la gata blanca y María tiene el negro.

J. has the.F.SG cat.F.SG white.F.SG and M. has the.M.SG black.M.SG

'Juan has the white female cat and María has the black male one'

c. John got black (male) cats for his birthday and Mary got a white (female) one.

The contrast in grammaticality between (7a) and (7b) shows that number and gender features behave differently in Spanish nominal ellipsis. Of course, since English does not have grammatical gender, this is not an effect we can examine. However, it is certainly possible to have a mismatch in number.

This contrast in Spanish has been examined by Depiante and Masullo (2001) and Saab (2010, 2004), among others. However, to my knowledge there have been no studies that investigate how this information is used during the development of child language and in what ways this may differ from adults.

Given the observed asymmetry in the unacceptability of gender and number mismatches for Spanish noun ellipsis, the studies presented here aim to develop an experimental approach that investigates if interpreting sentences with or without these violations affects sentence processing. Doing so can further our understanding of how different grammatical features are used during comprehension. Additionally, the results can provide further evidence for the formal representation of ellipsis structures that have been developed in the theoretical literature. To work towards these goals, the thesis has two parts.

First we will investigate if adult speakers of Chilean Spanish demonstrate any sensitivity to number and gender mismatches during the comprehension of noun ellipsis. We will then consider the extension of this research in the context of first language acquisition for speakers of

the same dialect. This will be achieved by comparing the performance of these adults to the processing patterns observed in children undergoing language development. To our knowledge, there is no research that investigates how young speakers interpret this language and if this differs in any way from their adult counterparts. Therefore, identifying any similarities or differences that exist between these two groups will help deepen our understanding of how this ellipsis is represented and used by speakers, and if this changes over time.

2. Theoretical Background

Numerous publications have sought to develop a better understanding of ellipsis. As van Craenenbroek and Merchant (2009) explain, early approaches to studying this phenomenon considered the structural similarities between elided material and its overt antecedent that make recovery possible. However, more recent work has highlighted the fact that in some cases recoverability is possible but the sentence is still unacceptable.

(8) *John read the long book and I read the short [$_{NP}$ *e*].

(van Craenenbroeck & Merchant 2009, p. 702)

This has led to additional research on the licensing components of noun ellipsis. Early proposals argued that ellipsis is represented in the grammar as a null pro-form *pro* whose presence is made licit by agreement. For example, Lobeck (1995) claims empty pronominals must be head-governed by an X^0 specified for strong agreement. Under this approach, strong agreement results from certain grammatical features such as [+tense], [+WH], [+poss] and [+plural]. Along similar lines, Kester (1996) argues that adjectival morphology or gender features on the determiner allow for the interpretation of *pro* in the case of noun ellipsis.

These accounts involving *pro* differ from an alternative, deletion-based theory of noun ellipsis. This is argued for by Merchant (2001), who proposes the presence of an E feature on certain syntactic heads. This feature causes the head's complement to undergo PF deletion. Unlike many other theories, this analysis relies heavily on the semantic interpretation of the identity relationship that must be established between an ellipsis and its antecedent. Corver and van Koppen (2009) adopt this feature for their analysis of noun ellipsis in Dutch. They claim that the *–e* morpheme that has often been considered an adjectival agreement marker which licenses

noun ellipsis is actually an overt focus head with the [E] feature. When an adjective raises to the specifier of FocP, the noun left behind in the complement position is deleted at PF.

In this project, we focus on the theory of noun ellipsis as developed by Saab (2004, 2010), who claims this process results from the non-insertion of phonological features into *n*P. Under this approach, ellipsis is licensed when all of the syntactic and semantic features in *n*P of the elided noun and its antecedent are identical. Unlike Merchant (2001), and other semantically oriented accounts, Saab's proposal points strongly to syntactic knowledge as the primary factor that licenses elided nouns. At this point it is necessary to review his work in order to establish the theoretical framework of the thesis.

(9) shows an asymmetry with respect to number and gender in the apparent identity requirement for Spanish noun ellipsis. He uses *tío/tía* 'uncle/aunt', what is referred to as an inflectional pair, to show the contrast. (Depiante and Masullo (2001) and Saab (2010))

(9) a. Juan visitó a su tío y María visitó a los ~~tíos~~ suyos.
J. visited to his **uncle.M.SG.** and M. visited to the **uncles.M.PL.** poss-3.M.PL.
'Juan visited his uncle and María visited her uncles'

b. Juan visitó a sus tíos y María visitó al ~~tío~~ suyo.
J. visited to his **uncles.M.PL.** and M. visited to.the **uncle.M.SG.** poss-3.M.SG.
'Juan visited his uncles and María visited her uncle'

c. ??Juan visitó a su tío y María visitó a la ~~tía~~ suya.
J. visited to his **uncle.M.SG.** and M. visited to the **aunt.F.SG** poss-3.F.SG.
'Juan visited his uncle and María visited her aunt'

d. ??Juan visitó a su tía y María visitó al ~~tío~~ suyo.
J. visited to his **aunt.F.SG.** and M. visited to.the **uncle.M.SG** poss-3.M.SG.

'Juan visited his uncle and María visited her aunt'

(Saab 2010, p. 19)

More specifically, (9a-b) show that there is no consequence for a sentence's grammaticality when the number feature of an elided noun does not match the number feature of its antecedent. This contrasts with (9c-d), which show that when the gender feature of the elided noun does not match the gender feature of the antecedent, the sentence becomes deviant.

The explanation given by Depiante and Masullo for the pattern in (9) is based on the theory that noun ellipsis results from PF deletion under strict formal identity. These researchers claim that grammatical gender is a root property and does not result from any type of morphological process. According to this theory, nouns enter the syntax already expressing gender. Thus, for ellipsis to occur, the elided noun and its antecedent must have identical gender features. If this is not the case, identity is not satisfied and deleting the noun at PF results in an unacceptable sentence (9c-d). Crucially, under this approach the morpheme for number is considered to be syntactically separate from the noun. As a result, if two nouns do not have the same number feature and one is marked with the plural /-s/ morpheme, while the other is marked with the singular zero morpheme (9a-b), the identity requirement of *n*P is unaffected by this type of mismatch. The result is the overall pattern in (7) in which gender mismatches, but not number mismatches result in ill-formed noun ellipsis structures.

Saab (2004, 2010) challenges Depiante and Masullo's explanation of the data patterns in (9) by arguing that not all instances of illicit mismatches involving noun ellipsis produce the same level unacceptability. This is demonstrated by the sentence in (10) that contains the suppletive pair *madre/padre* 'mother/father'.

(10) *El padre de Juan y la ~~madre~~ de María

the.M.SG father of J. and the.F.SG mother of M.

'Juan's father and María's mother'

(Saab 2010, p. 20)

When compared to the unacceptable sentences in (9c-d), there is no question that (10) is worse. However, Saab points out that the semantic relationship between *madre/padre* 'mother/father' is the same as that for *tío/tía* 'uncle/aunt' even though they form different pair types (suppletive vs. inflectional). Nevertheless, according to Saab, the lack of strict formal identity for the gender root property in (9c-d) and (10) is the same. Despite this, (10) is much less acceptable yet there is nothing in the work of Depiante and Masullo (2001) that is capable of accounting for this difference in acceptability. Therefore, Saab contends that an alternative theory of noun ellipsis in Spanish is necessary to account for the patterns observed here.

The explanation of ellipsis developed in Saab (2004, 2010) hinges on a more fine-grained distinction of the morpho-syntactic structure of different words in Spanish. To do so he highlights the different kind of word pairs that appear to exist. The four types are summarized here.

(11) a. Inflectional	*tío/tía*	'unle/aunt'
b. Suppletive	*padre/madre*	'father/mother'
c. Homophonous	*orden/orden*	'order (structure)/order (command)
d. Derivational	*manzano/manzana*	'apple tree/apple'

Traditionally, words such as those in (11) have been studied from a lexicalist perspective (cf. Depiante & Masullo 2001). Under this approach, it is argued that members of an inflectional pair such as *tío* 'uncle' and *tía* 'aunt' undergo word formation processes while they are in the lexicon. Only after this has happened are these items then inserted into the syntactic structure. However,

in a departure from this view, Saab (2004, 2010) takes an alternative approach in which he considers the same kinds of lexical items within the Distributed Morphology framework (Halle & Marantz 1993). In this system, there are no morphological processes that occur within the lexicon. Instead, the syntax manipulates bundles of syntactic features. Thus, in this case a word like *tío* 'uncle' is actually considered to be formed by the syntactic component of the grammar when the feature bundles representing a root feature √TI and a *n* valued with the feature [-fem] are combined. Once all of the operations in the syntax have run to completion, Vocabulary Items (VIs) are inserted into the structure at spell out. The VIs are the phonological features that associate with the proper nodes of the final structure determined by the syntax. In this case, the two VIs are *ti-* for the root feature and *o* for the node representing *n,* thus resulting in the phonological realization of *tío.*

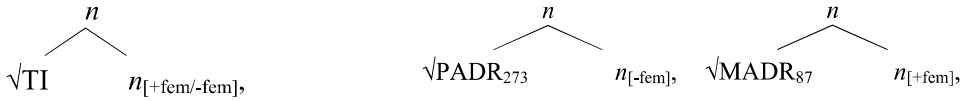
Saab proposes that different roots are labeled according to an index with which they are associated. For example, the root for *perro* 'dog' could be arbitrarily assigned to index 789, represented in the syntax as √789. Additionally, it is proposed that these roots are immediately dominated in the structure by *n*P, which carries the gender feature. Evidence for this is visible on the masculine word *hospital.* When this word is further combined with the morpheme *-ción* to form *hospitalización* 'hospitalization', its grammatical gender changes to feminine. Such a shift is used by Saab to suggest that the *-ción* affix in *n* is valued for [+fem].

Returning to the word pair types in (11), it becomes apparent from this proposal that one way to distinguish between them is based the representation of the gender features on their roots. Saab suggests that this information provides an important difference between inflectional pairs vs. suppletive, homophonous, and derivational pairs. More specifically, the two members of an inflectional pair are formed from a single root with the same index, which is later valued for

gender features. For the other cases, two separate roots with their own pre-valued gender feature and unique indices form the pairs. Comparing the structure of *tío/tía* in (12a) with the structure for *padre/madre* 'father/mother' (12b) represents this difference.

Figure 1: Diagram: Inflectional and suppletive pair word structures

(12) a. b.



(Saab 2004, p. 41)

In (12a) *tío* and *tía* are generated from the same root. The gender feature on *n* is then valued as [±fem]. Depending on which member of the pair is being generated, the grammar will insert the appropriate feature into the structure at *n*. This system works differently for the roots that form a suppletive pair in (12b). Here, *padre* and *madre* are generated from distinct roots. Although it is not shown here, Saab also contends that the roots in (12b) already contain a feature valued as [±fem]. Put another way, the sex feature for the each member of a suppletive pair is specified on the root. The value that appears on *n* in (12b) is the result of a process that takes the semantic information represented on the root and expresses it morphologically.

We are now finally at a point where it is possible to understand the implications that the structures in (12) will have on the theory of noun ellipsis developed by Saab (2004, 2010). However, it must first be noted that this approach adopts a standard DP structure that posits the existence of an intermediate Number Phrase directly below D and above *n*P.

(13) [$_{DP}$ D [$_{NumP}$ Num [$_{nP}$ *n* [$_{\sqrt{P}}$ √]]]]

With this structure, the hypothesis in Saab (2004, 2010) is that noun ellipsis in Spanish is specifically the ellipsis of *n*P. He refers to this section of the structure as the 'ellipsis domain'.

The functional projections above *n*P (NumP and DP) constitute the 'domain of the licenser'. Therefore, by demarcating these two regions of the structure Saab develops the following constraints on noun ellipsis in Spanish.

(14) a. Elements outside the *n*P cannot be elided

b. A constituent C can be elided if there is a constituent C' identical to C in the syntax

Identity:

(A) An abstract morpheme α is identical to an abstract morpheme β iff α and β match all its semantic and syntactic features.

(B) A Root A is identical to a Root B iff A and B have the same label.

(Saab 2010, p. 58)

The structure outlined in (13) together with the constraints in (14a-b) is capable of accounting for the different level of unacceptability for ellipsis involving an inflectional pair (*tío/tía* 'uncle/aunt') and the suppletive pair (*madre/padre* 'mother/father'). Although the elided noun in each case is contained in the appropriate structural domain, they both violate a requirement for identity. However, Saab argues the abstract morpheme identity violation (14A) for gender on the *n* of *tío/tía* is less severe the root identity violation (14B) for *madre/padre*. This same contrast applies to the other word pair types (homophonous and derivational) given that they also have members that correspond to different root indices in this theory.

This approach is also capable of accounting for the asymmetry in (un)acceptability for number and gender mismatches originally described at the beginning of this section in (8). Because NumP is located outside of the ellipsis domain, any information it contains must remain in the syntax after elision has occurred. Therefore, number features do not play a role in the identity checking that licenses ellipsis. As a result, there is no problem when the number features

of an antecedent and an elided noun do not match. Gender on the other hand, by virtue of being assigned to *n* within the ellipsis domain, must satisfy identity, which explains why gender mismatches in noun ellipsis result in unacceptable sentences.

Finally, it is important to discuss Saab's characterization of the syntactic process that ultimately results in noun ellipsis once the identity requirements within the ellipsis domain have been checked. Operating within the Distributed Morphology framework means the licensing features that must match are present in the terminal nodes of the syntactic structure before any lexical items are present. Considering this, Saab (2004, 2010) postulates that in cases when identity has been checked, noun ellipsis results from the non-insertion of phonological features into the syntax. As a result, no Vocabulary Items are realized for this section of the structure at PF. This differs from alternative accounts that consider noun ellipsis to be caused by the deletion of phonological material that is already present in the derivation. Instead, according to Saab this material never enters the tree to begin with and is left unpronounced.

Saab's (2004, 2010) approach is capable of explaining why gender mismatches between an antecedent and its elided noun are less acceptable in some contexts than number mismatches, but are not as bad as ellipsis of different roots. This is achieved by creating a representation of language that contains an *n*P ellipsis domain in which identity must be checked. In this case, identity refers to the root indices and features for abstract morphemes that must match in the *n*Ps of the elided noun and its antecedent.

In this study, we seek to investigate how adults and children make use of gender and number information while interpreting noun ellipsis. The general research question we seek to answer is if the participants in our study show a difference in how gender and number on syntactic remnants affects the retrieval of the proper antecedent when they encounter ellipsis in a

test sentence. However, we consider this in different ways for each age group involved. For the adults we ask the following:

(i) Is there a difference in the processing cost of interpreting a gender-mismatched ellipsis versus a number-mismatched ellipsis?

(ii) Do adults require more time to recover the identity of an elided noun that mismatches with its antecedent in gender, than when the elided noun mismatches with the antecedent in number?

We also ask if children are sensitive to gender mismatches while interpreting noun ellipsis. However, with regards to number, one factor that raises additional questions for this group is that Chilean children take longer to understand plural morphology due to the variable input they receive (Miller & Schmitt 2012, see Chapter 5). This means that many of the child participants may not understand or be aware of the plural markers that occur in the materials for this project. Therefore, we also ask if the children in these studies will be less successful at using number information to interpret ellipsis structures than gender information, which they are more likely to notice. The specific research questions for children can be summarized as follows:

(i) Are children capable of recovering the antecedent when interpreting a noun ellipsis construction?

(ii) If so, do children show a difference in the ability to use gender and number information to find an antecedent?

(iii) Will the fact that many of the children in this study lack awareness of plural morphology cause them to perform worse on trials testing number information when compared to trials testing gender information, which they already know?

In the following chapters we seek to address the research questions presented here. First, we present a general overview of the experimental technique used for this study. Then, we discuss adults in Chapter 4 before moving on to children in Chapters 5 and 6.

3. Experimental Technique: Eye tracking and the visual world paradigm

In order to investigate the theoretical account of noun ellipsis described in the previous section it is important to use an experimental technique that makes this possible. There are various methods available to evaluate if individuals demonstrate an unconscious awareness of certain constraints in their grammar. This includes the widely used grammaticality judgment tasks that seek to determine the level of acceptability native speakers ascribe to a particular construction within in a sentence. However, in addition to this technique that provides information on subjects' overall impression of a sentence, there are other methods that provide insight to the online processing that occurs during interpretation. This provides an advantageous approach to studying the structural representation of phenomena such as ellipsis because it creates the possibility of observing how subjects react to linguistic input in real time, thus enabling a closer look at specific grammatical elements at certain points in the speech stream. For this study, we use the online method of eye tracking in the visual world paradigm to monitor participants' eye movements during the interpretation of spoken language to observe how manipulating gender and number features in Spanish noun ellipsis may affect the processing of this structure. Such information can in turn provide important information about the structural representation of language by observing how the looking patterns and their timing change between different conditions based on the acceptability of the sentence.

Generally speaking, the visual world paradigm presents participants in a study with a set of images or objects while they listen to pre-recorded sentences that are played during an experiment. The images in the materials are typically described as targets or distractors based on which one corresponds to the correct interpretation of the auditory stimulus played during the procedure. Activities that employ this approach to studying language processing usually involve

some type of task that asks participants to either pick up a certain object or look at the screen while listening to specific information (Huettig et al. 2010). While the participants listen to the information and carry out whatever task they are asked to complete, the position of their eye gaze with respect to time is monitored for subsequent analysis. As a tool for understanding language processing, Altman and Kamide (2007) have demonstrated that individuals are more likely to focus on an object in front of them when said object has been activated by the linguistic stimulus they are listening to. Therefore, the timing and direction of an eye gaze serves as an indirect measure of how a specific individual processes and interprets the language he has been exposed to. A brief review of some of the important studies in developing the visual world paradigm will help illustrate this concept further.

Cooper (1974) conducted one of the first studies that investigated the relationship between individuals' looking patterns and the language to which they are exposed. In this study, university students from ages 18 – 30 looked at slides that consisted of a 3 x 3 picture display while listening to prerecorded passages. Each picture in the display corresponded to certain words in the passage that were divided into four categories depending the relationship between them. For example, one passage involving a dog named Scotty had words in the following categories associated with the dog image in the display: (i) direct non-contextual: "animals", (ii) direct contextual: "Scotty", (iii) indirect non-contextual: "barking", and (iv) indirect contextual: "frightened". When the participants heard these words, their fixation was coded as correct if the fixation on the dog picture (1) occurred during the word and lasted through its pronunciation, or (2) the fixation on the dog picture happened within one second of the word's offset and lasted for at least 300 ms.

The results of this study showed many interesting findings with respect to looking patterns as an indication of language processing. First, the percentage of correct fixations was highest for words in the "direct, non-contextual" category, showing that the participants made more looks to pictures related to the language they listened to when compared to the unrelated pictures. It is important to note that the participants were instructed to look wherever on the display they pleased. Considering this, such a pattern of looking at pictures that are semantically related to the words of the passage presented evidence of the link between processing language and eye gaze direction. Also, the result showing that correct fixations often occurred before the word was completely pronounced provided evidence for the online processing of language. That is to say, word-initial phonemes were a sufficient cue that helped participants fixate on a picture before the entire word had been uttered. Additionally, the associations between words and pictures that manifested themselves in such short latencies (mid-word or within 1 second), reflected anticipatory effects and provided some of the first evidence for the automatic nature of the response system that results in eye movements during language processing.

Although the results achieved by Cooper (1974) provided results linking eye movement to language processing, this method was not widely pursued until Tanenhaus et al. (1995) published another eye tracking study using the visual world paradigm to research spoken language comprehension. In a set of experiments, these authors showed that the visual display placed in front of subjects does in fact have an affect on how language is processed. For example, participants were given an instruction such as "Find the candy. Now put it above the fork". For such a sentence, it was reported that the participants took longer to initiate a saccade towards the target object "candy" when there was an object with a similar sounding onset such as "candle" in the display. Like Cooper (1974), this shows that individuals are capable of moving

their gaze towards the mentioned object before the entire word has been pronounced. However, here it is crucially shown that this process will be delayed based on whether or not there is a phonological competitor in the display with a similar onset as the target.

Tanenhaus et al. (1995) also showed how the visual world paradigm could be used to investigate the representation of syntactic structure. To do this, they used the ambiguous sentence *Put the apple on the towel in the box*. This sentence is ambiguous because the initial display involved an apple placed on a towel, another towel with nothing on it, and an empty box. Therefore, during an initial parse of the test sentence it is unclear if the PP *on the towel* is describing the location of the apple or where the participant should move the apple. It is not until the second PP *in the box* that it becomes clear the ambiguous *on the towel* is describing the location of the apple in this sentence. The eye tracking data shows that on roughly half of the trials, upon hearing *on the towel* the participants looked to the incorrect destination of the other towel rather than the empty box before they heard the final part of the sentence.

To further test if the destination reading of *on the towel* is parsed at the same rate as the modifier reading of apple, Tanenhaus et al. created a second condition with a different display. In this case, another apple on a napkin was added. In this setup, the first PP *on the towel* now disambiguates between the two apples placed on top of different items (towel and napkin). Crucially, in this condition, the eye tracking data shows that the looks to the empty towel fell to between 15-20% of the trials. In other words, altering the display to include two apples and making *on the towel* more informative significantly reduced the incorrect destination reading of this PP. The authors interpret this difference in the fixation patterns between the two visual displays as evidence for the fact that visual information plays a role in influencing how language is processed, and that our eye movements can be reflective of that.

The findings reached by Tanenhaus et al. (1995) make it possible to understand an important difference in the approaches taken towards eye tracking research. Heuttig et el. (2010) point out the distinction between constraint-based and structural theories of sentence processing. According structural approaches (Frazier 1987), the initial parse of a sentence is confined to syntactic information, while other factors such pragmatic or lexical information is not considered until the speaker's first pass through a sentence is complete. Conversely, under a constraint based model (Trueswell, Tanenhaus, & Garnsey 1994), syntactic processing is subject to multiple constraints at the "lexical, structural, and discourse level" (Heuttig 2010, p. 155). By carrying out research using the visual world paradigm, it may become possible to create a better understanding of the strengths and weaknesses associated with each theoretical model of language processing. It is evident that visual information plays a role in processing language. However, it is also clear that individuals are sensitive to syntactic constraints when attempting parse linguistic information. The experiments that follow combine visual information and grammatical constraints on Spanish noun ellipsis that may help us clarify further the role each kind of information plays in facilitating the successful interpretation of this syntactic structure.

4. Adult Experiments

This chapter describes two experiments: one that investigates number (Experiment 1) and another that considers gender (Experiment 2) and their role in noun ellipsis resolution. The results of each will be discussed together to consider what they can tell us about the research questions that have been raised. Considering the research questions presented at the end of Chapter 2, we make the following hypothesis about the outcomes of the two experimental tasks:

> Resolving a gender-mismatched ellipsis will be more difficult than resolving a number-mismatched ellipsis. Finding the referent will take longer for a gender mismatched sentence because it violates the identity constraints requiring the gender feature on *n* of the elided noun and its antecedent to be identical. Conversely, the number feature has no such requirement.

4.1 Study 1: Eye tracking of number mismatched ellipsis

4.1.1 *Participants*

The participants for this study were 21 adults who came to the CIAE lab in Santiago, Chile for testing. All of the participants were monolingual, native Spanish-speakers from Santiago de Chile. The participants were randomly assigned to one of two experimental conditions (described below). The participants received financial compensation for participating in the study.

4.1.2 *Procedure*

We tested adults' use of number features during the interpretation of noun ellipsis. This was accomplished by carrying out a combined eye tracking/picture selection task. Prior to starting the experiment, participants were seated in front of a monitor equipped with a Tobii T120 Eye Tracker. The participants were told they would listen to a story about different animals with a

puppet named Juan, who needed help understanding what was being said. To do this, the instructions told participants they had to point to the animal that is being referred to in the story when two images appeared on the screen (a target and a distractor). Crucially, these two images appeared at a point in the story that involved ellipsis. If the participant pointed to the target image, this served as an indication that they properly interpreted the noun ellipsis. The pointing was recorded by mounting a Logitech HD C270 Webcam on the wall behind the participants. At the same time the eye tracker monitored the position and duration of the participants' gaze. Under this design, the pointing and eye tracking produced an online and offline measurement of sentence comprehension.

In total there were ten trials in the activity that consisted of two practice items, four test items, and four distractors. The first practice trial had the format of a test item and the second one had the format of a distractor. After the practice phase, the test trials began and alternated with the distractor trials until the activity was completed. The duration of the task was about eight minutes. The test items required the participants to identify the referent of a noun ellipsis structure while the distractors required the subjects to identify the subject of a *pro* drop sentence.

4.1.3 *Materials*

Each critical item was designed to test if manipulating number features within the Spanish DP affected participants' interpretation of noun ellipsis. For this experiment, the antecedent and the elided noun were limited to inflectional pairs in an effort to keep the test materials consistent across trials. Also, this limited any type of identity violation to abstract number features only, as each member of the pair contained the same root label and gender. This is important because only the effect of number feature mismatches was under consideration in this study.

(15) a. *perro/perra* 'dog.M/dog.F'

b. *gato/gata* ‘cat.M/cat.F’

c. *mono/mona* ‘monkey.M/monkey.F’

d. *conejo/coneja* ‘rabbit.M/rabbit.F’

Each of the pairs in (15) was used in a test sentence that corresponded to one of two experimental conditions: Number Test and Number Control. Thus, for each condition there were four test sentences (one for each inflectional pair). The participants were randomly assigned to only one condition, resulting in a between subjects design. The two conditions differed in terms of matching and mismatching. The condition labeled test involved a mismatch for that feature while the conditions labeled control did not. Crucially, gender features between the elided noun and its antecedent were held constant. The test sentences for each condition involving the inflectional pair *gato/gata* ‘cat.M/cat.F’ are exemplified in (16). (see Appendix A for all items and accompanying drawings).

(16) a. Number Test

Los gatos blancos piden un pedazo de torta y el negro pide un helado.

The.PL cat.PL white.PL order a piece of cake and the.SG black.SG orders an ice cream

‘The white cats order a piece of cake and the black one orders an ice cream’

b. Number Control

Los gatos blancos piden un pedazo de torta y los negros piden un helado.

The.PL cat.PL white.PL order a piece of cake and the.PL black.PL orders an ice cream

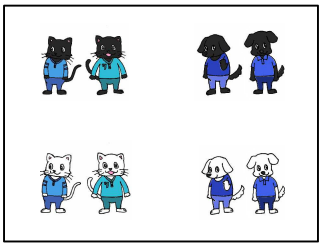
‘The white cats order a piece of cake and the black one orders an ice cream’

The audio files played during the experiment were prerecorded using an adult native speaker of Chilean Spanish. The native speaker spoke in a clear tone and made a particular effort to pronounce all of the /s/ consonants in the script. All of the trials in each of the two conditions

followed the same format while the audio played in conjunction with colorful images that represented what the story was describing. The first stage of each trial introduced the context and presented the story's animals. The second stage presented the antecedent. The third stage displayed a fixation cross to center the participants' gaze in the middle of the screen. During the fourth stage, participants listened to the ellipsis construction with two images displayed on the screen: the target and a distractor. After hearing the sentence, the participants were asked to point to the animal that the ellipsis was referring to. If the participant successfully interpreted the sentence, she would point to the target image when prompted. The following example shows the progression of a test item involving the inflectional pair *gato/gata* 'cat.M/cat.F' for the Number Test condition. The sentences below each picture show the audio that played for that section of the task.

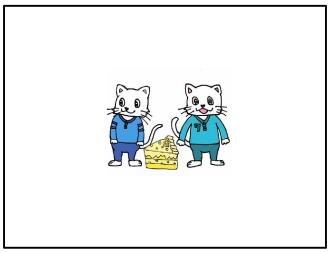
Figure 2: Image: Four-stage progression of number test trial item.

Stage 1: Introduction



Un grupo de gatos y perros van a un restaurante a comer. Mira lo que piden.
A group of cats and dogs go to a restaurant to eat. Look at what they order.

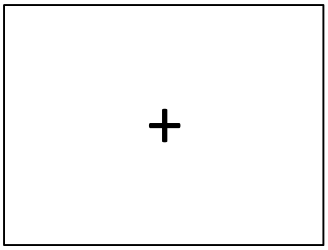
Stage 2: Antecedent



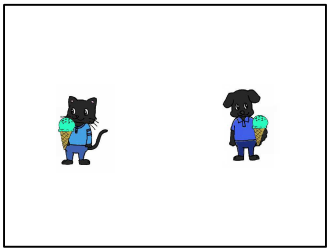
Los gatos blancos piden un pedazo de torta...
The white male cats order a piece of cake…

Figure 2 (cont'd)

Stage 3: Fixation (1s)



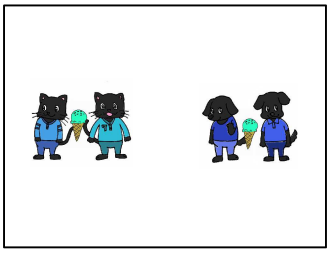
Stage 4: Ellipsis
(test condition)



y el negro pide un helado. ¿A cúal se refiere?
and the black male one orders an ice cream. Which one is being referred to?

For participants in the control condition, the stage-four ellipsis would not present any contrast in number with the plural antecedent.

Stage 4: Ellipsis
(control condition)



y los negros piden un helado. ¿A cúales se refiere?
and the black male ones order an ice cream. Which ones are being referred to?

The audio for Stage 4 was programmed to begin playing 500 ms after the images appeared. For this test item, the number feature for the ellipsis structure *el negro* 'the black (one)' is singular while the number feature for the antecedent *los gatos blancos* 'the white male cats' is plural. The fixation cross was only displayed for one second in order to minimize the time that passed between the presentation of the antecedent and the presentation of the elided noun. Crucially,

cuál ‘which’ does not inflect for gender and thus cannot act as any type of cue. Nevertheless, it would not matter given that on the ellipsis slide both animals are of the same gender. In order to identify the referent (target image) of *el negro* ‘the black (one)’, the participant was required to retrieve the identity of the antecedent, which in this case is *los gatos* ‘the cats’. Only if this was achieved would it be clear to avoid choosing the distractor image of the black male dog on the right side of the screen. The participants had four seconds after the offset of *refiere* ‘refer’ to select one of the two images. The side of the screen (left or right) of the target image was counterbalanced across trials.

To determine if participants showed sensitivity to the different types of (mis)match conditions in (20), we analyzed the eye tracking data for the gaze patterns obtained on the stage-four ellipsis slides. First, we calculated the proportion of looks to the target picture (PLT) for each condition. The PLT refers to the percentage of time that a subject spends looking at the target image, as opposed to the distractor, out of the total amount of time that both are visible. A lower PLT is usually indicative of some type of confusion that results from the violation of a grammatical constraint, which makes processing a sentence (and thus locating the target image) more difficult. Second, we calculated the correctness of the participants’ fixation at four points in the test phrase played during the stage-four ellipsis slide. In this context, a fixation is considered correct if the participant is directing her gaze towards the target image. This was taken 200 ms after the onset or offset of each word indicated below in (18) at the arrows. The delay was included to allow for the time needed by an individual to program and execute a saccade to one of the images. As with PLTs, lower fixation correctness is often indicative of the extra difficulty required for a subject to overcome a constraint violation in the grammar while processing language. Therefore, on trials with a more difficult processing load, this measurement would be

expected to increase more slowly as the sentence unfolds. The timing of onsets was determined using Praat (Boersma & Weenink 2015) and double-checked by a second individual to help ensure accuracy. The critical points marked for analysis are the onset of the determiner and the verb, and the offset of the verb phrase and the second verb *refiere* for each trial. The first three critical points were also used to create three time windows for the PLT analysis. The first window, labeled "Baseline", lasted from the beginning of the stage-four ellipsis slide until the onset of the determiner. The second window, labeled "Ellipsis", lasted from the determiner (D) to the verb (V_1). The third window, labeled "Verb Phrase" lasted from V_1 to the end of the VP (End_VP).

(18)

test phrase:		*y el negro pide un helado. ¿A cúal se refiere?*				
time:	0s	↑	↑	↑	↑	10s
critical point:		D	V_1	End_VP	End_V_2	
window:		Baseline	Ellipsis	Verb Phrase		

Considering the hypothesis, we make the following predictions about the results of the experiment:

> The participants in the Number Match and Number Mismatch groups will produce PLT and correctness of fixation measurements at similar levels. This is because changing the number feature between the antecedent and its elided noun is not expected to produce any increased processing cost given that it does not violate any constraint on ellipsis.

In all of the test items the target and distractor images in Stage 4 were never the same as the image that appears as the antecedent in Stage 2. To prevent the participants from noticing this pattern, distractor items were created that presented sentences with different animals that do not form inflectional pairs. The distractors followed the same four-stage progression as the test trials. However, in the distractor trials the audio plays a *pro* drop sentence instead of noun ellipsis. For

example, the stage two antecedent slide for the first distractor item presented a white male mouse while participants listened to *Primero, el ratón blanco pinta un pez rojo y después…* 'First, the white mouse paints a red fish and after…". This was then followed by a fixation cross and the presentation of the same white male mouse and a black female mouse. Upon seeing the two mice, the participants heard the *pro* drop sentence *pinta un sol amarillo* "(he) paints a yellow sun" before being asked to identify the referent. The result of this structure is that the target image is always the same as the animal that appeared in Stage 2. The objective behind this design was to keep the participants' attention high by creating trials in which the target image on the stage-four slide sometimes appeared in Stage 2 and sometimes did not. To see all of the test and distractor items see Appendix A.

4.1.4 *Results*

For the pointing task, the dependent measure was the percentage of correct responses. All of the participants in both the Number Control and Number Test conditions performed at ceiling on the four distractor items presented to them.

Table 1: Percentage of correct responses on distractor items

Condition	Number of participants	% Correct
Number Control	6	100 (24/24)
Number Test	15	100 (60/60)

The individuals completing this activity had no difficulty interpreting the *pro* drop sentences that were placed in between the test items. Not a single distractor trial was answered incorrectly. The participants also pointed correctly during the test items. Two incorrect answers in the Number Test condition slightly lowered this score.

Table 2: Percentage of correct responses on test items

Condition	Number of participants	% Correct
Number Control	6	100 (24/24)

Table 2 (cont'd)

Number Test	15	97 (58/60)

In the Number Control condition, all six of the participants correctly identified the target image on the ellipsis slide for all four trials. The 15 participants in the Number Test group each answered all four items. They pointed to the correct animal on 97% of the test items.

For the eye tracking data, the dependent measure was the PLT value. This was determined for three time windows in the test phrase for each condition.

Table 3: Average PLT by condition for each window

Condition	Baseline	Ellipsis	Verb Phrase
Number Control	.48	.67	.62
Number Test	.50	.61	.55

For the control condition, the average PLT for the four trials started at .48 in the baseline window, rose to .67 during the ellipsis window, and then lowered slightly to .62 during the final verb phrase window. The test condition averages are similar to those for the control items. This group has a PLT value of .50 for the baseline window, .61 for the ellipsis window, and .55 for the verb phrase window. The difference in PLT between the baseline and ellipsis windows was determined to be significant at the .05 level for Number Control ($t(62) = 3.23$, $p = .0023$) and Number Test ($t(92) = 2.44$, $p = .017$).

The individual items for the Number Control condition are presented here.

Table 4: Average PLT for Number Control Test Items

Test Sentence	Baseline	Ellipsis	Verb Phrase
Item 1	.37	.69	.65
Item 2	.52	.65	.51
Item 3	.50	.70	.64
Item 4	.54	.62	.66

The test items for the number control condition also show an increase from the baseline to the ellipsis windows. However, the difference was only significant for item 1 ($t(12) = 4.15$, $p = .0014$). One possible cause is the lower number of participants in this condition, which reduced the statistical power. Despite this, it is worth noting that there are signs of increased looks to target when moving from the baseline to the ellipsis window in the number control data.

The pattern of increasing PLT when moving from the baseline to the ellipsis window is also observed in the Number Test items with the exception of item 2.

Table 5: Average PLT for Number Test items

Test Sentence	Baseline	Ellipsis	Verb Phrase
Item 1	.42	.58	.51
Item 2	.59	.39	.50
Item 3	.55	.72	.34
Item 4	.47	.76	.70

The difference in PLT between the baseline and ellipsis windows is significant for item 1 ($t(20) = 2.71$, $p = .013$) and item 4 ($t(20) = 4.01$, $p = .0007$), and approaches significance for item 3 ($t(20) = 4.01$, $p = .073$). For reasons that are not entirely clear, the PLT from the baseline to the ellipsis window for item 2 actually decreases by a significant amount ($t(20) = 2.46$, $p = .023$). Given that this happened on only one item and the other three items pattern in the opposite direction, we assume something in the test materials might have caused the participants to behave differently on this test item in comparison with the others. Nevertheless, three out of the four Number Test items show an increase in PLT when going from the baseline to the ellipsis windows of the test phrase.

In addition to the PLT data that was measured, the fixation correctness at the four points of interest in (18) was also determined. A summary of these values across the four trials for each condition in this study is presented here.

Table 6: Averages of the fixation correctness at four points of interest in the test phrase

Condition	D	V_1	End_VP	End_V_2
Number Control	.50	.50	.64	.50
Number Test	.36	.34	.36	..41

The basic averages indicate that there were more looks at the target throughout the test phrase for the participants in the Number Control condition. However, there is no statistical analysis of these results due a methodological concern with respect to how these data were collected. A closer item-by-item analysis of the fixation correctness shows a large range of values among members of the same experimental condition.

Table 7: Averages of the fixation correctness at the four points of interest for Number Test items

Item	D	V_1	End_VP	End_V_2
1	.09	.18	.36	.36
2	.36	.45	.36	.27
3	.64	.27	.27	.45
4	.36	.45	.45	.55

Examining the column for D in Table 7 shows an accuracy range from .09 for item 1 to .64 in item 3. These large changes are observed throughout the different trials and conditions in this study. The problematic nature of these data is addressed in in the discussion of the results, and a better-developed approach for collecting and examining fixation correctness data will be proposed.

4.1.5 *Discussion*

Overall, the participants in this experiment successfully interpreted noun ellipsis in both the Number Control and Number Test conditions. The offline picture selection task showed that the participants comprehended the referent of the sentence regardless of number match or mismatch. In addition to this, both conditions showed increased looks to the target during the ellipsis window. When combined, the four trials for each condition showed a significant increase in PLT

during the ellipsis window compared to the baseline. However, it should be pointed out that when the trials were analyzed individually, the significant increases occurred only in the Number Test condition (Items 1 and 4, with 3 approaching significance). These results will be discussed further after the findings from the second experiment have also been presented.

4.2 Study 2: Eye tracking of gender mismatched ellipsis

4.2.1 *Participants*

The participants in this study were 29 adults who also came to the lab for testing. As in the first study, the participants were monolingual, native-speakers of Spanish from Santiago de Chile. This experiment divided these participants into two separate conditions for test and control items. These participants were compensated for their participation as well.

4.2.2 *Procedure*

The eye tracking procedure and picture selection task was the same as that of Study 1, but in this case the materials were modified to test for adults' use of gender features during the interpretation of noun ellipsis.

4.2.3 *Materials*

The same inflectional pairs in (15) were used to create the test items for Study 2. In this case, the test items belonged to two conditions created in order to compare gender features: Gender Control and Gender Test. These conditions were similar to the conditions used for Study 1 in that the items for the Gender Control contained an elided noun that matched with its antecedent in gender. This differed from the items in Gender Test that contained a mismatch in gender feature between the elided noun and its antecedent.

(19) a. Gender Test

La gata blanca pide un pedazo de torta y el negro pide un helado.

The.F cat.F white.F orders a piece of cake and the.M black.M orders an ice cream

'The white female cat orders a piece of cake and the black make one orders an ice cream'

b. Gender Control

La gata blanca pide un pedazo de torta y la negra pide un helado.

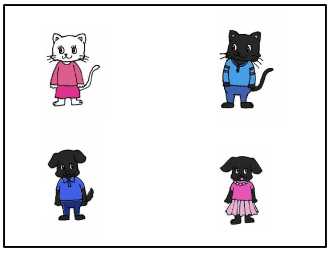
The.F cat.F white.F orders a piece of cake and the.F black.F orders an ice cream

'The white female cat orders a piece of cake and the black female one orders an ice cream'

The same native speaker of Chilean Spanish recorded the audio files and the images followed the same theme as the previous study. Crucially, during these trials the participants watched and pointed to stories that involved either a gender match or mismatch between the antecedent and the elided noun. The progression of a Gender Test trial using the same *gato/gata* 'cat.M/cat.F' pair is shown here.

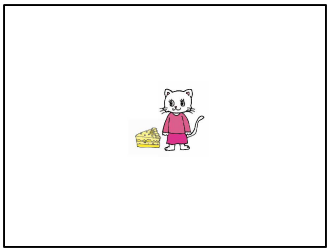
Figure 3: Image: Four-stage progression of gender test trial item.

Stage 1: Introduction



Un grupo de gatos y perros van a un restaurante a comer. Mira, los animales piden algo.
A group of cats and dogs go to a restaurant to eat. Look, the animals order something.

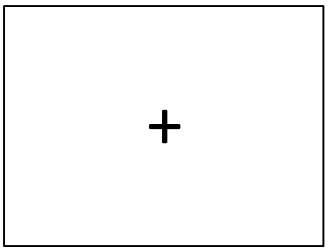
Stage 2: Antecedent



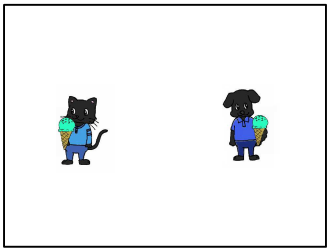
La gata blanca pide un pedazo de torta…
The white female cat orders a piece of cake…

Figure 3 (cont'd)

Stage 3: Fixation (1s)



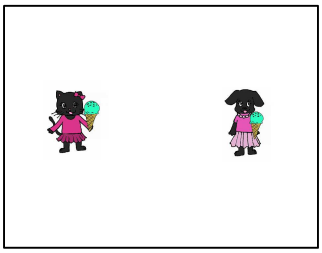
Stage 4: Ellipsis
(test condition)



y el negro pide un helado. ¿A cúal se refiere?
and the black male one orders an ice cream. Which one is being referred to?

Participants in the control condition are presented with two female animals that match the female antecedent.

Stage 4: Ellipsis
(control condition)



y la negra pide un helado. ¿A cúal se refiere?
and the black female one orders an ice cream. Which one is being referred to?

Here it becomes evident that the stage-four ellipsis test slide displays two male animals that contrast in gender with the female antecedent while the number feature is maintained as singular. Successfully identifying the target image still requires the participant to retrieve the animal on the antecedent slide. Crucially, in the case of a Gender Test sentence, the theoretical constraint requiring the gender feature on *n* to be identical for the elided noun and its antecedent is violated.

This created a critical difference with the Number Test and Number Control trials, neither of which actually violate any theoretical constraints on the licensing of nominal ellipsis.

To test the effects that alternating the gender feature on *n* has on the processing of these sentences, the PLT and fixation correctness from Study 1 for the different conditions will also be compared here. By creating sentences that have the same format as those in Study 1, we were able to use the same critical points at which to evaluate participants' fixation correctness. This also enabled the creation of the same "Baseline", "Ellipsis" and "Verb Phrase" time windows for the analysis of the PLT values. Considering these metrics and the important distinctions with the previous study, we made the following predictions about the outcomes of Study 2:

> We expect to see a difference in the PLT and fixation correctness values generated by the participants in the Gender Control and Gender Test conditions. This is because the Gender Test condition involves sentences that violate the grammatical constraints on ellipsis, which will cause lower a PLT and fewer correct fixations in comparison with the Gender Control subjects.
>
> In addition to this, we expect to observe a difference in the effect gender and number mismatches have on the time participants spend looking at the target. The PLT values for Gender Test should be lower than those for Number Test (from Experiment 1), because between these two conditions, only a Gender Test critical item violates the constraints on ellipsis in (14).

The same distractors used in Study 1 were used in this version of the experiment as well.

4.2.4 *Results*

For the pointing task, the dependent measure continues to be the percentage of correct responses. This was again at ceiling for the distractor items, which happened to be the same for both studies in this section.

Table 8: Percentage of correct responses on distractor items

Condition	Number of participants	% Correct
Gender Control	14	100 (56/56)
Gender Test	15	100 (60/60)

Like the previous study, the participants in this experiment made no errors when pointing to the referent of the *pro* drop distractors. This was largely the case on the actual test items as well. However, a few errors made by participants in the test condition slightly lower the percent correct for this group.

Table 9: Percentage of correct responses on test items

Condition	Number of participants	% Correct
Gender Control	14	100 (56/56)
Gender Test	15	97 (58/60)

In the Gender Control condition, the participants answered correctly on 100% of the trials. The 15 participants in the Gender Test condition pointed to the correct image presented on the ellipsis test slide on 97% of the trials.

The results of the eye tracking data again focus on the PLT for the three time windows marked in in the test phrase.

Table 10: Average PLT by condition for each window

Condition	Baseline	Ellipsis	Verb Phrase
Gender Control	.54	.62	.49
Gender Test	.50	.60	.60

Averaging the test items for the control condition shows that the PLT for this group increased from .54 during the baseline window to .60 during the ellipsis window before lowering

to .52 during the verb phrase window. For the Gender Test condition, the PLT began at .50 during the baseline window before maintaining itself at .60 for the ellipsis and verb phrase portions of the test phrases.

The increase in PLT from baseline to ellipsis was not significant for the control condition ($t(72) = 1.34$, $p = 0.18$), but it was significant for the test condition ($t(102) = 2.49$, $p = 0.014$). Neither condition shows a significant difference when comparing the change between the ellipsis and the verb phrase windows. One reason that may help account for the lack of significance between the baseline and ellipsis periods for the Gender Control PLT values is that the eye tracker recorded no valid input for the fourth trial in this condition. This reduced by a substantial quantity the amount of data available for analysis. As a result, the smaller number of data points makes it less likely to produce a meaningful difference between the regions outlined in Table 10, which combines the four trials into one overall value for the condition.

The results for each item in the two conditions are also available.

Table 11: Average PLT for Gender Control items

Test Sentence	Baseline	Ellipsis	Verb Phrase
Item 1	.40	.55	.60
Item 2	.60	.63	.43
Item 3	.62	.70	.44

Items 1 – 3 demonstrate the increase from baseline to ellipsis that has been noted throughout the results. For item 1, this difference is very nearly significant ($t(26) = 2.04$, $p = .051$). One interesting pattern in the results is the increase in PLT during the baseline period for items 2 and 3. These results suggest that after the first trial, the adults in this experiment had an idea of what the task was asking them to do and started to look at the target earlier than in the original trial. One characteristic of the Gender Control data is that the values appear to be less consistent and

more spread out in comparison to items from other conditions. This is also observed in the data for Gender Test.

Table 12: Average PLT for Gender Test items

Test Sentence	Baseline	Ellipsis	Verb Phrase
Item 1	.43	.68	.70
Item 2	.53	.51	.62
Item 3	.59	.62	.41
Item 4	.46	.61	.69

For the Gender Test items in table 12, the PLT values also appear to increase during the ellipsis window after the baseline period. However, it is important point out that unlike the Number Test trials, the t-test results only indicated that the difference in item 1 was significant ($t(22) = 4.06$, $p = 0.005$).

Fixation correctness data was also generated for each condition in Study 2 to examine if manipulations in the gender features in the ellipsis test phrase influenced the looking patterns at specific points in the test phrase. These involved the same points of interest as the previous study. The general averages do not show any strong patterns. Given the unreliability of this information no statistical analysis was performed on the values presented in table 13.

Table 13: Averages of the fixation correctness at four points of interest in the test phrase

Condition	D	V_1	End_VP	End_V_2
Gender Control	.27	.43	.48	.43
Gender Test	.46	.51	.51	.47

As in Study 1, the same type of large variability is observed when comparing the generalized performance of subjects by different items within the same condition.

Table 14: Averages of the fixation correctness at the four points of interest for Gender Control items

Item	D	V_1	End_VP	End_V_2
1	0	.42	.50	.50
2	.17	.42	.50	.42

Table 14 (cont'd)

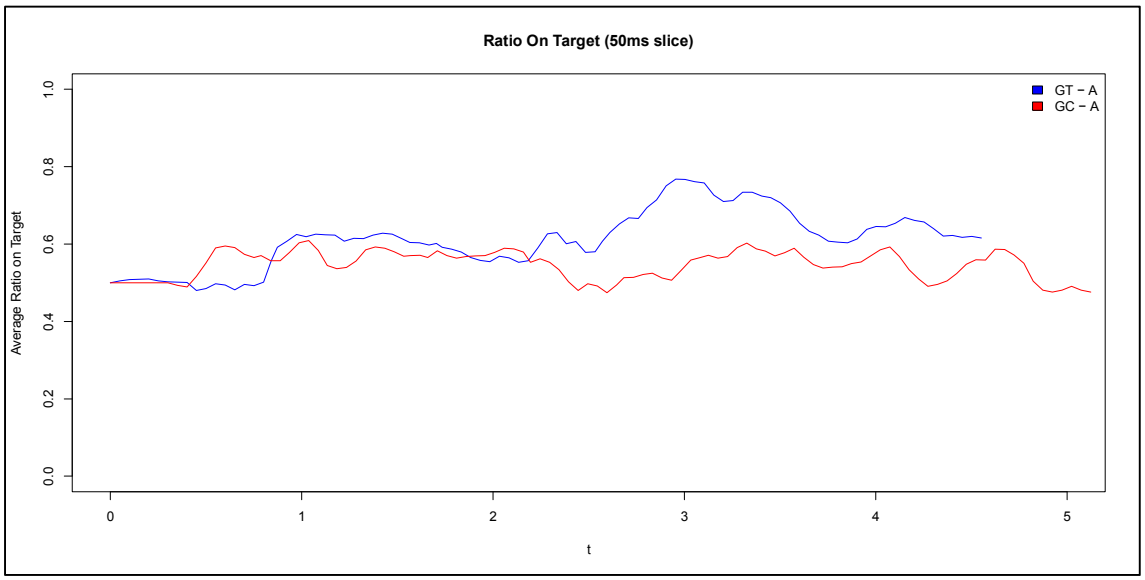
3	.64	.45	.45	.36

The .64 difference in fixation correctness data for D between items 1 and 3 in table 6 mirrors the large differences that were observed in both of the number conditions from Study 1 as well. Therefore, these results provide additional evidence that it is necessary to develop an alternative approach to analyzing the correctness of participants' fixations during the test phrase for the ellipsis stage of each item.

4.2.5 *Discussion*

Examining the PLT values does not show evidence for the expected difference in processing between the Gender Test and Gender Control conditions. There is not a very strong pattern of increased looks to target during the ellipsis window. It seems possible the reduced amount of data that resulted from failing to record information during the fourth Gender Control trial may have lowered the significance of the results for this condition. Despite this, however, it is important to note that when the time course plots for the two conditions are compared to one another there is a visible distinction between them. In figure 4, it is evident from the graph that the red line representing the PLT of the Gender Control condition increases at around 600 ms from roughly 0.5 to 0.6. This occurs roughly 500 ms before the blue line representing the Gender Test PLT value shows a similar type of increase. Crucially, this period of around 0.6 – 1.1 second corresponds generally to the ellipsis window for these trials, which began between 770 – 1100 ms.

Figure 4: Graph: Average PLT across trials for adult GT (blue line) and GC (red line) groups. t = time (seconds)



Taking all of the individual data points from each participant that were used to create the averaged lines in Figure 4, a series of t-tests were conducted to compare the values of the lines between 0.5 – 0.8 seconds. Despite the split in the graph that occurs at this point, there was still no significant difference between the conditions during this period. However, it appears that these initial results do capture a difference between these types of mismatches and the effect they have on sentence processing. The Gender Control group shows a faster increase in looks to target that does not occur until later in the Gender Test group. This may also be indicative of some type of anticipatory effect between the two groups that the data is reflecting. Considering this, one possible alternative type of analysis that may help distinguish between the two gender groups in this experiment is a multiple logistic regression developed for eye tracking by Barr (2008). This technique creates an alternative to a t-test comparison by calculating the likelihood of fixating on the target image as a function of time, which more traditional statistical approaches that rely on data aggregation are incapable of achieving.

One final point to consider is the value of creating the time course plot in addition to the PLT values for each window. As figure 1 shows, time course information is capable of showing more changes in data that may not be reflected in the overall proportion of looks to target for a window lasting 500 ms. Therefore, it becomes evident how it can be helpful to have a more fine grained way of looking at this data in order to maximize the likelihood of finding any contrasts between conditions. In some ways, it is difficult to conceive of a 500 ms period as being potentially too large. However, the rapid online reactions participants have been shown to execute during sentence processing makes it clear that when researching with this technique, it often helps to break down the data into units as small as 50 – 100 ms.

4.3 *General Discussion*

The results from the two experiments described in this chapter provide interesting information with respect to the use of number and gender features during the interpretation of noun ellipsis. First of all, in Experiment 1, we observed more significant increases between the baseline and ellipsis PLT in the Number Test condition than the Number Control condition. The fact that there is no significant increase in PLT during the ellipsis window for Number Control goes against our predictions, which expected no difference between control and test items for this grammatical feature. However, as mentioned in the results section, if more participants could be added to the experimental control group, it seems possible that the two number conditions would pattern in similar ways with respect to looking patterns for the different sections of the test phrase. After all, the general pattern is evident in both conditions, but the Number Control group needs more participants to help ascertain that this change is in fact meaningful. One reason to believe this is the case comes from comparing the two number conditions in a time course plot.

Figure 5: Graph: PLT averages for adult Number Test (blue line) and Number Control (red line) conditions. t = time (seconds)

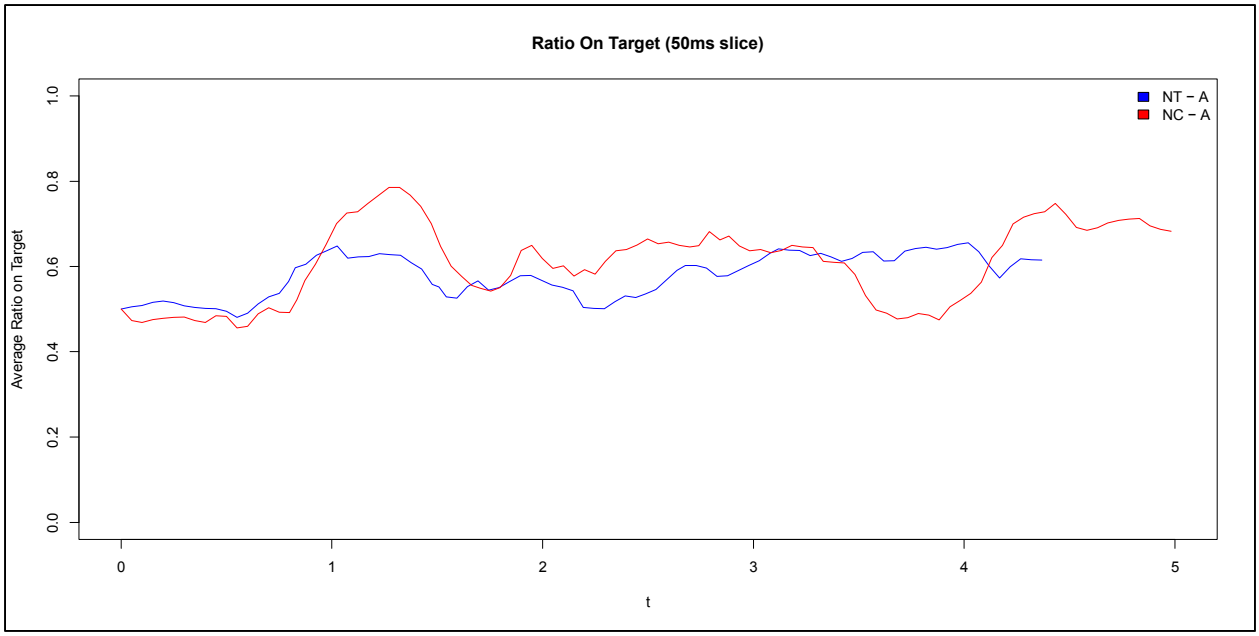


Figure 5 has plotted the looks to target as time progresses for each of the number conditions together. The blue line corresponds to Number Test while the red line represents Number Control. The figure shows that from about 1 to 3 seconds the fixations on target is actually greater for the control condition. Using the same method used to compare the Gender conditions in the previous section shows that the difference between Number Test and Number Control is in fact significant at 1.3 seconds ($t(70) = 2.02$, $p = 0.047$). Such a pattern indicates that the Number Control participants are by and large spending at least the same, if not more, time looking at the target as the Number Test participants. Because the timing is different for each condition the windows cannot be displayed. Nevertheless, these lines suggest number matches are actually being processed as well as number mismatches. For this reason, additional Number Control participants will help show that increased looks to target during the ellipsis window do show a meaningful increase from the baseline measurement. If this turns out to be the case, our

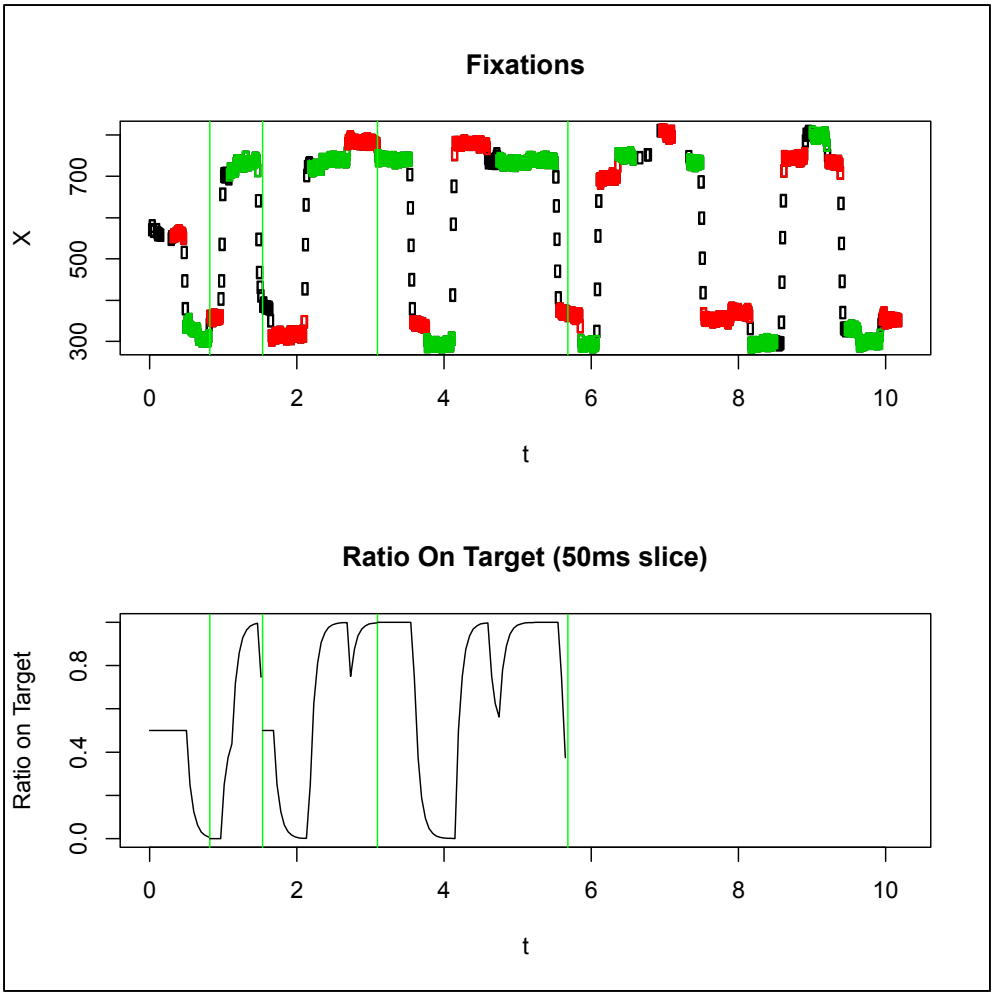
prediction that number matches and mismatches pose no processing difference still has the potential to be correct after all.

Although Number Control did not necessarily produce the results we expected when analyzing the windows, the Number Test data provides results that should be discussed. Out of the four test items that composed the materials for the Number Test portion of Experiment 1, two trials showed a significant increase in the PLT between the baseline and ellipsis windows. In a third trial, this increase was approaching significance. These results suggest that the participants in the Number Test condition were successfully interpreting the ellipsis construction to identify the correct referent(s) on the test screen despite the change in number features that existed between the antecedent and the elided noun. This is because when compared to the preceding baseline period, the proportion of time participants spent looking at the target during the ellipsis window was significantly higher.

This pattern is represented visually in figure 3 where the direction of a participant's eye gaze during the stage-four ellipsis slide is shown. The target image is on the right side of the screen, which corresponds to the top of the upper part of the fixation plot. The difference in green and red coloring simply differentiates between separate fixations. Moving from left to right, the four green vertical lines in figure 3 represent the four critical points of interest: the first green bar marks the determiner onset (D), followed by the verb onset (V_1), the end of the verb phrase (End_VP), and the offset of *refiere* 'refer' (End_V_2). See (18) for a diagram that shows where these points are within the test phrase. Recall that the point at End_V2 marks the end of the pointing prompt and does not form part of the three windows used for PLT analysis. Therefore, the space between the y-axis and the first green line represents the baseline time window. The space in between the first and second lines forms the ellipsis window, and the

space in between the second and third line marks the VP window. Using this information, the bottom plot in figure 6 shows that shortly after the onset of the determiner in the ellipsis window the participant begins moving her eyes towards the target image almost right up to the point at which the onset of the verb occurs. The increasing ratio of looks to target during the ellipsis window suggests that this individual became aware of the appropriate referent during this point in the Number Test critical item. Additionally, the fact that this pattern was significant for the Number Test condition as a whole is evidence that numerous participants displayed the same pattern of behavior.

Figure 6: Graph: Fixation patterns and ratio of looks to target for Number Test trial 1. t = time (seconds)

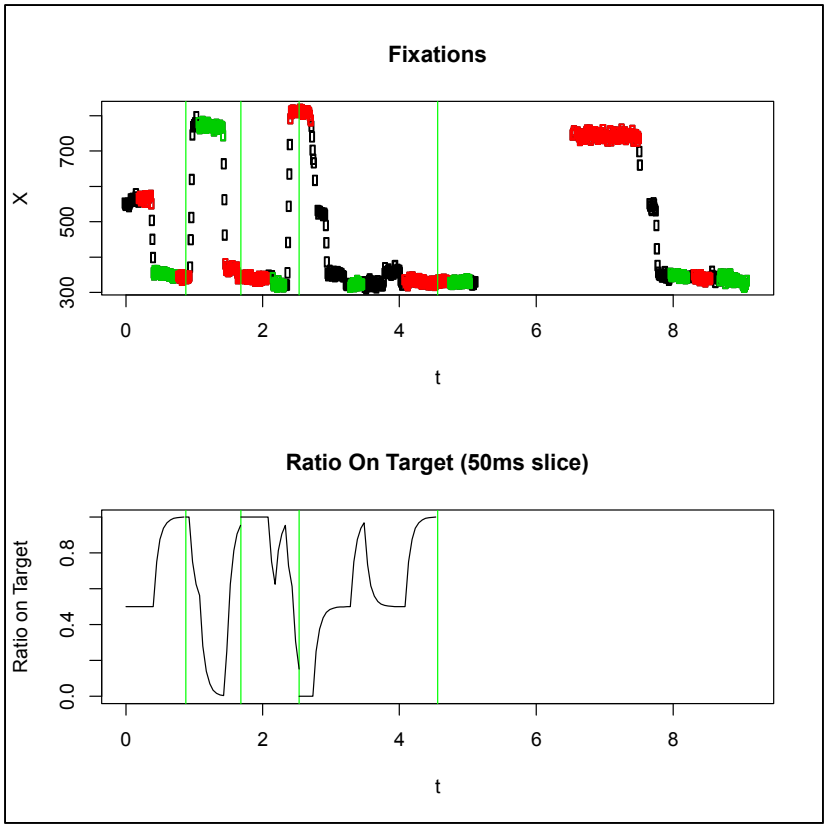


Moving on to gender, the results for this group do not appear to pattern the same way as those for number, as expected. In the Gender Control condition the results show no significant increase in the PLT between the baseline and the ellipsis window. This is not necessarily predicted by the theoretical constraints we are investigating. However, it is important to point out that the trend of increasing looks to target during the ellipsis phase of the test sentences for the control condition is beginning to emerge. Furthermore, it is unfortunately the case that due to apparent technical problems the gaze patterns for the final item in this condition were lost. Therefore, given the fact that the expected trend is generally visible in the available data, it seems reasonable to believe that with additional participants in this group, a significant result could be achieved to help support our initial findings for Gender Control, which do point in the correct general direction with respect to our expectations.

For the Gender Test group, we predicted that because mismatching the gender features on an elided noun and its antecedent violate syntactic identity constraints on ellipsis, participants would be less successful in locating the proper referent for items in this condition. The results suggest that this does in fact appear to be the case. When moving from the baseline to the ellipsis windows of the test phrase, the participants' PLT increased significantly for only one trial. This is far less when compared to the number test trial, which as stated earlier, showed a significant increase in PLT for two trials and a nearly significant increase on a third. Therefore, this contrast between the two types of test phrase mismatches shows that for the participants in these studies, those who were required to interpret gender mismatches did not locate the referent of an ellipsis with the same success as those who interpreted number mismatches. This provides support for our prediction of a contrast in looking data for Number Test and Gender Test participants.

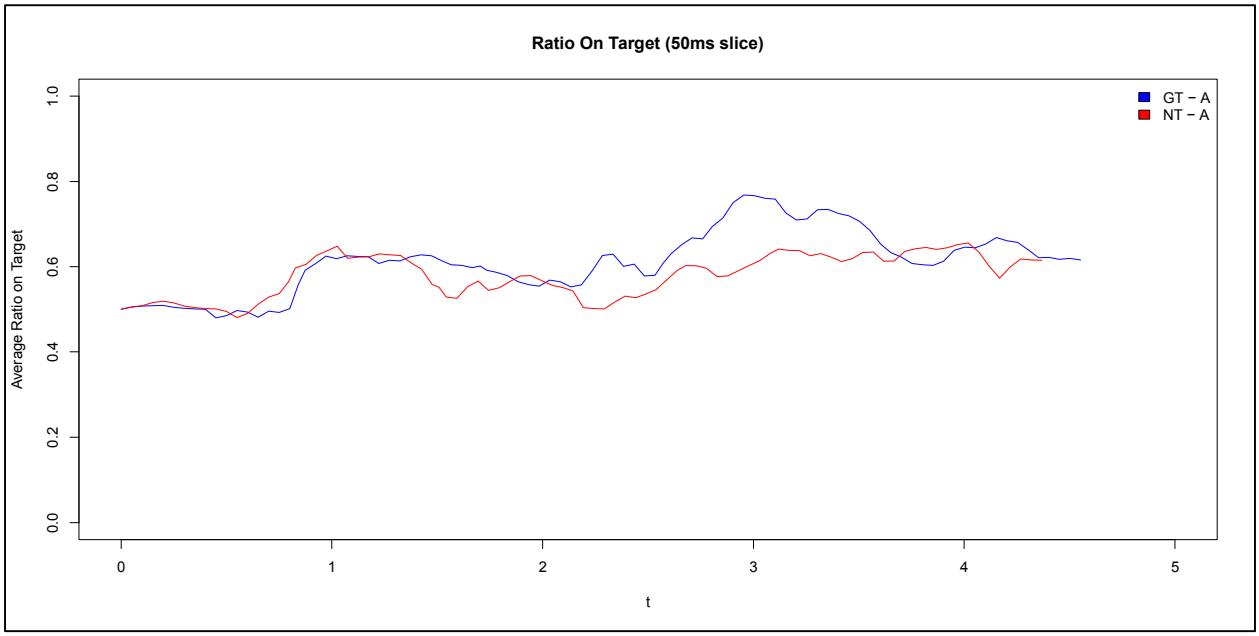
Figure 7 below shows the Ratio on Target plot and fixations for a participant on Gender Test trial 2. The target is on the left in this case, which corresponds to the bottom of the fixation plot. In this trial, the participant's PLT decreases after the onset of the determiner in the ellipsis window that occurs between the first and second green line. This downward slope indicates movement away from the target and thus a reduced amount of time looking at the correct referent. It is the opposite of what we see in the number mismatch ellipsis window in figure 6, which has a steadily increasing line throughout the ellipsis window. And although these figures show behavior of individual participants, the significance of the results taken for all the members of the different conditions indicates that finding the referent in a gender mismatch item is more difficult overall when compared to finding the referent in a number mismatch item.

Figure 7: Graph: Fixation patterns and ratio of looks to target for Gender Test trial 2. t = time (seconds)



So far, the graphs that show the contrast in PLT between the Gender Test and Number Test conditions correspond to individual participants that reflect the overall trend of the group they belong to. For a more comprehensive view, it is possible to plot the averages in the PLT across the four trials for each condition and display them in the same plot.

Figure 8: Graph: Average PLT for Number Test (red line) and Gender Test (blue line) adult groups. t = time (seconds)



In figure 8, the red line represents the PLT for all of the Number Test participants and the blue line represents the same for all of the Gender Test participants. The crucial area of interest in figure 5 occurs at approximately 600 ms (0.6 s) along the x-axis. This point corresponds to just before the ellipsis window in the test sentences. At this point it is possible to observe that the red Number Test line begins to increase before the blue Gender Test line, which shows a sharper increase later on closer to 1 second. A t-test analysis of the values used to create these lines did not show a significant difference between the conditions. Although this difference is less pronounced than the individual data already presented, the combined graph in figure 5 also

shows that the PLT for the Number Test participants combined demonstrates an earlier increase in overall looks to target during the ellipsis window in these test phrases. This serves as another indication of the more efficient processing speakers reflect in the number mismatched ellipsis compared to gender mismatched ellipsis.

Up to this point, there has been little discussion about the transition from the ellipsis window to the final verb phrase window. This is primarily because there appears to be no notable patterns in the changes of PLT when moving across this boundary in either of the experiments reported on here. At first glance, this seems to suggest that the participants who did resolve the ellipsis did so early on before moving into the last period of analysis for PLT. This should be examined with additional participants. For instance, it would be interesting to examine if children require additional time within the VP window to resolve noun ellipsis.

Lastly, it appears the initial data collected in order to examine the correctness of fixations at the four critical test points is not a very reliable indicator of how the different conditions affect the interpretation of ellipsis. Generally speaking, the values change significantly among the different trials within the same condition and do not appear to display any patterns that can help us understand how gender and number features influence the online interpretation of ellipsis structures.

One possible cause of these data's unreliability is the relative isolation of each interest point that results from where it is placed within the test phrase. In other words, choosing individual points and measuring if the participants are looking at the target is not a very useful measurement because there is no way to discern from this information if the participant was already fixating her gaze towards the target. Considering this, it is necessary to establish a reference point just prior an interest point. Under this design, by comparing where a participant's

gaze was directed just before the interest point, it will be possible to determine if she changed the gaze direction towards or away from the target image, or simply maintained the gaze direction in the same location. In some ways, this type of comparison mirrors the same kind of evaluation that occurs between the baseline and ellipsis windows when examining the difference in PLT between these two periods of the test phrase.

In an effort to produce more informative fixation correctness data for this study, I propose making changes to the way this information is collected in future work. Namely, rather than marking four individual points of interest, it will be more effective to choose a specific point with a reference point just before that in the speech stream. For example, it is proposed here to measure the fixation correctness at the onset of the adjective in the ellipsis constructions. The actual adjective onset can serve as the reference point from which to generate a baseline determination of whether or not a participant is looking towards the target when the adjective begins. This measurement can be used group together all of the participants who are looking away from the target at this point in the sentence. A second point of interest will then be marked 300 ms after this reference point. Again, 300 ms is generally considered to allow for the amount of time individuals need to program and execute a saccade (Brandt-Kobele & Höhle 2014, and references therein). Using this second point 300 ms after the baseline point will allow us to determine what portion of the participants that were looking away from the target at the baseline point have moved their fixation onto the target at the interest point 300 ms later. As a result, we will have a two-point comparison to determine if the proportion of looks to the target at the interest point is a significant value when compared to the reference point. The result will be more informative fixation correctness data capable of providing more useful information in comparison with what has been collected to date. In the diagram below, the arrow marked with R

indicates the reference point that can be used to group all of the participants who were looking away from the target at the onset of the adjective in the ellipsis structure *la blanca* 'the white (one)'. The arrow marked 'I' represents the interest point 300 ms later that can be used to compare if the location of the fixation changed with relation to R. The increased space between the letters simply allows for the representation of these points. It does not suggest an alteration in the way the word is pronounced.

(23) la b l a n c a
↑ ↑
R I

It is proposed here that the adjective should be used to consider fixation correctness because this is when the participants completing the task will be interpreting the ellipsis. It is worth noting that the other interest points should still be maintained, but this is because they serve to indicate the beginning and end of different windows for PLT analysis. The fourth critical point is also useful to investigate the direction of looks at the end of the pointing prompt.

In conclusion, although the initial results collected from the participants in Experiments 1 and 2 are not very consistent in some respects, there are some valuable patterns that can be observed in the data. This is reflected primarily in the PLT data for the ellipsis and baseline windows between the Number Test and Gender Test conditions. The greater amount of significant increases in looks to target when moving from the baseline window to the ellipsis windows for the Number Test trials indicates that changing the number features between an elided noun and its antecedent does not present an increased processing load for speakers. Conversely, the smaller amount of significant increases between the same windows for the Gender Test items provides some evidence that mismatching the gender feature between an

elided noun and its antecedent does increase the processing difficulty by lowering the amount of looking time to target.

It is also important to point out that the two conditions within each Experiment show signs of patterning in different ways. More specifically, as predicted, the two number conditions in Experiment 1 did not show much difference in looks to target during the early part of the test phrase that involves the ellipsis window. Conversely, in Experiment 2 the plot comparing Gender Test to Gender Control (figure 1) provides evidence that the participants in the control group demonstrated a faster increase in looks to the target when compared to the test group. The theory by Saab (2010) predicts this asymmetry between the test and control conditions in the two experiments because it is only gender mismatches that involve a constraint violation on noun ellipsis that would result in more difficult processing. In the Experiments 1 and 2, this would be evident in slower reaction times and fewer looks to target for Gender Test trials, which appear to be emerging in the data.

Lastly, it appears that the fixation correctness measurements at the four interest points reported here are not reliable indications of how manipulating number and gender features in ellipsis affects the interpretation of the test sentences. For these reasons, an alternative approach was developed and will be implemented in follow up work.

5. Extensions to Child Language Acquisition

The results from the adult studies presented in the previous section provide initial evidence that gender and number do seem to play different roles in establishing the identity between an elided noun and its antecedent. One question to ask at this point is if the observed contrast in sensitivity to gender and number features during the interpretation of noun ellipsis is also present in children. The studies carried out on adults in Section 3 are compatible for use with children. However, before considering any application of the experimental methodology to this population, it is important to first review the previous research that has already been conducted with respect to children's production of noun ellipsis. Additionally, because this study is investigating how number and gender information affects the interpretation of ellipsis, a review of how children process this kind of information online is presented.

5.1 *Production of Noun Ellipsis in Child Speech*

Although noun ellipsis has been studied extensively from a theoretical perspective, there is little work pertaining to the acquisition of this phenomenon in children. However, there is some research that looks at children's production of noun drop that can help guide further work on this topic. In addition to these studies, there is also an extensive body of literature that examines how children process gender, number and person agreement in a variety of languages. Some of this previous research will also be considered here in order to lay the groundwork for the current study. This section reviews child language with respect to three areas: (1) the production of noun ellipsis in 5.1, (2) the comprehension of gender features in 5.2, and (3) the comprehension of number features in 5.3.

5.1.1 *Spanish*

Snyder et al. (2001) conducted a study on the production of noun drop in two Spanish-speaking children. They set out with the goal of examining the long-standing belief that noun ellipsis is licensed by rich agreement morphology. As is well known, determiners and adjectives agree in number and gender with the number and gender of the noun in this language. In order to find evidence of a correlation between agreement morphology and noun ellipsis, the authors studied longitudinal corpora of spontaneous production by two children, María and Koki, from the ages of 1;7 to 3;0 and 1;7 to 2;11, respectively. They searched the transcripts for cases of attributive adjectives and coded whether or not they occurred in the presence an overt determiner and noun. This process continued until noun ellipsis was well attested in the children's speech. The authors also recorded whether or not the DP contained grammatical agreement morphology. By taking these steps, it became possible for the researchers to determine if María and Koki produced overt nouns despite mastery of person and number agreement. This was done because the presence of such a pattern would actually provide evidence of additional or alternative factors beyond agreement morphology that play a role in licensing noun ellipsis.

The results reached by Snyder et al. (2001) varied when comparing the individual production of the two children used in their study. By age 2;1, María demonstrated mastery of agreement morphology for person and number features. This coincided with the first appearance of noun drop in her speech, which was well attested by 2;3. However, Koki displayed a different pattern in her speech. Between the ages of 1;7 and 2;1 she produced 95 determiners, making only three number matching errors and no gender matching errors. Despite this, although attributive adjectives began appearing in her speech at 2;2, she produced seven overt D-N-A DPs before dropping her first noun at 2;6. With this interesting result, one question to ask is what could account for the delay in Koki's use of noun drop given that her production of agreement

morphology is essentially error free? To answer this, the authors suggest making a distinction between the (morphological) identification and (abstract) licensing components of noun ellipsis. They propose that these components are not necessarily acquired at the same time, as demonstrated by Koki, who is still developing the licensing component despite her robust knowledge of the morphological component necessary for identification. Whatever the exact causes of the asymmetry between María and Koki may be, the findings reported on by Snyder et al. (2001) are notable in that they provide evidence challenging the idea that morphological agreement alone is capable of accounting for ellipsis patterns in child Spanish. Without a doubt, these results raise interesting questions that can be addressed by future work.

5.1.2 *French*

In addition to Spanish, there have also been two corpus-based approaches to investigating noun ellipsis in the spontaneous production of French speaking children. Valois et al. (2009) conducted a cross-sectional study with fifteen French speaking children between the ages of 1;8 and 2;12. During data collection, the children played individually with a research assistant while their conversations were recorded. These conversations were then transcribed and each DP in the children's speech was coded according to whether they contained (i) a proper noun, (ii) a PP complement, (iii) a complex structure (defined as an NP containing at least one adjective or PP), or (iv) noun ellipsis. All of these cases were categorized according the grammatical gender of the noun and checked for the proper use of agreement on the determiner, as well as on the adjective when one was present. It is important to note that for this procedure, plural DPs could not be considered because the plural morpheme on regular French nouns is not expressed at PF. Additionally, plural determiners in this language make no distinction between feminine and masculine gender.

The results reached by Valois et al. (2009) show that French-speaking children also have near perfect use of agreement in the DP from a very early age. The participants in this study produced proper agreement for masculine and feminine singular determiners at a rate of 96.4%. This was the case for even the youngest children who were less than two years old at the time of data collection. Further evidence of proper morphological agreement was also demonstrated in that the gender features on pronouns and variable adjectives were also practically error free. Despite this pattern, the first cases of noun ellipsis first appear in the transcripts for the child participant aged 2;2. The authors explain that this is a notable result because they were able to demonstrate proper use of agreement in child speech even earlier than Snyder et al. (2001). Nevertheless, no children studied in Valois et al. (2009) drop their nouns before age 2;2. Interestingly, this is roughly the same age as the Spanish-speaking child María. Given this five-month difference between the appearance of agreement and noun drop in the child French produced for this paper, the researchers conclude that this provides additional evidence against the position that morphological agreement licenses noun ellipsis.

In an effort to build upon the cross sectional study of Valois et al. (2009), Valois and Royle (2009) carried out a similarly designed longitudinal study of another French-speaking child, Pauline. Pauline was recorded at intervals of 10-20 days between the ages of 1;2:20 and 2;6:13. For this investigation, the researchers expanded their observations of agreement to both DP internal and DP external environments. More specifically, DP external contexts require concord involving clitics, predicative adjectives, and past participles. This is contrasted with DP internal environments that require local agreement involving determiners, classifying adjectives and noun drop. By examining both DP external and DP internal contexts, a more expansive consideration of agreement in child speech becomes possible.

As was the case for the cross sectional study, each DP in the transcripts of Pauline's speech was coded for the presence of proper nouns, PP complements, complex structures, and noun drop. For each of the six cases studied (3 DP external and 3 DP internal), the authors recorded Pauline's age at which the following three criteria occurred: (i) the first observation, (ii) the production of four tokens, and (iii) 80% correct production of target structure. Valois and Royle show that when using the second and third criteria as a benchmark, the structures involving agreement appear in Pauline's speech in the following order with her age according to the third criterion in parenthesis.

Det(1;6)>Pred Adj(1;8)>Noun drop(2;0)>PPart(2;1)>Class Adj(2;2)>Clitic (2;4)

This order suggests that agreement is mastered on past participles, classifying adjectives, and clitics *after* noun drop. If morphological agreement is supposed to permit the occurrence of noun ellipsis, the ranking above becomes problematic when one observes that for certain structures, evidence of agreement does not emerge until after the appearance of dropped nouns in Pauline's production. In addition to this finding, the authors also point out that the first clear cases of noun drop appear in the data at age 1;10 with the word *autre* 'other'. The first occurrence of noun ellipsis with an adjective other than *autre* does not appear until 2;1. This falls in line that data produced by the French-speaking children from the cross sectional study as well as María from the work carried out by Snyder et al. (2001). Therefore, we have another result providing evidence against an agreement requirement for producing noun drop, which in this case comes from longitudinal data of a single child.

Although the studies on child French have produced similar findings to the study of child Spanish, the researches differ on how to account for the phenomenon under consideration. While Snyder et al. (2001) propose a syntactic based approach that differentiates between

morphological identification and abstract licensing components in the grammar, Valois et al. (2009) and Valois and Royle (2009) pursue a semantically based explanation of noun ellipsis. More specifically, they incorporate the atomization of DP developed by Bouchard (2002) into their explanation of the data. According to this approach there is no functional head for number in the syntax. Instead, he claims that for French, number features appear only on the determiners themselves. The authors claim that this creates a notion of cardinality associated with DPs that allows them to be atomized, which refers to the selection of a referent from a set of similar individuals. Applying this to the case of noun ellipsis, Bouchard (2002) follows the analysis of French noun drop by Sleeman (1996) that stipulates the presence of a classifying adjective for noun drop to occur. According to Valois and Royle (2009), a classifying adjective possesses some type of quantificational property that is capable of expressing partitivity. With this characterization, Bouchard (2002) argues that noun drop results from a double partitivity within the DP. In other words, the adjective creates a group of individuals out of all the possible referents in the discourse while the noun creates an additional subgroup. Ultimately, it is the number feature on the determiner that then allows interlocutors to select and individual from the group created by the adjective and the noun. In the case of noun ellipsis, the overt elements (determiners and adjectives) contain enough information to identify the omitted noun. This also explains why noun drop is less common in a language like English, which carries number features on the noun. Therefore, if the noun is dropped, the number features are not present and it becomes impossible to atomize the DP and select the correct referent.

Valois at el. (2009) and Valois and Royle (2009) claim that the data produced by French-speaking children provides support for this approach. These authors point out that in their data there is no case of ellipsis without a determiner and a classifying adjective. Furthermore, at least

in the cross sectional study the first cases of noun drop occur at the same age as determiners. However, this is not the case in the longitudinal study. Nevertheless, it is argued that these patterns in the result show that it is the number feature carrying determiner in the presence of a classifying adjective that creates the partitive reading of the DP, thus allowing noun drop to happen.

Regardless of the theoretical explanation pursued by Snyder at al. (2001), Valois et al. (2009) and Valois and Royle (2009), all three studies produce interesting child speech data that have lead to one unifying conclusion: mastery of agreement morphology is not the limiting factor in the production of noun ellipsis. As these researchers point out, many of the children produced noun drop concurrently to their development of agreement, rendering a cause and effect relationship difficult to discern. Furthermore, for French-speaking children noun drop actually preceded the productive use of agreement in some syntactic structures involving concord. Additionally, the Spanish-speaking child Koki did not elide nouns in her production despite having no problems with local agreement for number and gender features in the DP.

One important aspect of the research conducted to date on noun drop in child language is that it appears to focus exclusively on production. For obvious reasons, this is a crucial component for understanding what kind of linguistic competence is necessary for using the structure. However, at this point pursuing additional research on different factors that may affect how noun ellipsis is comprehended has the potential to provide important information as well. Crucially, a comprehension experiment permits the controlled manipulation of gender and number features in varying configurations that involve matching and mismatching features, which is not possible in a production analysis. To my knowledge, there have been no studies conducted that investigate how the use of gender and number information affects the way

children interpret noun ellipsis, and in what ways this may differ from adults. Therefore, conducting an eye tracking experiment that includes an additional picture selection task will allow us to observe how individuals process this structure in spoken language. Although there is very little work on ellipsis processing, there is a large amount of research that has investigated children's use and awareness of gender and number features. As a result, using this information will make it possible to consider if children and adults show any sensitivity to these features in the context of processing syntactic structures with dropped nouns. Before moving on to the experiment, a review of previous research that describes how children process gender and number features will help lay the groundwork for the present study.

5.2 *Child Comprehension of Gender*

Lew-Williams and Fernald (2007) conducted a study that looked at the use of gender information on determiners in child Spanish. They recruited 26 2-3 year-old children with at least 85% exposure to Spanish for a looking-while-listening task. During the experiment, the children were seated in front of two monitors, each displaying the images of a different noun. For some trials, the two nouns shared the same grammatical gender and for other trials the two nouns had different grammatical gender. While the participants looked at the images, they heard auditory stimuli that instructed them to find one of the two images, such as: *Encuentra la pelota. La ves?* 'Find the ball. Do you see it?'. Crucially, in each trial, the target noun was introduced by a singular definite determiner *el* or *la* 'the'. This is important because the determiner changes based on the noun's gender. More specifically, masculine singular nouns occur with the definite determiner *el* while feminine singular nouns occur with the definite determiner *la*. This means that for trials when the two nouns presented have the same gender, the determiner will not be informative of the target because it is the same for both images. Conversely, on trials in which

the two nouns have different genders, the determiner in the auditory stimulus had the potential to serve as a cue to the target noun because it only matched the gender for one of the images. Therefore, the goal of this study was to investigate if children were capable of using the gender information on the definite determiner during sentence processing as a potentially informative cue to identify a target image.

During the test phase of the study, children observed two monitors while one image was presented on each screen. There was a two second visualization period, a three second vocalization period, and a one second silence period during the trials. The researchers coded each trial with respect to whether the subject was looking left or right during the task. Overall, they measured the response time needed to fixate on the target image, which was defined as the latency of the first shift towards the correct picture 300ms after the article onset. The results showed that children responded faster on different gender trials by an average of 90ms when compared to the same gender trials. This demonstrated that 2-3 year old Spanish-speakers are capable using the gender information on definite determiners during sentence processing and that this information is used to help identify and track the referent of a sentence. This contrasts interestingly with speakers of other languages that do not use gender marked determiners and have been shown to wait until the onset of a later lexical item that occurs after the determiner to begin shifting their looks towards the target noun (Sedivy 1999).

Overall, the results obtained by Lew-Williams and Fernald (2007) demonstrate that Spanish-speaking children are aware of gender information while listening to spoken language. Although they were shown to be slower when compared to adults, they are still capable of using this information to help them differentiate between two nouns when there is a gender contrast between them. This suggests gender marking on determiners can act as an anticipatory cue to

help track referents during online sentence processing. Considering this, a natural question to ask next would be whether or not gender can also be used as a tool to help children resolve ambiguity in anaphoric contexts that require a speaker to consider a previously mentioned entity. The interpretation of noun ellipsis presents one context in which this may be possible.

Children's use of gender information on definite determiners has also been studied in other languages. Johnson (2005) investigated this using the Dutch definite determiner, which takes the form *de* for common gender nouns and *het* for neuter gender nouns. Using a Split-screen Preferential Looking Paradigm similar to the design of Lew-Williams and Fernald (2007), this author designed an experiment to see if Dutch-speaking 26-30 month old children are sensitive to gender information during sentence processing. In order to do this, participants were divided into three experimental groups that presented different images with an accompanying audio file. The first 'Correct' group presented two items of different gender while playing a sentence that instructed the participant to look at one of the images (*Kijk eens naar de bal* 'look at the.COM ball.COM'). In this case, the determiner properly matched the noun's gender, which differed from the gender of the other noun. The second 'Incorrect' group was the same as the 'Correct' group with the exception that there was a gender mismatch between the noun and the determiner in the instructions (**Kijk eens naar het bal* 'look at the.NEU ball.COM'). The final 'Uninformative' group presented two items of the same gender, rendering the prenominal determiner unhelpful as a gender cue given that it is used with both of the nouns presented to the participants. The testing sessions were taped and the eye-movements were coded offline frame by frame.

To analyze the looking patterns, the author began with the frame that occurred 240ms after the onset of the determiner. If the participant was fixating on the distractor item at this

point, the latency to shift to target was measured. For the *de* word trials, there was a significant difference for incorrect vs. correct trials and uninformative vs. incorrect trials. However, there were no significant differences between any of the groups for the *het* word trials. The author also measured the latency to shift to the distractor when the participant originally fixated on the target image at the 240ms point after the determiner's onset. In this case, there were significant differences between incorrect vs. correct groups and uninformative vs. incorrect groups for the subjects that listened to sentences with *de*. As with the previous measurement, there were no significant differences between the groups for the *het* word trials. These results suggested that the Dutch-speaking children did in fact show that they were affected by the gender information on Dutch definite determiners. Crucially, however, this was only the case for the *de* determiner that occurs with nouns expressing common gender. To explain this asymmetry in gender sensitivity, the author explains that *de* is far more frequent than *het.* Additionally, the diminutive forms of nouns with common gender occur with the *het* determiner. It is also pointed out that *het* also serves an expletive like *it* in certain environments. Considering this extra information, the results produced by Johnson (2005) provide further evidence that young children, in this case Dutch children from age 2;2-2;6, use gender information on the *de* definite determiner when processing sentences. It seems likely that this will also be the case for *het,* but at a later point given some complexities about this word in Dutch.

In another split-screen preferential looking experiment, Van Heugten and Shi (2009) investigated if French-speaking children use gender information on definite determiners. The researchers used a design similar to that of Johnson (2005) that divided 25 month-old monolingual speakers of Quebec French into three experimental conditions. The first different-gender 'Informative' condition presented the subjects with two pictures. One picture represented

a masculine noun while the other represented a feminine noun. During this time the children listened to a sentence asking them to look at one of the images (*Regarde, le ballon!* 'Look, the.M ball.M). The second condition consisted of a same-gender 'Uninformative' condition in which the two images presented on the split screen shared the same grammatical gender, rendering the definite determiner that the participants heard in the auditory stimulus unhelpful as a cue with respect to which of the two nouns would follow. Lastly, the third 'Unacceptable' condition presented to different-gender objects in conjunction with an unacceptable sentence that mismatched the gender of the determiner and the noun (*Regarde, la ballon!* 'Look, the.F ball.M'). The recorded sessions were later coded offline for which direction (left or right) the children were looking.

The researchers for this experiment examined the proportion of looks to the target image (PLT) within a time window from 500-2000ms after the article onset. The results showed that the PLT for the different-gender informative trials was .61. This was significantly higher than the PLT for the same-gender uninformative trials and the unacceptable trials, which was .45 for both groups. Therefore, this indicates that when there is a gender contrast between two nouns presented in the split-screen display, two year-old French-speaking children use the gender information on the determiner as a guide to move their gaze towards the following noun of the appropriate gender. When this cue is absent in the case of looking at two nouns with the same gender or listening to an unacceptable use of the determiner, the processing advantage is lost.

Taken together, the results of Lew-Williams and Fernald (2007), Johnson (2005), and Van Heugten and Shi (2009) all provide evidence that 2-3 year-old children in the process of acquiring a language that uses gender morphology are aware of this information during comprehension tasks. The studies discussed here demonstrated this for Spanish, Dutch and

French, in which the child participants used gender marked definite determiners to process language more efficiently when this feature provided useful information about the referent in a sentence. When considered in the context of the ellipsis production studies, these results suggest the simultaneous development of correct production and awareness of gender features. At this point, the next question to ask is if the same pattern exists with respect to number features.

5.3 *Child comprehension of number*

Various studies similar to the split screen experiments that investigated the use of gender have also been carried out for number. For example, Robertson et al. (2012) designed a task using the same set up to study how number features in the determiner are used during sentence comprehension. In this case, the authors tested 20 two year-old monolingual French-speakers for sensitivity to number mismatches between the definite determiner and the noun. The design created three trial types that were then distinguished by the plural or singular determiner that was used. French allows this because of the phonological contrast between the French singular definite determiner *le* 'the.SG' and the plural definite determiner *les* 'the.PL'. For the first trial type labeled 'match', the participants listened to a sentence instructing them to look at certain objects. Crucially, for the match condition, the definite determiner always had the same number feature (plural or singular) as the following noun. While this was happening, there was an appropriate image or pair of images presented on the screen in front of them. For example, the child listened to the sentence *Regarde, le chien* 'Look, the dog' while on one side of the split screen display a single dog appeared and on the other side a pair of cats appeared. This differed from the second 'uninformative' trial type in which the image(s) on both sides of the split screen matched the auditory stimulus. That is to say, if the participant heard the same sentence *Regarde, le chien* 'Look, the dog', in the case there would appear a single dog and a single cat, which

could both associate with the singular masculine definite determiner *le* 'the'. It is important to note that in French *chien* 'dog' and *chat* 'cat' are both masculine nouns. This was maintained in all the trial types to test only for number. Finally, in the mismatch trials the number feature on the definite determiner would not match the number feature of the target image expressed on the noun, but rather on the distractor. Therefore, in this case *Regarde, le chat* 'Look, the cat' would accompany the appearance of two cats on one side of the split screen and a single dog on the other. All of the examples here involve the singular definite determiner, but this experiment had a plural equivalent for the 'match', 'uninformative' and 'mismatch' trials.

The sessions were recorded and coded for the proportion of looks to target for each of the six trial types. The researchers divided their analysis into two windows. The determiner-processing window ranged from 300ms-564ms after the determiner onset. During this period, children showed no evidence of recognizing the noun based on the number information expressed on D, just as Dahan et al. (2000) has shown with French-speaking adults. During the noun-processing window from 630ms after the determiner onset to 400ms after the noun offset the children looked longer at the target for all trial types except for plural *les* mismatch items. Crucially, however, the children in this experiment demonstrated higher PLTs on trials when the number features on the noun matched the number features on the determiner. When this was not the case, the participants spent less time looking at the target image, which suggests that when the number features between determiner and the noun were not the same confusion ensued. Overall, this pattern in the results indicates that 24 month-old French speaking children are aware of the number features on the determiner and use this information when interpreting sentences. It is also interesting to note that these patterns mirror those of French adults, providing support for a continuity-based explanation of language acquisition.

Although the results from Robertson et al. (2012) show young learners are aware of the number features on D, there is other work that indicates additional factors may complicate how successfully children can use this information. One specific issue relevant to my study is the variable input of plural morphology that children learning Chilean Spanish receive during the course of acquisition. Generally speaking, the plural morpheme for Spanish is realized as /s/ after spell out. As noted above, for a noun with plural features, this morpheme is also expressed on determiners and adjectives, which must agree for number in the NP. However, Miller and Schmitt (2009) have shown that this is not consistent across all dialects of Spanish. More specifically, for Chilean Spanish it is very common for word final /s/ to undergo a lenition process that reduces this phoneme to aspirated /h/ or is omitted entirely in both morphological and non-morphological contexts. Therefore, this process affects the pronunciation of plural morphology.

(20) a. Las niñas dormilonas DET: la[s]/la[h]/la

the.PL girls.PL sleepy.PL NOUN: niña[s]/ niña[h]/niña

'The sleepy girls' ADJ: dormilona[s]/dormilona[h]/dormilona

(Miller & Schmitt 2009, p. 7)

By completing a free speech, naming, and repetition task the researchers were able to demonstrate that Mexican adults produced plural morphemes at a rate of 99%. However, Chilean adults produced [s] or [h] as the plural morpheme 64% of the time, while completely omitting it in the other 36% of contexts that required it. Thus, the while the input for plural morphology to Mexican children is clear and consistent, the input to Chilean children is ambiguous in that it appears in two different forms ([s] and [h]) or is sometimes left completely unpronounced. This is especially the case for working class adults who were shown to omit the

morpheme 50% of the time, which is higher than the 30% rate found in middle class adults. For definite determiners specifically, Chilean working class adults and middle class adults omitted the plural morpheme in 33% and 8% of cases respectively.

In order to test if the variable input Chilean children receive affects their interpretation of the plural morpheme, Miller and Schmitt (2009) conducted an act out task. The participants included middle class and working class Chilean and working class Mexican children between the ages of 4;5-6;4. The subjects were presented with a doll and then asked to perform various instructions about moving the dolls body parts.

(21) Tócale la rodilla/ las rodillas
touch.her the.SG knee.SG the.PL knees.PL
'Touch her knee/knees'

(Miller & Schmitt 2009, p. 20)

By using the feminine form there is a possibility to test if children perceive the word-final [s] morpheme in the plural form of the definite determiner *las,* which is not present in *la*. In Experiment 1, Chilean and Mexican children were tested on their ability to associate the plural [s] morpheme to a 'more than one' interpretation by moving both knees upon hearing *las rodillas* 'the knees' in (16), for example. In Experiment 2, Chilean working class and middle class children were tested on their ability to interpret the [h] morpheme as indicating 'more than one'. Therefore, the plural morpheme was always pronounced as [s] in Experiment 1 and [h] in Experiment 2.

The results of this study showed that the Mexican working class children associated the plural definite [s] to the 'more than one' response 71% of the time in Experiment 1. This was significantly higher than the Chilean middle class and working class participants who gave plural

responses to the commands containing [s] at a rate of 50% and 58% respectively. Such a result shows that unlike the Mexican children who receive unambiguous input linking [s] to the plural form, not all of the Chilean children interpreted this morpheme as signaling 'more than one'. Interestingly, in Experiment 2 the Chilean middle class children reached the adult like performance of the Mexican working class children when the plural morpheme was realized as [h]. It was only the working class children from Chile who consistently gave singular responses to the plural condition regardless of the morpheme. Overall, these results show that the variable input Chilean speakers receive during acquisition makes them less successful in associating the presence of a plural morpheme as an indicator that the plural form is being used. As a result, this makes the interpretation of number features in noun phrase less adult like when compared to children of the same age who receive reliable input. Given this result, it would be interesting to examine if the Chilean children struggle with number in other contexts that involve the use of interpreting number features in the noun phrase. Noun ellipsis has the potential to provide one such case.

The findings reached by Robertson et al. (2012) and Miller and Schmitt (2009) can together provide us with important information about how young children use number information. That is to say, the results from the French and Mexican Spanish-speaking children show that when the input lacks ambiguity, individuals as young as two years old are aware of this information in comprehension tasks. However, the inconsistent input that young learners of Chilean Spanish are exposed to has shown that not all children notice number cues in language. Interestingly, a similar explanation of more varied input is potentially relevant to the Dutch children's failure to make use of gender information on the *het* determiner in the study by Johnson (2005). Nevertheless, focusing on the results for number reported on here will have

important implications for any results with respect to a test on whether or not number information has an effect on the interpretation of noun ellipsis given that the experimental population is composed Chilean Spanish-speaking children.

Considering the previous research on noun ellipsis production in children and how they interpret gender and number features leads us to the following research questions for children originally presented in Chapter 2, and repeated here:

(i) Are children capable of recovering the antecedent when interpreting a noun ellipsis construction?

(ii) If so, do children show a difference in the ability to use gender and number information to find an antecedent?

(iii) Will the fact that many of the children in this study lack awareness of plural morphology cause them to perform worse on trials testing number information when compared to trials testing gender information, which they already know?

To work towards answering these questions we will replicate the previous studies testing number and gender (mis)match effects on recoverability in Spanish with children in the next Chapter.

6. Child Experiments

In this chapter, two more experiments like those in Chapter 4 are presented. This time they are run with child participants. Based on what is known about the way Chilean children have been shown to interpret plural morphology, and how Spanish-speaking children make use of gender information, we make the following hypotheses for the two experiments in this chapter:

(i) For children, given that speakers this age have been shown to be aware of gender, it is expected that they will show sensitivity (be slower) in finding a referent for gender mismatching ellipsis versus gender matching ellipsis.

(ii) Unlike adults, it is expected that children will struggle to interpret ellipsis constructions that contain the plural marker. Because this knowledge is still being acquired, the accuracy of responses and the time it takes to find the referent will be lower when compared to singular ellipsis constructions.

6.1 Study 3: Eye tracking of number mismatched ellipsis in children

6.1.1 *Participants*

The participants in this study were 19 children ages 4;0-7;0 from Santiago, Chile. They were brought to the CIAE lab at the University of Santiago by a caregiver. All of the children were monolingual, native speakers of Chilean Spanish and they were divided into two experimental groups: Number Test (12 children) and Number Control (7 children). Each child received a storybook for participating in the study.

6.1.2 *Procedure*

The procedure for this study was the same eye tracking and picture selection task that the adult participants in Study 1 (see section 3.1 for details) completed for number (mis)matched

ellipsis. The children were placed on a booster seat so their gaze could be recorded by the eye tracker and properly calibrated prior to the start of the activity.

6.1.3 *Materials*

This study used the same materials that were presented to the adults (see section 4.1.3 for examples and images). All of the critical items corresponded to the same Number Test and Number Control conditions and used animals from the same inflectional pairs. The distractors were also maintained. Because this study is essentially identical to the adult number mismatched ellipsis experiment, we also used the same windows to compare PLT values and took the fixation correctness data from the same interest points. Given that the measurements taken were the same, our predictions for the looking patterns in these children use the same metrics. In this experiment, we predict the following:

> Child participants in both the Number Test and Number Control conditions will have similar PLT values in the three windows of interest during the test phrase. This is because we expect number to be difficult for them to interpret regardless of whether or not the elided noun matches or mismatches with its antecedent.
>
> Furthermore, when compared to their adult counterparts in Experiment 1, the child PLT values should be lower given that we know many of them have difficulty interpreting number information, unlike adults. This should be no different in an ellipsis context. We also predict lower scores than adults on the offline-pointing task.

6.1.4 *Results*

The percent of correct responses was calculated as the dependent measure for the pointing task in this experiment. For the distractor items, there is a notable decrease in the performance of the children in both conditions.

Table 15: Percentage of correct responses on distractor items

Condition	Number of participants	% Correct
Number Control	4	60 (9/15)
Number Test	11	68 (30/44)

The data from one participant in the test group and three participants in the control group had to be removed for failing to carry out the pointing task properly. In both conditions, the participants were only able to identify the subject of the *pro* drop distractor on between roughly 60 and 70 percent of the items. Curiously, these averages are higher than the participants' performance on the actual test items.

Table 16: Percentage of correct responses on test items

Condition	Number of participants	% Correct
Number Control	4	45 (5/11)
Number Test	11	56 (24/43)

The participants in both conditions performed at chance. A t test against chance 0.5 for groups showed no significant difference: $t(20) = 0.21$, $p = 0.84$ for Number Control and $t(84) = 0.54$, $p = 0.59$ for Number Test. The difference between the two groups is also not significant. This suggests the children in this study had a difficult time retrieving the antecedent. A more detailed view of the results can be achieved when grouping the participants based on the number of correct responses they produced during the activity. Recall that there are a total of four test items.

Table 17: Number of participants grouped by number of correct responses

# Correct	**NC**	**NT**
3-4	0	4
2	1	4
0-1	3	3

Note. NC = Number Control, NT = Number Test

Table 17 indicates that out of the 15 children from both conditions that produced useful pointing data, only four of them in the Number Test group answered correctly more than 50% of the time.

The eye tracker recorded the PLT values of every child participant for the baseline, ellipsis, and verb phrase windows.

Table 18: Average PLT by condition for each window

Condition	Baseline	Ellipsis	Verb Phrase
Number Control	.54	.55	.43
Number Test	.49	.46	.54

For the control group, the PLT in the baseline and ellipsis window remained virtually unchanged before falling in the final verb phrase window. There is also no significant change in the looks to target when moving from one window to the next for the participants that made up the test condition. In all of the windows fixating on the target appears to be essentially at chance, regardless of the condition.

The correctness of fixations at the four points of interest was also determined for the child studies.

Table 19: Averages of the fixation correctness at four points of interest in the test phrase

Condition	D	V_1	End_VP	End_V_2
Number Control	.37	.43	.43	.71
Number Test	.24	.49	.30	.39

Generally speaking, these values tend to be higher for the participants in the control condition, with the exception of the looking patterns at the verb's onset. However, the difference at this point appears to be minimal. Looking at each individual item for the control group also shows a larger amount of variability than was observed in the previous studies with adults from section 3.

Table 20: Averages of the fixation correctness at four points of interest for Number Control items

Item	D	V_1	End_VP	End_V_2
1	.08	.42	.25	.33
2	.36	.54	.45	.54
3	0	.60	.20	.30
4	.50	.40	.30	.40

The wide range of values and the lack of any discernable pattern in the fixation data for the individual interest points that appear in this study as well raise further doubts about the reliability of this information as an indicator for how successfully participants interpreted the sentences. For these reasons, we think it would be a better approach to reanalyze the fixation correctness data for an individual point using the alternative method outlined at the end of section 4.3.

6.1.5 *Discussion*

Experiment 3 demonstrated that children have a difficulty interpreting ellipsis structures that contain plural markers. The pointing responses and the looks to target were much lower than the levels reached by the adult participants in Experiment 1. These results will be discussed in greater detail in the General Discussion in section 6.3. However, to understand better if the results from this experiment are specific to children's interpretation of the plural marker, it is necessary to compare to these data to the gender results in Experiment 4, which contains items that are all singular.

6.2 Study 4: Eye tracking of gender mismatched ellipsis in children

6.2.1 *Participants*

The participants in Study 4 were 26 monolingual Spanish-speaking children ages 4;0-7;0. A caretaker brought them to the CIAE lab in Santiago, Chile. For this experiment 15 children were placed into the Gender Test condition and 11 were placed into the Gender Control condition. These children also received a storybook for taking part in the study.

6.2.2 *Procedure*

The procedure was identical to that used for the adult gender mismatch study in section 3. See section 3.2 for details that outline the way this experiment was set up.

6.2.3 *Materials*

The same materials used for the Gender Study in section 4.2 were also used for this study involving children. The two conditions use inflectional pairs to test for how creating a match or mismatch between an elided noun and its antecedent affects the way these sentences are interpreted. Based on how the materials are created, we make the following predictions about this study:

Like adults, children are expected to show a smaller increase in the PLT value between the baseline and ellipsis windows in the Gender Test condition compared to the Gender Control Condition. We make this prediction because it has been shown that children younger than those in this study are already aware of gender and use it for the online interpretation of sentences.

On the pointing task, the children should be less accurate at identifying the referent of an ellipsis in the Gender Test condition than the Gender Control condition because the test condition actually contains the constraint violation on gender matching between an ellipsis and its antecedent.

6.2.4 *Results*

As in the previous experiment, the children in Study 4 showed a much lower ability to identify the referents during the pointing task in this experiment. The dependent measure of percent correct responses for the distractor items are first shown here.

Table 21: Percentage of correct responses on distractor items

Condition	Number of participants	% Correct
Gender Control	7	68 (19/28)
Gender Test	9	69 (25/36)

In this case, four participants in the Gender Control condition and six in the Gender Test condition had to be removed for not completing the activity properly. The overall percent correct

for each group shows the participants in both conditions answered the distractor items at essentially the same rate. The responses on the test items showed more of a contrast.

Table 22: Percentage of correct responses on test items

Condition	Number of participants	% Correct
Gender Control	7	81 (22/27)
Gender Test	9	65 (22/34)

The percentage of correct responses on the pointing task for the Gender Control participants was higher than that for the children in the Gender Test condition. A t-test comparison showed that this difference was not significant. However, if the pattern continues with more participants these data indicate that it is easier for children to find the referent of an ellipsis in a gender-matching context when compared to a gender-mismatching context.

Breaking the participants down into groups based on how many correct answers they produced gives us a more nuanced take on the patterns that exist within each condition.

Table 23: Number of participants grouped by number of correct responses

# Correct	**GC**	**GT**
3-4	6	4
2	0	4
0-1	1	1

Note. GC = Gender Control, GT = Gender Test

The results in Table 23 make the contrast between the two conditions in Experiment 4 more apparent. Six out of seven children who were given gender-matching ellipses (GC) answered correctly on at least three of the four items presented to them. Conversely, only four out of nine children in the gender mismatching (GT) condition reached this level.

The PLT values for each of the three windows in the two gender conditions from Experiment 4 do not show the same kind of contrast that is evident in the pointing results.

Table 24: Average PLT by condition for each window

Condition	Baseline	Ellipsis	Verb Phrase
Gender Control	.51	.48	.51
Gender Test	.52	.44	.51

Across items the participants in both conditions began and ended with the same PLT in the baseline and verb phrase windows. During the ellipsis window this value dropped slightly more for the test group, but the difference is minimal and not significant. In fact, the change in PLT across all of the windows is not meaningful for any of the boundaries in either group. The participants appear to be essentially at chance with respect to whether or nor they are looking at the target for the entire test phrase.

Finally, as with the other three studies, the correctness of fixation results are reported here for the children completing this gender mismatch experiment.

Table 25: Averages of the fixation correctness at four points of interest in the test phrase

Condition	D	V_1	End_VP	End_V_2
Gender Control	.34	.46	.40	.49
Gender Test	.34	.32	.47	.49

It appears that at the onset of the verb the participants in the gender control condition may have been more accurate with their looks to the target. However, it turns out that the difference at this point in the test phrase is not significant ($t(97) = 1.41$, $p = .16$). Considering this in connection with the fixation correctness data from the other three studies, it becomes clear that this group's results are much like the previous conditions that display a wide range of different values. It simply underscores the need to create a more systematic way of determining how the participants' eye gaze is affected by the previous information closer to the point of interest.

6.2.5 *Discussion*

The pointing results obtained in Experiment 4 show that children retrieved the correct antecedent more often on Gender Control items than Gender Test items, as would be expected if they were using gender to process language. Comparing the PLT in the different time windows does not show the same kind of distinction between the experimental groups. However, the general discussion will consider how the time course plot in figure 7 may in fact present evidence for a contrast in the time spent looking at the target between the two conditions.

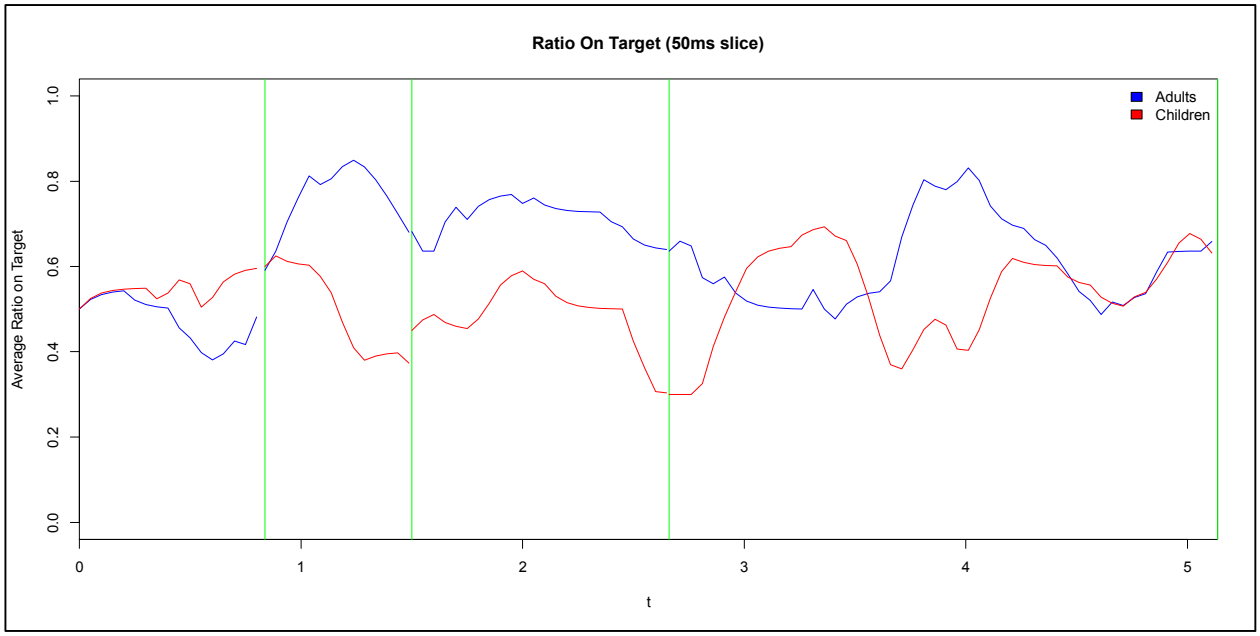
6.3 *General Discussion*

The data that has been collected can now be considered in the context of our predictions for Experiments 3 and 4. First, we expected the groups in Number Control and Number Test to show similar signs with respect to how they process noun ellipsis, and that each group would struggle to find the correct referent. For the offline-pointing task this appears to be the case. The control group only answered 45% of the test items correctly when asked to resolve an ellipsis. Compared to the test group at 56% correct, this was lower but the difference between these conditions is not significant. These numbers are much lower than the results produced for the same pointing task by the adults, who scored 100% correct on the Number Control items and 97% on the Number Test items. This contrast provides further evidence that the children have not yet acquired the ability to use the plural marker on syntactic remnants like determiners and adjectives to resolve ellipsis in the same way adults can. To provide further evidence in support of this conclusion, it would be useful to carry out the number experiments with a Spanish-speaking population that does not omit plural /s/ morphemes in the same way Chilean speakers of Spanish do.

In addition to pointing, another place where we observed the improved interpretation of ellipsis by adults in the number studies comes from the processing data. For the children in the

Number Test condition, the PLT across trials actually decreases from .49 to .46 when moving from the baseline window to the ellipsis window. However, for the adults in this condition, the PLT shows a significant increase from .50 to .61 when moving from the baseline to ellipsis periods. This pattern is also observed in the Number Control condition. The child PLT values remain flat at .54 and .55 in the first two windows, while the adults showed another significant increase in PLT from .48 to .67 during the same period. One way to observe this difference is by plotting the PLT of adults vs. children, as is shown here for trial 4 in the Number Test condition.

Figure 9: Graph: Adult and child PLT for Number Test trial 4. t = time (seconds)



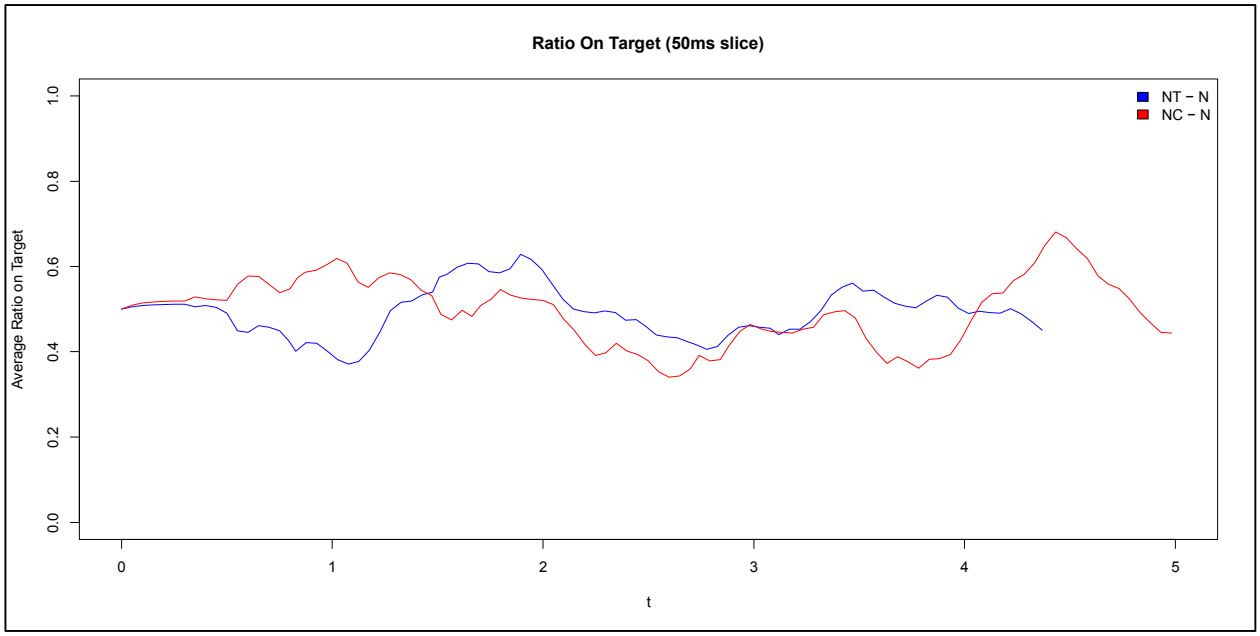
In this figure, we see the proportion of looks to target for Children (represented by the red line) and adults (represented by the blue line). During the baseline period from the y-axis to the first vertical green line, it is evident that both groups are looking more or less at the middle of the screen. However, during the ellipsis window between the first and second green line, the adult PLT increases while the Child PLT decreases. This is despite the fact that at the beginning of the window both groups are looking more at less equally at the target. Using the individual values from these two groups it was determined that at 0.9 seconds in figure 6 the difference between

the PLT for children and adults becomes significant ($t(85) = 2.56$, $p = .012$). This appears to be maintained throughout the third verb phrase window. Overall, the plot shows that adults were more successful in directing their gaze towards the referent of the ellipsis during this trial, showing they have more effective processing abilities for this type structure, as we predicted prior to Experiment 3.

One additional question that we asked before conducting the child experiments in this section is if young speakers show an online sensitivity to number information that is not reflected in the offline pointing data. In response to this question, it is our initial conclusion that there is no evidence for this. The reasoning comes primarily from the PLT data. That is to say, in none of number trials, regardless of condition, was there ever an observed increase in looks to target that was significant when moving from the baseline to the ellipsis windows. The fact that there appears to be no difference between the test and control trials seems to suggest that children are not showing sensitivity to any kind of number match or mismatch. However, this could also be due to a methodological problem in the study's design and additional research into this question should be pursued.

Despite the PLT findings that suggest against an online sensitivity to number, additional data may indicate that this is not necessarily the case. It is interesting to point out that when the PLT across trials for the different number conditions among the children are plotted against one another, there appears to be a slight difference early on in the test phrase.

Figure 10: Graph: Child Number Test (blue line) and Child Number Control (red line) PLT plotted together. t = time (seconds)



In figure 10, the PLT for the Number Test (blue line) and Number Control (red line) for the child participants are plotted together. The N in the figure legend refers to *niño* 'child'. No windows are marked because they are slightly different for the separate trials. For example, the baseline window ends between 778 ms – 837 ms on the four Number Test items and 797 – 852 ms on the four Number Control items. These differences are all roughly at the same point in the sentence and means the average lines represented in figure 7 all correspond to similar windows. Thus, comparing any trends between them is still useful. For example, it becomes apparent that at around 600 ms along the x-axis, a divergence in looks to target takes place between the two conditions. This corresponds roughly to the ellipsis window in these conditions. Such a pattern could provide evidence that the children in this study actually do show some type of reaction to different number (mis)matches while processing noun ellipsis. What is important to point out is that the difference in the values for the two lines reaches significance at the 1-second mark. When all of the data points from each individual at this point were entered into a t-test the result

suggests the distance between the two conditions is meaningful ($t(84) = 2.16$, $p = 0.033$). Considering this result, further work that looks more deeply into a processing difference that is not picked up by the pointing or window data has the potential to unveil useful information about the potential sensitivities to number information that young learners may possess, but do not demonstrate in offline tasks.

To summarize the discussion so far, our predictions for Experiment 3 investigating number (mis)matches for children appear to be supported by the data. Children in both test and control conditions performed similarly when interpreting ellipsis structures. This was shown in both offline pointing tasks and online PLT processing data. We also observed that adults are more successful at processing and interpreting the ellipsis structures in both the match and mismatch conditions. Additionally, it was concluded that an initial answer to our question regarding the online sensitivity to number is that Chilean children are not aware of this information given that they do not show any difference between the test and control conditions in pointing or processing. However, the plot in figure 7 shows a pattern that could make looking into this question more closely an interesting line of future work.

We now move on to our predictions from Experiment 4, which attempted to investigate how children interpret gender (mis)matches during nominal ellipsis in Spanish. It was our prediction that because children have been shown to be aware of gender early on in language development, they should demonstrate sensitivity to an ellipsis that does not have the same gender feature of its antecedent. The results of the offline pointing data seem to provide some support for this position. This because the children in the Gender Control condition pointed to the correct referent on 81% (22/27) of the trials compared to 65% (22/34) for the participants in the Gender Test group. Although a t-test showed this difference to be not significant, it appears

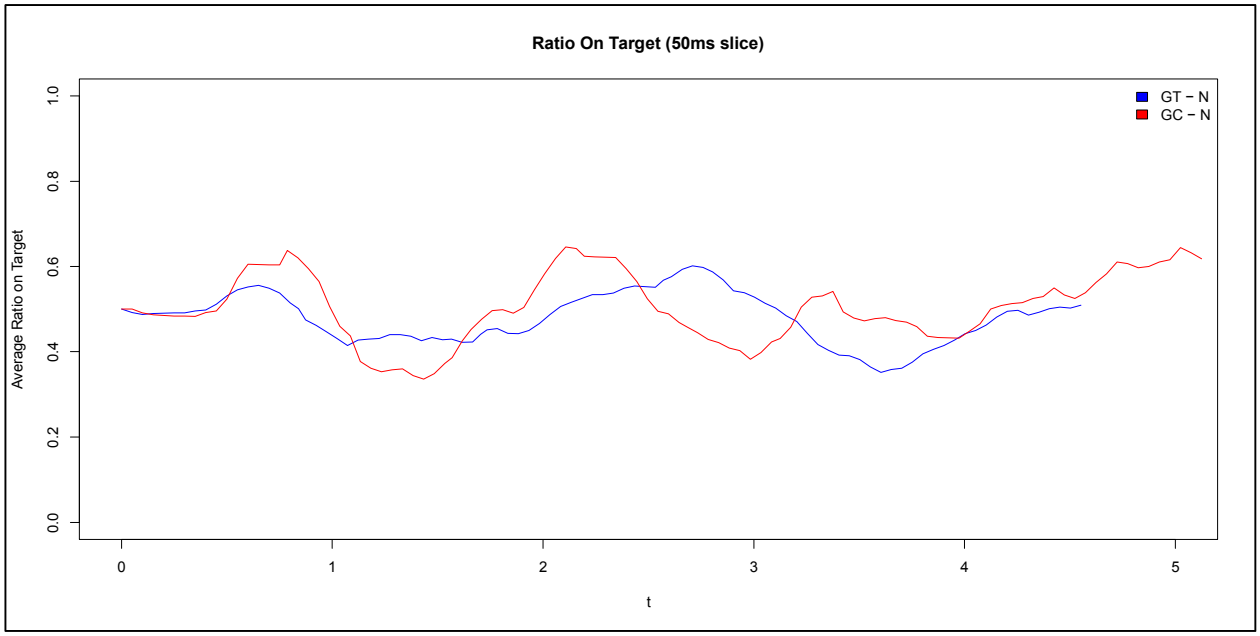
that a pattern in these data is beginning to emerge. When the participants are classified according to how many correct trials each one achieved, we see more support for this. Of the seven participants who completed the Gender Control picture selection task, six of them answered correctly on at least three of the four questions. This contrasts with the Gender Test group, for which less than half (4/9) of the participants answered at least three of the four questions correctly (see Table 23). Such a result suggests that for the children, retrieving the referent on a gender test item was more difficult compared to the control group in which all of the gender features matched. As expected from the work by Miller and Schmitt 2012, as will be discussed, we do not see this distinction between test and control sentences in the number study involving children. The lack of contrast between Number Test and Number Control suggests children are not sensitive to this feature and do not notice or comprehend it.

Although the pointing data indicate that children do demonstrate sensitivity to gender mismatches between an elided noun and its antecedent, the eye tracking data seem to be less conclusive. As shown in the results section, the PLT during the baseline period for both the control and test condition in Experiment 4 is 0.52 and 0.51. However, moving into the ellipsis windows shows that the PLT actually decreases to 0.48 and 0.44 for the control and test groups respectively. The difference between these windows is not significant, so it is unclear if there really is a reduction on looks to target during this period. What is clear, however, is that there is no significant increase for the control condition, which is what we would expect. Recall that this is also observed in the adult data. As was mentioned in the discussion of the adult experiments, one factor that may be contributing to this lack of contrast between the two conditions in the change of PLT from baseline to ellipsis is the problematic fact that during data collection no information was recorded during the fourth trial of the Gender Control task. This could

potentially be reducing the change for the Gender Control data, but only additional data collection will be able to resolve this problem definitively.

Despite the fact that PLT numbers do not show a significant increase in any of the individual Gender Control (or Test) trials in Experiment 4, the combined plot of these two conditions appears to provide some indication that a difference between these groups may still exist with respect to how the match or mismatched structures are processed.

Figure 11: Graph: Child Gender Test (blue line) and Child Gender Control (red line) PLT plotted together. t = time (seconds)



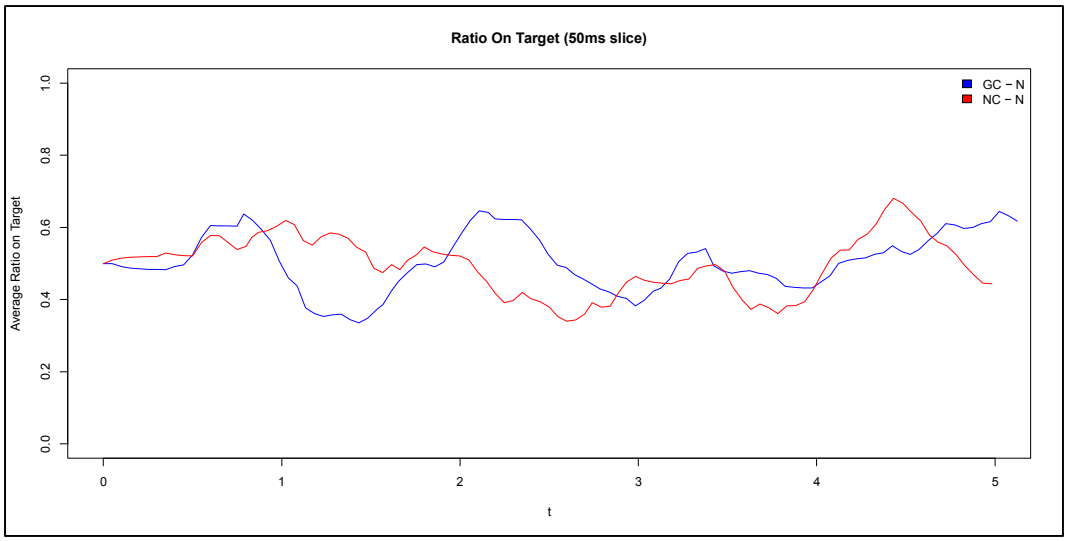
What is notable about Figure 11 is that both the Gender Test and Gender Control conditions appear to progress almost identically for the first 500 ms or so of the trial. At this point, we observe a divergence in which the red Gender Control line shows a higher increase in PLT compared to the blue Gender Test line. This split also happens to occur in what corresponds roughly to the ellipsis windows for both conditions. Therefore, the plotted data representing the progression of looks at 50 ms time intervals could be showing the slight difference in the processing of Gender Test and Gender Control that the overall PLT within the entire ellipsis

window is incapable of capturing. With the data of additional participants, the combined plot in figure 8 could provide evidence yet for sensitivity to gender mismatches in children that the other processing data is not capable of capturing. If this turns out to be the case, we would now have processing and offline results to support the idea that children do in fact notice gender mismatches in ellipsis, which increase the difficulty of interpreting this kind of sentence as reflected in lower looks to target and less accurate pointing.

Up to this point, the discussion of the Experiment 4 results has focused on the difference between the two gender conditions. However, there is also a notable contrast between Experiments 3 and 4. When comparing the difference in the pointing task score between the child participants for Number Control (45%) and Gender Control (81%), the difference between them is significant ($t(9) = 3.28$, $p = .0095$). This is interesting because although the Number Control test items always contained a match, half of the items were singular and half were plural. This differed from the Gender Control sentences, which all contained singular DPs for the antecedent and ellipsis site. Therefore, the difference between these two groups provides some additional support that the Chilean children in this study struggle with number despite the matching nature of the test sentences. In addition to this result, when the participants from the two number groups are combined only 4/15 participants answered three or more of the four test items correctly. This is much lower than the 10/16 participants who reached the same level in the gender experiment.

Plotting the results from Experiments 3 and 4 reveals some of the patterns observed in the data.

Figure 12: Graph: Average PLT across trials for child Gender Control (blue line) and Number Control (red line). t = time (seconds)



The blue line in figure 12 that corresponds to the Gender Control subjects' PLT shows a larger increase in the same 0.5 – 1 second period that marks the beginning of the ellipsis period in these trials. While there is no significant difference between the conditions in this period of the graph, comparing the Gender Control to Number Test conditions presents a more pronounced contrast.

Figure 13: Graph: Average PLT across trials for child Gender Control (blue line) and Number Test (red line). t = time (seconds)

In this case, the data points used to create the averages at 0.8 seconds in figure 10 result in a significant difference between gender and number ($t(70) = 2.08$, $p = .041$). Comparing a test and control condition is not the most ideal approach, but it does point to a lighter processing load that exists for the participants interpreting sentences in Experiment 4 for gender when compared to Experiment 3 for number.

In conclusion, the results from Experiment 4 indicate that children are sensitive to gender mismatches in ellipsis. The accuracy of the pointing data is greater for participants in the Gender Control condition than the Gender Test condition. However, the PLT values do not increase significantly between the baseline and ellipsis windows for either condition. Despite this, for the child plots that show the PLT in 50 ms increments rather than for an entire window, there does appear to be a point in the graph where the looks to target for the Gender Control group appears to increase over the Gender Test group. It also seems that this is replicated, albeit weakly, in the adult plot from Chapter 3 showing a similarity between age groups for gender, unlike number. If additional participants turn out to strengthen this effect in the data, it will provide processing evidence for sensitivity to gender mismatches after all, which is what we expected in both age groups. Additionally, when comparing the pointing task between Experiments 4 and 3 there is evidence that children had an easier time retrieving the referent of an ellipsis in the gender experiment. This is most evident in the overall pointing results, but a comparison of the PLT at certain points between certain conditions, namely Gender Control and Number Test, also points to a similar finding.

7. Conclusion

The results from this study provide information that can be used to further our understanding about the role gender and number features play in helping Spanish-speakers interpret noun ellipsis. We did find evidence for the theoretical account of ellipsis being limited by a constraint requiring gender matching between the elided noun and its antecedent that does not exist for number. This is evident in the PLT values during the baseline and ellipsis windows that were produced in the Number Test and Gender Test conditions from Experiments 1 and 2. Overall, there were more significant increases in the looks to the target during the ellipsis period on the Number Test items when compared to the Gender Test items. Such a pattern indicates that these adults looked to the target image representing the referent of the ellipsis faster and more frequently during number mismatches than gender mismatches. The observed difference between these conditions suggests that speakers use gender features to retrieve the elided noun, given that looks to the target appear to increase faster when the *n* features between an elided noun and its antecedent match. Conversely, mismatching number features in the test sentences does not seem to produce the same effect. Taken together, these findings support the notion of Saab's (2010) *n*P ellipsis domain that limits the identity requirements for noun ellipsis to the structural components of the DP below the projection for Number.

The results from Experiments 3 and 4 show that children were less successful than adults at retrieving the referent of the ellipses they were presented with. However, although the number of correct responses was lower for the young participants, the children in Experiment 4 testing gender-mismatched ellipsis produced results that show similarities to adults from Experiment 2. More specifically, it appears that regardless of age speakers demonstrate sensitivity to mismatches in gender between an ellipsis site and its antecedent when processing language. This

is most evident in the difference of correct responses on the pointing task for the children, which showed a higher number of correct responses produced by members of the gender control group. This result in the offline task in the young participants falls in line with the faster increase in looks to target from the adult online data in the matching control condition. Interestingly, the source of this information comes from different measurements for each group: the offline task for children and the online gaze data for the adults. Nevertheless, that both groups appear to have a better time with gender matching sentences over gender mismatching sentences is an important pattern in their responses to the experimental stimuli.

The adult pattern that is beginning to emerge in the child participants for gender (mis)matches in ellipsis resolution does not carry over to the results from the number experiment. Children performed essentially at chance for both test and control items in Experiment 3, which is far below the near perfect levels for adults. Furthermore, unlike Experiment 4, there is no indication of a notable difference between the two conditions on the pointing task. This indicates the difficulty Chilean children appear to have when they are required to use plural markers to interpret a sentence containing noun ellipsis. The result makes sense when considered in the context of work by Miller and Schmitt (2012) that showed Chilean children acquire knowledge of plural morphology later in their development due to the variable input they receive. For example, consider a test item that asks children to identify *las blancas* 'the white female ones'. If the children do not understand, or are unaware of, the *–s* attached to the determiner and adjective, being presented with two pairs of animals and no singular option would be challenging and lower the number of correct answers. This is especially the case if the task is difficult to begin with, as the low rate of correct answers on the gender test confirm. Therefore, the low percentage of correct responses on both number conditions and the large

difference between the adults and children in number Experiments 1 and 3 suggest that the Chilean children in this study are still learning the plural marker, which added to the difficulty of interpreting noun ellipsis.

Finally, unlike some of the adult trials, the PLT values for different window periods in the test phrase proved to be less informative for the children. The values for these periods are likely to be another indication of the difficulty they experienced while completing the task. Nevertheless, the time course plots show some differences between various groups. This is the case for the faster increase in PLT for Gender Control compared to Gender Test (see figure 8). The plotting data also shows a distinction between Number Test and Number Control that becomes significant. These contrasts between the plots reveal the value of having a representation of the data taken at 50 ms intervals as opposed to analyzing an entire window. This is because presenting the plots with smaller time increments has the potential to reveal more subtle differences that are lost in the overall PLT for a longer period. For these reasons, a more effective way of analyzing the data from all of the experiments in this study may be to use the multiple logistic regression model developed by Barr (2008). As discussed in Chapter 3, this approach estimates the probability of looking at the target as a function of time. This could prove to be an advantageous method because it does not necessarily require the aggregation of data for t-tests or other statistical analyses that were not originally developed for eye tracking data, which inherently includes a time component that traditional tests do not take into account. In a future analysis of the data collected for this study, it would be interesting to see if a linear regression is capable of finding significant differences in the looking patterns of the participants that are not indicated by the t-tests.

Overall, the results from this thesis provide evidence in support of a theoretical constraint on noun ellipsis that requires gender matching but not number matching between the ellipsis and its antecedent. That such a constraint appears to be supported in the processing and offline-pointing tasks reported on here in turn supports the structural representation of the Spanish DP involving an *n*P with an intermediate projection for number. This structure, together with the constraints proposed by Saab (2010), have allowed us to show the different effects gender and number play in an individuals' ability to retrieve an antecedent during ellipsis resolution. If the results presented in the current study can be replicated with more significant effects, we may find ourselves in a position to better understand what types of grammatical features play a role in the cognitive process of retrieving the antecedent of an ellipsis. Given that ellipsis structures occur across a variety of languages and syntactic environments, knowing what kind of grammatical components contribute to helping speakers properly use anaphoric structures like this has the potential to move our understanding of language processing forward. Considering this, research that investigates offline and online measurements involving the interpretation of ellipsis structures creates an interesting area of research that brings together the theoretical and cognitive elements of the way language is represented and used in the human mind.

APPENDIX

Items by Experimental Condition

I. Gender

(1)
Hoy el día está muy lindo y estos animales van al parque para jugar con los otros perros, perras, gatos y gatas. Para entretenerse llevan juguetes. Mira lo que llevan.
Today it's very nice out and these animals go to the park to play with other dogs and cats. To have fun, they take toys. Look what they take.

El perro negro lleva un volantín
The black male dog takes a kite

y la blanca lleva una pelota de fútbol. ¿A cuál se refiere? test
and the white (female one) takes a soccer ball. Which one?

y el blanco lleva una pelota de fútbol. ¿A cuál se refiere? control
and the white (male one) takes a soccer ball. Which one?

(2)
Luego un grupo de gatos y perros van a un restaurante a comer. Mira, los animales piden algo.
Later a group of cats and dogs go to a restaurant to eat. Look, the animals order something.

La gata blanca pide un pedazo de torta
The white female cat orders a piece of cake

y el negro pide un helado. ¿A cuál se refiere? test
and the black (male one) orders and ice cream. Which one?

y la negra come un helado. ¿A cuál se refiere? control
and the black (female one) orders and ice cream. Which one?

(3)
Hoy es el cumpleaños de la mona blanca y sus amigos le van a traer regalos. Mira lo que traen.
Today is the black female monkey's birthday and her friends are going to bring her gifts. Look what they bring.

El conejo negro trae un peluche
The black male rabbit brings a teddy bear

y la blanca trae un robot. ¿A cuál se refiere? test
and the white (female one) brings a robot. Which one?

y el blanco trae un robot. ¿A cuál se refiere? control
and the white (male one) brings a robot. Which one?

(4)
Algunos monos y conejos van al cine. Como tienen hambre van a comprar cosas para comer durante la película. Mira lo que compran.
Some monkey and rabbits go the cinema. As they are hungry they are going to buy things to eat during the film. Look what they buy.

La mona blanca compra palomitas
The white female monkey buys popcorn

y el negro compra chocolate. ¿A cuál se refiere? test
and the black (male one) buys chocolate. Which one?

y la negra compra chocolate. ¿A cuál se refiere? control
and the black (female one) buys chocolate. Which one?

II. Number

(1)
Hoy el día está muy lindo y las gatas y las perras van al parque a jugar. Para entretenerse, llevan juguetes. Mira lo que llevan.
Today is very beautiful and the female cats and dogs go to the park to play. To have fun they take toys. Look what they take.

Las perras negras llevan un volantín
The black female dogs take a kite

y la blanca lleva una pelota de fútbol. ¿A cuál se refiere? test
and the white (female one) takes a soccer ball. Which one?

y las blancas llevan una pelota de fútbol. ¿A cuáles se refiere? control
and the white (female ones) take a soccer ball. Which one?

(2)
Los gatos y los perros van a un restaurante. Piden algo para comer. Mira lo que piden.
The male cats and dogs go to a restaurant. They order something to eat. Look what they order.

Los gatos blancos piden un pedazo de torta
The white male cats order a piece of cake

y el negro pide un helado. ¿A cuál se refiere? test
and the back (male one) orders an ice cream. Which one?

los negros piden un helado. ¿A cuáles se refiere? control
the black (male ones) order an ice cream. Which one?

(3)
Los monos y los conejos van a una fiesta de cumpleaños y todos traen un regalo. Mira lo que traen.
The male monkeys and the male rabbits go to a birthday party and everyone takes a toy. Look what they take.

Los conejos negros traen un peluche
The black male rabbits take a stuffed animal

y el blanco trae un robot. ¿A cuál se refiere? test
and the white (male one) brings a robot. Which one?

y los blancos traen un robot. ¿A cuáles se refiere? control
and the white (male ones) take a robot. Which one?

(4)
Las monas y las conejas van al cine y compran cosas para comer durante la película. Mira lo que compran.
The female monkeys and the female rabbits go to the cinema and they buy things to eat during the film. Look what they buy,

La mona blanca compra palomitas
The white female monkey buys popcorn

y las negras compran chocolate. ¿A cuáles se refiere? test
and the black (female ones) buy chocolate

y la negra compra chocolate. ¿A cuál se refiere? control
and the black (female one) buys chocolate. Which one?

III. Distractors

(1)
En la clase de arte los ratones y las ranas se sientan juntos en la misma mesa. Están pensando en lo que quieren pintar.
In art class the mice and the frogs sit together at the same table. They're thinking about what they want to draw.

Primero el ratón blanco pinta un pez rojo y después
First, the white mouse draws and red fish and later

pinta un sol amarillo. ¿A cuál se refiere?
(he) draws a yellow sun. Which one?

(2)
Después de la clase de arte los ratones y las ranas salen a recreo. Hay muchas actividades para divirtirse.
After art class the mice and the frogs go out for recess. There are many activities to do for fun.

Normalmente la rana blanca juega al luche y a veces
Normally, the white frog plays hopscotch and sometimes

juega al básquetbol. ¿A cuál se refiere?
(she) plays basketball. Which one?

(3)
Los osos y las ardillas pasan mucho tiempo juntos. Durante el verano una de sus actividades favoritas es hacer excursiones. Lo que más les gusta es buscar plantas e insectos.
The bears and the squirrels spend a lot of time together. During the summer one of their favorite activities is hiking. They like more than anything to look for plants and insects.

La ardilla blanca siempre elige flores rojas y de vez en cuando
The white squirrel always picks red flowers y once in a while

atrapa a una mariposa azul. ¿A cuál se refiere?
(she) catches a blue butterfly. Which one?

(4)
Otro sitio donde los osos y las ardillas pasan mucho tiempo juntos es el parque. Ahí también pueden hacer muchas actividades divertidas.
Another place where the bears and squirrels spend a lot of time together is the park. They can do a lot of fun activities there as well.

Normalmente el oso blanco sube al columpio y muchas veces
Normally the white bear goes on the swing and many times

sube el árbol. ¿A cuál se refiere?
he climbs a tree. Which one?

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