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FILLED-GAP EFFECTS IN SENTENCE PROCESSING: DIFFERENT ACCOUNTS COMPARED

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1. Introduction¹

It is widely accepted that the human sentence parsing mechanism is subject to real-time constraints that demand some decisions to be made on-line. One of the areas of research in sentence processing has been to look at how long-distance dependencies where there is a relation between a fronted phrase ('filler') and its canonical position ('gap') are constructed on-line. These dependencies where there is an element that has been displaced are interesting to examine because they provide relevant cues for how sentence interpretation proceeds when the information that can be used to interpret the sentence is not immediately available. Research on the processing of long-distance dependencies has focused on different questions. One of the questions was directed to examine the specific point in time and the position in the sentence at which the parser posits gaps while processing long-distance dependencies. The other was to examine how the fronted phrase is interpreted and if the verb is necessary to interpret the dislocated phrase.

This paper focuses on the different approaches that have been suggested to explain how long-distance dependencies are processed and how the fronted phrase gets interpreted. The objective is to look at whether the verb is completely necessary when trying to interpret information on-line. Bearing this in mind, I examine how the different processing theories account for the results of an experiment on clitic pronouns in Spanish. I compare parsing theories that presuppose the existence of gaps, parsing theories that presuppose a direct semantic association and HPSG theories against the Spanish data and conclude that there is pre-verbal information such as clitic pronouns that can be used to interpret displaced elements in sentence processing.

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2. Classic paradigms and questions in the processing of long-distance dependencies

2.1. The position to look for a gap

The first attempts to look at the time-course of processing long-distance wh-dependencies were conducted in the 1970's. It was generally agreed that in long-distance dependencies, the parser searched for a gap in order to interpret the displaced phrase and relate the displaced phrase to its argument assigner. However, it had to be determined at which specific point in the processing of the sentence this gap was posited. The proposals that were put forward differed in whether they considered the search for a gap to be a first-resort or a last-resort strategy in the parser. The gap as first-resort strategy predicted that the parser does not wait for confirming evidence to posit a gap position in the sentence. It predicted that gaps are posited at grammatically possible positions. The prediction of a gap was based on the encountered input. The gap-as-last resort strategy, on the other hand, presupposed that the parser waits for clear evidence that an argument slot is empty to posit a gap. In this strategy the parser does not posit a gap until it finds clear confirmation, therefore this option does not allow for the prediction of gaps.

As discussed in Fodor (1978), neither of these two perspectives seems to directly reflect what the processor does in its "gap-finding routine". The last-resort hypothesis only postulates a gap when all other structural hypotheses about that part of the sentence have been tried and failed. This implies that some of the temporary ambiguities about gap location could not be detected if this strategy was used.

The gap as first-resort hypothesis proposed that the parser would hypothesize a gap at every possible point in the sentence without first looking at which word comes next, which means it will not have look-ahead. It seems implausible that the parser would follow this strategy if the gap-hypothesis could be immediately proved wrong just by looking at the upcoming word. This will not correspond with an efficient parser.

The gap as first-resort strategy had many variants considering whether the gap would be posited based on the lexical expectations created by the verb or the strictness in the application of grammatical constraints on parsing. The variant that received most attention within the first-resort strategy was the Active Filler Hypothesis.

Following work done by Frazier and others, Clifton & Frazier (1989) and Frazier & Clifton (1989) proposed a version of the gap as the first-resort hypothesis named the Active Filler Hypothesis (henceforth AFH) which they explicitly stated as follows.

Active Filler Hypothesis: (Clifton & Frazier 1989)

When a filler of category XP has been identified in a non-argument position, such as COMP, rank the option of assigning its corresponding gap to the sentence over the option of identifying a lexical phrase of category XP.

The AFH considered that readers actively construct dependencies on-line and do not wait to see them confirmed at the gap position. AFH emphasizes active gap crea-

tion once the parser has processed a displaced *wh*-phrase. AFH assumes that, given the option of positing a gap or waiting to see whether a lexical NP complement could appear, the parser will prefer to posit a gap as a first choice. Hence, this gap-finding strategy predicts that if there is a lexical NP filling the first position where the gap is posited, there should be some processing difficulty associated with the fact that the parser expected an empty position.

This effect had been previously demonstrated in experiments with long distance dependencies involving *wh*-phrases. The discussion of these experiments is developed in the next section.

2.2. The time-course of dependency formation

The first attempts to show that the parser posits a gap at the first available position after processing a *wh*-phrase were conducted by Crain & Fodor (1985) and by Stowe (1986).

Crain & Fodor (1985) showed in a self-paced reading experiment that processing an object noun phrase in a *wh*-question was more difficult than processing the same object noun in a declarative sentence. They showed that the reading times at the *wh*-question sentence in (1a) for the noun phrase occupying the potential gap position (*us*), were longer than the reading times for the same noun phrase in its declarative counterpart (1b), where no gap is predicted. This effect was specifically named “Filled-gap Effect” since the longer reading time at the pronoun “*us*” in the extraction case in (1a) is due to having a noun phrase that occupies the position predicted for the gap.

- (1) a. Who had the little girl expected **us** to sing those stupid French songs for ___ at Christmas?
- b. The little girl had expected us to sing those stupid French songs for Cheryl at Christmas.

Stowe (1986) subsequently showed that the same ‘Filled-gap Effect’ could be found at a pronoun. She showed how this Filled-gap Effect can be found when there is an embedded *wh*-question, as in (2a), and the processing of the pronoun occupying the potential gap position is compared with the same pronoun in a condition with no extraction in the embedded sentence, as in (2b).

- (2) a. My brother wanted to know who Ruth will bring **us** home to ___ at Christmas.
- b. My brother wanted to know if Ruth will bring us home to Mom at Christmas.

Both studies (Crain & Fodor (1985), Stowe (1986)) argued that the slowdown at the noun phrase “*us*” in (1a) and (2a) reflects the expectation that the parser has for a gap which has been triggered by the filler. In sum, these studies showed that the parser constructs object gap sites as soon as it encounters an appropriate verb, and that it does not wait for confirming evidence to find the location of this gap.

2.3. The parts of the dependency

The results of the filled-gap experiments discussed in section 2.1.2, led to a series of studies directed to investigate whether the slowdown in reading time found in the experiments could be taken to be a diagnosis for a gap, or whether this effect could be explained without appealing to the existence of empty categories.

The studies presented henceforth differ in their approaches to explain the active construction of filler-gap dependencies. Depending on the theoretical premises of the studies, the foot of the dependency will be considered to be a different element. In the first studies, the premises are those of GB-framework where the foot of the chain consists of a trace that is the residue of the movement that the filler (e.g. a *wh*-phrase, a fronted phrase) has undergone. Secondly, the studies that argue in favor of theories such as Head-Driven Phrase Structure Grammar (HPSG) and Generalized Phrase Structure Grammar (GPSG) do not contemplate that there is movement in any dependency. The studies under this framework propose that the foot of the chain is the verb and that what links the verb with the fronted phrase is a SLASH feature that propagates the information of the unbounded dependency along the tree up to the filler. And finally, the direct association, studies suggest that the foot of the chain is the verb, where the filler is interpreted via a semantic association with it. This last set of studies relies on Categorical Grammar (CG) or Combinatory Categorical Grammar (Steedman 1996, 2000), a grammar that counts on the lexicon to explain the combining properties of words and that abandons transformations entirely.²

Briefly speaking, the way in which the last two approaches differ from each other is in how the verb (which is the foot of the chain for both) is linked to the filler. In HPSG this is undertaken by a SLASH feature, whereas in direct association is undertaken by a semantic link with the subcategorizer.

2.3.1. *Gap-based approaches*

A first round of experiments tried to support the existence of traces in sentence processing by showing reactivation of antecedents at potential gap positions, where fast recognition times of a probe word or priming effects, were taken to indicate that the parser was positing a gap at a particular position in the sentence (Bever & McElree 1988, MacDonald 1989, Nicol & Swinney 1989, Bever & Sanz 1997).

In a couple of experiments, Bever & McElree (1988) used a priming technique to test whether gaps access their antecedents in single sentences. Their task involved looking for faster probe recognition times for probe words that were part of a fronted phrase, where the probe words were the adjectives contained within the antecedent for the gap. These probe adjectives were presented once the subjects have processed the whole sentence. The task of participants was to respond whether the probe word had appeared in the immediately preceding text.

² All constructions are treated as equally basic in this grammar and there is no need to assume that one of the forms is derived from the other. Therefore unbounded constructions are treated in the same fashion as other constructions.

Bever & McElree's (1988) first experiment involved the replication of reactivation for the antecedents of pronouns. Their results showed that the time to decide that the probe word (an adjective) displayed at the end of the task was present in the sentence was faster where there was a co-referential pronoun in the sentence. They interpret these results as showing that the pronoun accesses a representation of its antecedent phrase, where this access refreshes the salience of the noun phrase containing the adjective and makes its recognition faster.

In experiment 2, Bever & McElree (1988) were interested in examining whether the distinctions made by theoretical linguistic descriptions between different kinds of gaps (e.g. NP-raising, tough-movement, NP-trace in passive constructions, PRO) could be shown behaviorally. This experiment tested the contrast between movement traces and PRO to determine if gaps also access their antecedents with the same recognition effects as pronouns and to examine if different kind of traces behaved similarly or differed in their recognition speed. Results showed that probe adjective recognition was faster for sentences containing movement traces or gaps. In the case of PRO the effect was less strong. Nevertheless, Bever & McElree (1988) took this facilitation to indicate that gaps other than those generated by *wh*-phrase movement access their antecedent during comprehension.

In a study with a similar spirit, Nicol & Swinney (1989) focused on the specifics of differences in antecedent reactivation in processing English sentences with overt pronouns, anaphors, movement traces and PRO to test whether reactivation effects are restricted by grammatical constraints. Results of their cross-modal priming studies showed that both *wh*-traces and overt anaphors immediately trigger reactivation of their referent, whereas pronouns and PRO, on the other hand, cause reactivation of multiple referents.³ Thus, results suggest that in sentences where there is more than one referent that might be co-indexed with the pronoun or PRO, there is multiple activation of referents. Finally, the NP-traces in passive sentences showed less clear reactivation effects.

In a probe recognition task that also looked at antecedent reactivation effects at gap positions, MacDonald (1989) examined the processing of English adjectival passive sentences, where no gap is implied in their representation, with verbal passives, which are represented with empty categories within GB theory. McDonald (1989) included an adjectival condition as in (3a) as a baseline for the comparison between adjectival and verbal passives. This condition was included to test that none of the adjectival or adjectival passive sentences in (3a,b) should reflect faster probe responses at sentence final position when the probe antecedent is presented. This is expected if it is the case that the adjectival passives do not have a gap in their syntactic representations. In contrast, words in verbal passive constructions such as (3c) that correspond to the antecedent of a gap should show faster probe recognition times, since the syntactic representation of verbal passives includes a gap. Results of the probe recognition task showed faster responses to the antecedent probe in verbal passives in (3c) than to the probe in adjectival passives in (3b) or in pure adjectivals in (3a).

³ In pronouns cases, the subject of the clause where it appears is not reactivated and in PRO cases, both potential antecedents are reactivated.

- (3) a. The new mayor at the centre podium was furious. (adjectival)
- b. The new mayor at the centre podium was surprised. (adjectival passive)
- c. The new mayor at the centre podium was shot __. (verbal passive)

McDonald's (1989) results supported the linguistic implications for the existence of gaps in verbal passives but not in adjectival passives

After the previous studies using English as the test language, the study by Bever & Sanz (1997) explored the use of traces in sentence processing with a probe recognition experiment that focused on the processing of unaccusative and unergative predicates in Spanish. The probe words in the experiment were the adjectives that modified the head of the subject (e.g. *apuesto/severo*). The sentences Bever & Sanz (1997) used in the study had an additional manipulation that differed in whether the subject was pre-verbal as in (4a) or post-verbal as in (4b). This manipulation was included to test if the trace in unaccusative verbs facilitates the recognition of its antecedent. This recognition facilitation should only show in constructions with unaccusative verbs where the subject is pre-verbal (e.g. *habló* in 4a).

- (4) a. Preverbal subject
 El apuesto/ severo crítico que visitaba el museo habló __ (unaccusative)/
 llegó (unergative) con cuidado.
 The handsome/strict critic who visited the museum spoke/arrived with care.
- b. Post-verbal subject
 Habló (unaccusative)/llegó (unergative) con cuidado el apuesto/ severo
 crítico que visitaba el museo.
 Spoke/arrived with care the handsome/strict critic who visited the museum.

Results showed probe-word facilitation at the verb in unaccusative verb sentences with a pre-verbal subject (*habló* in 4a) and faster recognition times in unaccusative verb constructions than in unergative verb constructions (*habló* < *llegó*). However, this result was only apparent when Bever & Sanz (1997) focused on a subset of their participants, who they classified as using a 'syntactic search strategy'. These were participants which searched for a syntactic representation to find the probe word.

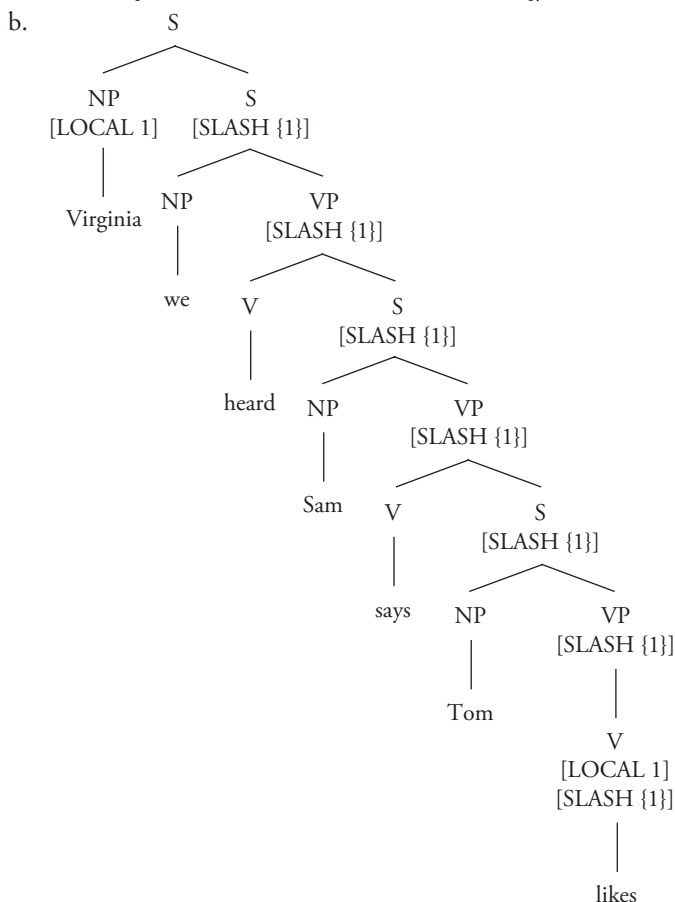
The previous studies have in common a search for speeded recognition times associated to the antecedents of gaps. They all looked for evidence that would bridge the assumptions of the linguistic theory about empty categories with the sentence comprehension data. The aim of these studies was to show that the speeded recognition times associated to the antecedents of pronouns or anaphors hold also for gaps.

2.3.2. Head-Driven Phrase Structure Grammar (HPSG) approach

A second approach to explain the filled-gap effect is that of frameworks such as Generalized Phrase Structure Grammar (GPSG) and Head-Driven Phrase Structure Grammar (HPSG), where the gap is represented as a SLASH feature that encodes the missing information and that is lexically unified to its antecedent, the filler (Gazdar et al. 1985, Pollard & Sag 1994, Sag & Fodor 1994, Miller & Sag 1997, Balari 1998, Monachesi 1998, Abeillé et al. 1998).

In Pollard & Sag's (1994) HPSG terms,⁴ the filler and the foot of the chain share features. In order for these features of the base of the chain to be propagated without any movement to the filler so that the filler is interpreted, the SLASH feature is required. The SLASH feature is in charge of transferring the information⁵ up to the filler. Once the SLASH feature at the verb is bound off to the filler by identification with the local features of this filler, the dependency gets interpreted. A graphic representation of this is shown in (5b) below.⁶

(5) a. Virginia₁, we heard Sam says Tom likes ____₁.



⁴ It's only in chapter 9 in Pollard & Sag (1994) that they start considering a traceless account of long distance dependencies, therefore, the references henceforth to Pollard & Sag (1994) refer to this chapter.

⁵ For Pollard & Sag (1994: 160) the information encoded in the SLASH feature is the content, subcategorization and local feature information.

⁶ Note that this is a simplified version of Pollard & Sag's (1994) representation of a long distance dependency involving a topicalization under HPSG in chapter 4. It has been adapted to a traceless account such as the one they propose in chapter 9.

Sag & Fodor (1994) adapt Pollard & Sag's (1994) traceless proposal into a Complement Extraction Lexical Rule whose COMPS-list is reduced by a complement but whose SLASH value contains the information associated with the missing complement.

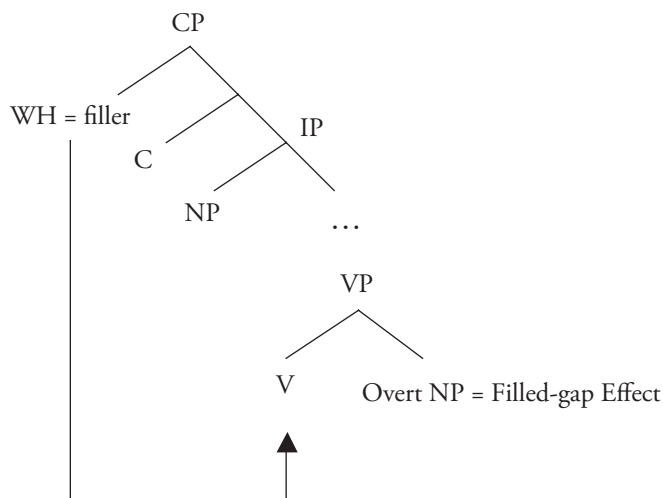
Sag & Fodor's (1994) Complement Extraction Lexical Rule:

$$\left[\begin{array}{l} \text{COMPS } \langle \dots, 1, \dots \rangle \\ \text{SLASH } \langle \rangle \end{array} \right] \Rightarrow \left[\begin{array}{l} \text{COMPS } \langle \dots \rangle \\ \text{SLASH } \langle \{1\} \rangle \end{array} \right]$$

The HPSG traceless proposals demonstrate that they can account for the active construction of filler-gap dependencies by encoding the information of the dislocated element in the SLASH feature. This SLASH feature is then percolated so that the filler is linked to its position within the argument structure of the verb.

2.3.3. *Direct Association approach*

The third and final perspective on the filled-gap effects is that of the direct association theory proposed by Pickering & Barry (1991). Pickering & Barry (1991) argued that empty categories play no role in processing and that there is no need to assume a gap-creation mechanism for unbounded dependencies. They argued for a processing of long-distance dependencies where the filler is directly associated with the subcategorizer. The displaced argument is linked to the subcategorizer directly without mediation of traces, via checking its subcategorization information. Furthermore, Pickering & Barry (1991) provide specific examples that they use to argue that the effects of interest happen at the verb position, and not at the gap position.



As seen in section 2.2., in previous studies the experimental evidence could not provide a way to distinguish between different accounts for explaining filled-gap effects because the trace was adjacent to the verb that subcategorized for it and the filled-gap effects could be related to the verb or the gap position depending on the

view that was adopted. To avoid this confound, Pickering & Barry (1991) concentrate on cases where the verb and the trace are separated by an intervening post-verbal argument. They provide evidence such as the data in (6) to show that the dependency is interpreted at the verb and not at the gap. They contrast the predictions that the direct association theory does in (6) with those that gap-filling theories do in (7) for the same set of sentences in (a) through (d).

- (6) Direct association account:
- a. [In which box]₁ did you [put]₁ the cake?
 - b. [Which box]₁ did you put the cake [in]₁?
 - c. [In which box]₁ did you [put]₁ the very large and beautifully decorated wedding cake bought from the expensive bakery?
 - d. [Which box]₁ did you put the very large and beautifully decorated wedding cake bought from the expensive bakery [in]₁?
- (7) Gap-filling account:
- a. [In which box] did you put the cake ____?
 - b. [Which box] did you put the cake in ____?
 - c. [In which box] did you put the very large and beautifully decorated wedding cake bought from the expensive bakery ____?
 - d. [Which box] did you put the very large and beautifully decorated wedding cake bought from the expensive bakery in ____?

For a sentence like (6a), Pickering & Barry (1991) argue that the parsing mechanism proposed by the direct association account could complete the filler's interpretation at the verb "put" by creating a semantic association with it. On the contrary, if the existence of empty categories (henceforth ECs) is presupposed, the sentence that corresponds to (6a) under gap-filling accounts shows that the parser would have to wait for the trace position after the object, to interpret the filler. In (6b) and (7b), the theories do not make different predictions because the assumed gap location is adjacent to the main subcategorizer.⁷ Pickering and Barry's (1991) contribution becomes crucial in sentences (6c) and (7c), where a longer post-verbal object intervenes between the filler and its trace. From a direct association point of view, the filler could be interpreted in (6c) at the verb position without having to wait to the end of the complex NP as in (7c). The crucial step of the argument is given by sentences (6d) and (7d) where the awkwardness of the sentence seems to be due to the fact that the filler has to be remembered while the complex noun phrase is processed. This provides evidence to think that the filler in (6c) is being associated with the verb directly and not with the gap at the end of the sentence because the processing of this sentence is easier than that of (6d), where the filler cannot be interpreted until the preposition (which in this case is the main subcategorizer) is processed. Hence, Pickering & Barry (1991) use memory load reasons and the processing properties of nested constructions as evidence for a direct association.

⁷ This context resembles the situation found at the filled-gap effect studies discussed in section 2.2 where the purported gap location and the verb were adjacent and the effect could be attributed to both the gap and the subcategorizer.

Gibson & Hickok's (1993) and Gorrell's (1993) criticism of the study by Pickering & Barry (1991) agrees in that, even if the direct association arguments are too strong, standard gap-filling does not correctly predict the processing asymmetry of sentences (6c) and (6d) respectively. As discussed by Gibson & Hickok (1993), the problem lays in the common assumption in standard gap-filling that a wh-phrase filler cannot be associated with an empty category until all intervening lexical material has been processed. Based on this basic premise, Pickering & Barry's (1991) argument is well taken because, if it is the case that empty categories are not associated to their fillers until all the previous lexical material has been processed, there should not be a processing difference associated with (6c) and (6d) above.

Gibson & Hickok (1993) propose a more predictive gap-filling account, where a wh-phrase filler (or any filler) can be associated with an empty category before intervening lexical material has been processed. Under their view, once a filler that needs to be associated with a thematic role has been processed, a gap can be posited as soon as an appropriate subcategorizer licenses the position for that filler, whether or not the intervening lexical requirements for that filler are fulfilled. Crucially for their proposal, once the gap has been posited, the intervening lexical material can be processed and attached between the subcategorizer and the gap, leaving the trace to the right of this yet-to-be encountered material.

They show, through a gap-positing algorithm, how the processing contrast between (6c) and (6d) is explained in terms of predictive gap-filling without having to disregard the existence of empty categories. This is summarized in (8) below.

- (8) Predictive gap-filling account for the sentence in (6c):
- c. In which box did you put the very large and beautifully decorated wedding cake bought from the expensive bakery?
- Step 1:* Argument structure of the verb is accessed; parser hypothesizes appropriate argument structure to the right.
- c_1 . [_S[_{PP}In which box] did you [_{VP}[_Vput][_{NP} h_1][_{PP} h_2]]]
- Step 2:* Since the PP argument position is licensed by the theta-assigning verb and since the material of the wh-phrase matches that PP position, h_2 can be filled with a trace which is co-indexed with the filler wh-phrase.
- c_2 . [_S[_{PP}In which box]_{*i*} did you [_{VP}[_Vput][_{NP} h_1][_{PP} e_i]]]
- Step 3:* Because the gap e_i is non-lexical, attachments to the hypothesized NP position h_1 can still be made.
- c_3 . [_S[_{PP}In which box]_{*i*} did you [_{VP}[_Vput][_{NP} the very large and beautifully decorated wedding cake bought from the expensive bakery] [_{PP} e_i]]]

Predictive gap-filling account for the sentence in (6d):

- d. Which box did you put the very large and beautifully decorated wedding cake bought from the expensive bakery in?
- Step 1:* Argument structure of the verb is accessed; parser hypothesizes appropriate argument structure to the right.
- d_1 . [_S[_{NP}Which box] did you [_{VP}[_Vput][_{NP} h_1][_{PP} h_2]]]
- Step 2:* Intervening material avoids interpreting the filler wh-phrase as the NP position of the verb, h_1 is filled with the complex direct object NP.

d₂. [_S [_{NP} Which box] did you [_{VP} [_{VP} put] [_{NP} the very large and beautifully decorated wedding cake bought from the expensive bakery] [_{PP} h₂]]]

Step 3: Until the preposition is processed, the parser cannot co-index the trace with the wh-phrase filler.

d₃. [_S [_{NP} Which box]_i did you [_{VP} [_{VP} put] [_{NP} the very large and beautifully decorated wedding cake bought from the expensive bakery] [_{PP} in e_i]]]

The difference in the processing of these two sentences is that in (8c) the wh-phrase can be linked to the verb via an empty category as soon as this verb is processed, whereas in (8d) the wh-phrase has to be maintained in memory until the sentence final preposition is processed; because there is no previous subcategorizer with which the filler could be licensed and a gap could be posited.

In sum, Gibson & Hickok (1993) propose that gaps can be posited as soon as their positions are licensed by the grammar. They assume that the parser can build structure to the left of a gap that has already been attached. Crucially, since all the data Pickering & Barry (1991) included can be accounted for under their first-resort gap-positing algorithm, empty categories may still take part in sentence processing.

As reflected in the discussion in Pickering & Barry (1991) and Gibson & Hickok (1993), both direct association accounts and predictive gap-filling accounts can explain the processing differences of sentences with long-distance dependencies such as (8c) and (8d). Both accounts can be right when considering the evidence found to that moment because both need to count on the subcategorizer for their proposals. The direct association supporters need it to establish a semantic association with the filler and the predictive gap-filling supporters need it to license the position of the filler once the gap has been posited.

3. Pre-verbal filled-gap effects in head-final languages

Given that the research in processing long distance dependencies in head-initial languages was empirically indistinguishable with respect to the different competing theories discussed in section 2.3, similar effects were investigated in languages where a filled-gap effect could be found in pre-subcategorizer position. The rationale was that, if filled-gap effects are detected before the subcategorizer, it would be possible to tease apart theories supporting a predictive gap-filling parser (e.g. Gibson & Hickok 1993) from those supporting a parser that employs a direct semantic association (e.g. Pickering & Barry 1991). Head-final languages offer an ideal ground for investigating this question because in these languages the canonical position of the arguments comes before the main subcategorizer (e.g. the verb). A predictive gap-filling account would predict that, if the parser posits a gap as soon as a filler that needs to be associated with a thematic role is processed, it should be possible to find evidence demonstrating that the trace can be projected at the pre-verbal position before this verb is finally encountered. On the other hand, a direct association account would predict that no gap is expected once the filler has been processed and that this filler can only be interpreted when the verb is encountered and a semantic association is made between the filler and the verb.

Most of the research undertaken to look for pre-verbal effects in head-final languages comes from Japanese. In Japanese, objects precede the verb (since it is an SOV language). If we have object scrambled structures in which the object has been displaced within the sentence, the trace has to be posited before the verb is encountered. Hence, if filled-gap effects at pre-verbal gap positions can be shown for Japanese, it would demonstrate that when the parser encounters a displaced phrase it predicts the occurrence of a gap and, with relevance to our discussion, it does not need to wait for the occurrence of the verb to predict the gap.

In what follows, I discuss two studies that have looked for pre-verbal gap effects in Japanese. These studies are by Nakano et al. (2002) and Aoshima et al. (2003). Nakano et al. (2002) looked for antecedent priming effects in pre-verbal position in sentences with long-distance scrambling and Aoshima et al. (2003) looked at pre-verbal filled-gap effects in scrambled sentences.

Nakano et al. (2002) used a cross-modal lexical priming technique and tested Japanese long-distance scrambled constructions to search for antecedent priming effects at pre-verbal position. They tested long-distance scrambling sentences in which the object had moved from within the embedded clause across the main clause subject as in (9). The target words were either identical (e.g. 'lemon') or semantically unrelated to the head noun of the displaced object (e.g. 'sonata'). These target words were presented at the experimental test point, which was in the offset of the second dative-marked argument, and at the control test point, which was 500 ms before the experimental point (both indicated with # in 9a and 9b). Their predictions were to find priming effects at the position preceding the embedded verb ('ask') in the offset of the second dative-marked argument ('female person'), because that is where the gap position should be predicted.

- (9). a. NP-ACC # [NP-NOM NP-DAT [NP-NOM NP-DAT # t_i V COMP] V]
 b. Suruto remon-o_i [CP/IP futari-me-no hito-ga shikai-sha-ni [CP
And then lemon-ACC # the second person-NOM M.C.-DAT
sono kodomo-ga onna-no hito-ni t_i nedatte-iru to] kotae-ta
that child-NOM female person-DAT # asking COMP answered
 'And then, a lemon, the second person answered to the Master of Ceremonies that that child was asking the woman for'

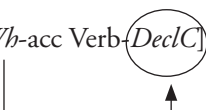
Since Nakano et al.'s (2002) sentences were long-distance scrambling cases; they seemed to involve a high processing cost on the processor. For this reason, Nakano et al. (2002) split their subjects into high and low memory span groups and they only found priming effects at pre-verbal position for scrambled direct objects (e.g. priming of the word 'lemon' at the pre-verbal position in the most embedded clause) in high-span participants. Nakano et al. (2002) took this result to mean that the processor was accessing the antecedent at pre-verbal position when encountering its trace. This evidence sustained theories that assume dislocated elements are related to their subcategorizers through empty categories. However, it has to be noted that this result was only apparent when Nakano et al. (2002) focused on a subgroup of their subjects (the high span group) and that the priming effects cannot be taken completely independent from the verb since the trace position (#) immediately precedes the verb. Therefore, priming effects

should be looked for prior to the trace position so that they cannot be considered priming effects of the verb.

With the same objective of looking for preverbal gap effects in Japanese, Aoshima et al. (2003) examined the processing of long distance scrambled wh-phrases in Japanese and conducted a number of self-paced reading experiments.

Aoshima et al.'s (2003) first experiment was built upon the Typing Mismatch Effect (henceforth TME) findings by Miyamoto & Takahashi (2001). Miyamoto & Takahashi (2001) tested whether Japanese participants predict a Q-marker at the embedded verb once they have processed a wh-phrase in order to license the in-situ wh-phrase. Miyamoto & Takahashi (2001) predict that, if instead of the predicted Q-marker Japanese readers find a declarative complementizer at the first verb they encounter, they will slowdown.

(10) Miyamoto & Takahashi's (2001) TME for Japanese:

- a. [NP-nom *Wh*-acc Verb-Q]... Verb
- 
- b. [NP-nom *Wh*-acc Verb-*DeclC*]... Verb-Q
- 

Results show that participants slow down at the declarative complementizer in (10b) relative to the Q-marker in (10a) because they expected a Q-marker after processing the wh-phrase in-situ. This result is taken as confirmation that readers expect a question particle on the verb which is in the same clause as the thematic position of the in-situ wh-phrase.

Aoshima et al. (2003) examined at which specific point in the sentence fronted wh-phrases are interpreted in Japanese. They used dative wh-phrases that could be associated either with the matrix or the embedded verb. Their aim was to determine whether a fronted wh-phrase is preferentially interpreted in the matrix or in the most embedded clause in Japanese. They hypothesize that if the wh-phrase is interpreted in the main clause, it means that processing of long-distance dependencies is driven by gap creation, whereas if it is interpreted in the most deeply embedded clause, it means that it is driven by interpretive reasons such as thematic interpretation. Therefore, they expect to observe a TME (Miyamoto & Takahashi 2001) at the embedded verb if the wh-phrase is interpreted in the most deeply embedded clause.

The main finding of this first experiment is that Japanese readers slow down when encountering a complementizer in the embedded verb, both when the wh-phrase is in situ and when it is fronted. Hence, a TME is found both for the conditions that contained a in-situ and a scrambled wh-phrase. Aoshima et al. (2003) suggested that this expectation for a Q-marker in the scrambled condition can only arise if the processor interprets the fronted wh-phrase as being a thematic argument of the embedded verb.

Based on the results of experiment 1 where the fronted wh-phrase seemed to be associated with the most deeply embedded verb, Aoshima et al. (2003) investigated the time-course of this association process by conducting a second experiment. They adapted the filled-gap effect paradigm from English experiments (Crain & Fodor 1985, Stowe 1986) to Japanese. The sentences they tested consisted of scrambled da-

tive wh-phrases. The filled-gap paradigm was created by placing an overt dative NP right before the embedded verb where the gap for the scrambled dative wh-phrase should be predicted. They predicted that, if they found association effects between the scrambled wh-phrase and the embedded verb, it would lend support to direct association theories where the subcategorizer is necessary; whereas if they found association effects between the wh-phrase and the gap before the embedded verb, it would lend support to theories that do not require the subcategorizer to interpret a dependency. Their stimuli had the following two conditions: a condition that had a scrambled dative wh-phrase (11a), and a condition where the wh-phrase was in-situ and had nominative case (11b).

(11) a. *Scrambled condition*

Dono-syain-ni senmu-wa syacyoo-ga
Which employee-DAT managing director-TOP president-NOM
 kaigi-de kacyoo-ni syookyuu-o yakusokusita-to iimasita-ka?
meeting-at assistant manager-DAT raise-ACC promised-DeclC told-Q
 ‘To which employee did the managing director tell that the president promised a raise to the assistant manager at the meeting?’

b. *Control Condition*

Dono-syain-ga senmu-ni syacyoo-ga
Which employee-NOM managing director-DAT president-NOM
 kaigi-de kacyoo-ni syookyuu-o yakusokusita-to iimasita-ka?
meeting-at assistant manager-DAT raise-ACC promised-DeclC told-Q
 ‘Which employee told the managing director that the president promised a raise to the assistant manager at the meeting?’

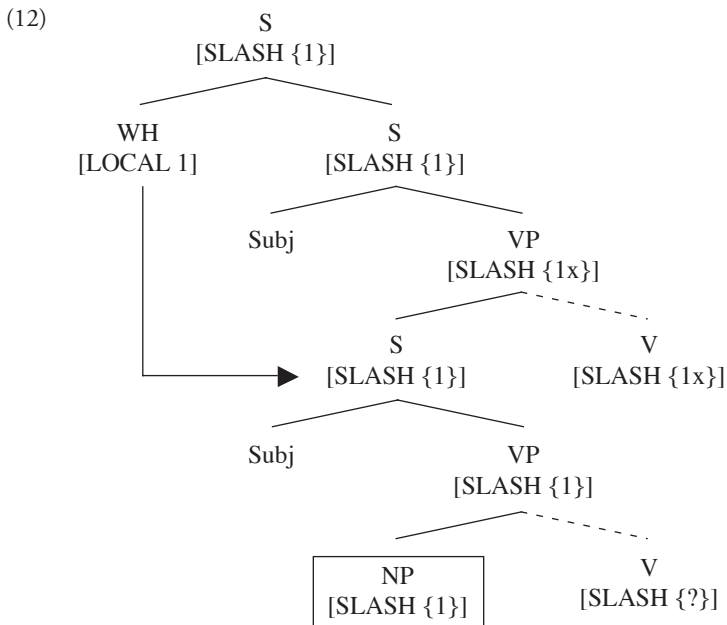
The predictions were that if the fronted wh-phrase in the scrambled condition in (11a) is associated with the embedded clause before the second dative-marked NP (“assistant manager”) is encountered, readers should be surprised to find a second dative phrase and there should be an effect equivalent to the English filled-gap effect (Crain & Fodor 1985, Stowe 1986). This pre-verbal gap effect would be interpreted as resulting from the parser having posited a gap for the wh-phrase at the embedded verb and finding that gap position being filled. On the other hand, in the control condition in (11b) the second dative-marked NP in the embedded clause should be understood as the only dative of the embedded clause and should be read faster than its correspondent in the scrambled condition.

The main finding of their second experiment was a reading slowdown in the scrambled condition at the embedded dative-marked NP. The reading time of the dative marked NP was significantly slower than its correspondent NP in the control condition. This slowdown was taken as evidence that the parser is interpreting the fronted wh-phrase in the embedded clause. Since readers have already interpreted a dative marked phrase in the embedded clause, they do not expect to find a second dative-marked NP. Therefore, this effect could only arise if readers create a gap-site in the embedded clause before they reach the embedded verb.

When the results by Aoshima et al. (2003) are considered under the different processing accounts that have been discussed in section 2.3, it is difficult to see how

a strong version of traceless processing theories such as the direct association by Pickering & Barry (1991) could account for the pre-verbal gap effects found for Japanese scrambled wh-phrase constructions, because the filled-gap effect in Japanese is found before any subcategorizer. There is no explanation for the slowdown at the overt dative-marked NP preceding the verb if the parser has to wait to encounter the verb to do a semantic association with the fronted wh-phrase.

On the other hand, the possibility that HPSG could account for the same filled-gap effect without having to assume that long distance dependencies involve gaps cannot be excluded. It is possible that HPSG could account for Aoshima et al's (2003) results if additional assumptions would be added to the proposal by Sag & Fodor (1994) discussed in section 2.3.2. Aoshima (2003) shows which extra assumptions a system like HPSG needs, to account for pre-verbal effects in Japanese. The first assumption that HPSG needs is that the VP, and not the verbal head, collects the SLASH values. This has to be done to guarantee that the filler at the top of the dependency is linked to the relevant position in the argument structure of the verb before encountering the verbal head. Nevertheless, this assumption would predict the SLASH values to be discharged at the matrix VP in (12) when the embedded subject is encountered and it would not explain the pre-verbal filled-gap effects found in the embedded clause. To account for the pre-verbal filled-gap effect data, Aoshima (2003) proposes that the system would need to assume multiple phrase structures in a parallel parser, where one embedded VP has a SLASH value and the other embedded VP kept in parallel does not. Then, the analysis whose SLASH features are first found compatible with a lexical verb in the input will be given preference. Moreover, the HPSG version of Japanese pre-verbal gap effects would need to claim that case information is encoded in the SLASH feature to predict that the sec-



ond dative NP is surprising. Other assumptions that would be additionally required to account for the pre-verbal filled-gap effects will concern the cancellation of the SLASH remaining at the matrix VP once the SLASH feature at the embedded clause has been discharged and whether the embedded verbal head would have a remaining SLASH feature or not.

In sum, the evidence from the experiment on pre-verbal gap effects by Aoshima et al (2003) could be taken to support gap-based theories of processing and to argue against a direct association approach. On the other hand, a traceless approach such as HPSG could possibly account for the results of pre-verbal gap-effects in Japanese, but once extra assumptions such as those discussed in Aoshima (2003) are assumed.

4. Pre-verbal effects in head-initial languages

As it has been discussed in section 3, accounts such as HPSG could still be compatible with the finding of pre-verbal gap effects in Japanese scrambled wh-phrases without necessarily assuming that there will be a gap. Bearing this in mind, a study in Spanish examined the processing of clitic pronouns in Clitic Left-Dislocation constructions (Pablos 2006) to test if there could be evidence within head-initial languages that showed preverbal interpretation effects not compatible with HPSG. The aim of this study was to test whether the clitic pronoun could contribute to the interpretation of the fronted topicalized phrase before the verb was encountered.

4.1. Pre-verbal interpretation of topic-clitic dependencies through clitic pronouns

The interest of examining clitic pronouns in the study by Pablos (2006) centered in whether HPSG could account in SLASH terms for the information encoded in a pronoun contained in a long-distance dependency, when this pronoun preceded the subcategorizer and it was part of the argument structure of the verb.

The structural properties of Spanish allow a clitic pronoun that co-refers with a topicalized fronted phrase and that can anticipate the interpretation of the dependency before the verb. This pre-verbal clitic position can be used to test the predictions done by some of the theories discussed in section 2.3 that argue that the interpretation of long-distance dependencies is only done at the main subcategorizer. The study on clitic pronouns in Spanish tested this prediction and results demonstrated that the interpretation of long-distance dependencies can start at the clitic pronoun that precedes the verb.

In experiment 1, Pablos (2006) examined the processing of CLLD constructions in a self-paced reading paradigm. She tested whether clitic pronouns were used to interpret the topicalized phrase in advance of the verb and whether an active search for clitic pronouns was triggered by manipulating the appearance of this pronoun in different positions of the sentence. The sentences she tested in experiment 1 included an early completion condition and a late completion condition where the contrast was in whether the fronted phrase could be interpreted in the main clause, as in (13a); or whether it could not be interpreted until the clitic matching with the fronted phrase in agreement was encountered in the most embedded clause, as in (13b). Both in the early and the late completion, the clitic appeared in pre-verbal po-

sition, meaning that the clitic could contribute to the interpretation of the fronted phrase before the verb.

(13) Context sentence:

Yendo a la escuela, mi hermana mayor y yo vimos a mis amigas Ana e Irene.
 ‘Going to school, my older sister and I saw my friends Ana and Irene’

a. *Early Completion condition*

A estas chicas, mi hermana mayor más tarde **les** dijo que
To these girls, my sister old later on them-dat told that
 ya **lo** cree que las conoce desde hace tiempo.
indeed it-acc(masc) thinks that them-acc(fem) knows since long time.
 ‘To these girls, my old sister later told them that she indeed thinks she knows them for a long time’

b. *Late Completion condition*

A estas chicas, mi hermana mayor más tarde dijo que ya
To these girls, my sister old later on said that indeed
 lo cree que **las** conoce desde hace tiempo.
it-acc(masc) thinks that them-acc(fem) knows since long time.
 ‘These girls, my old sister later said that she indeed thinks she knows them for a long time’

Results of the experiment 1 in Pablos (2006) showed a facilitation effect at the most embedded clitic pronoun in the late completion condition, suggesting that the active search mechanism was triggered for clitic pronouns after processing a fronted phrase, and that the delay in the appearance of the expected clitic pronoun resulted in this clitic being read faster. More importantly for our discussion, this facilitation also shows that clitics are used to interpret the topicalized phrase before the verb. These results lend support to processing theories that use underlying argument positions projected by the verb to interpret a fronted phrase in long-distance dependencies. This indicates that the processing of long-distance dependencies might not be uniquely relying on the subcategorizer and that if there is an underlying argument such as a clitic pronoun before the verb, this argument will be used to interpret the filler.

4.2. HPSG’s account of clitics in Romance languages

The sentences in Pablos’ (2006) study were topicalized sentences that required a clitic pronoun to interpret the topicalization, therefore, in this section we will examine whether HPSG has any account of sentences where topicalization and clitics co-exist and how HPSG accounts for clitic pronouns in these topic-clitic dependencies.

There are studies in Romance languages that have looked at clitics in HPSG (Miller & Sag 1997, Abeillé et al. 1998, Balari 1998, Monachesi 1998).⁸ These stud-

⁸ Except Balari’s (1998) proposal, it is important to note that other studies considered the status of clitics to be pronominal affixes instead of lexical words.

ies differ in how they encode the information in the clitic pronoun in SLASH terms. In what follows, we compare their accounts against the data for experiment 1 in Pablos (2006) to see whether the accounts of HPSG for constructions involving clitics cover this particular dependency.

Monachesi's (1998) HPSG account for sentences containing clitics in Italian includes a CLTS feature that carries the information of the clitic along the sentence.⁹ If we consider this lexical rule in Monachesi (1998) and compare it with the data in Pablos (2006), the rule does not succeed in accounting for topic-clitic dependencies because this rule prevents the co-occurrence of a clitic and a phrasal complement that co-refers with this clitic.

Miller & Sag (1997) investigate constructions that combine wh-phrases extraction and clitics and propose the rule in (14) for French. This rule operates on a verb whose Argument Structure (ARG-ST) list contains both a clitic (a pronominal affix under their view) and a gap encoded as a SLASH value.¹⁰

(14) Miller & Sag's Complement Cliticization Lexical Rule¹¹ for French:

$$\left[\begin{array}{l} \text{HEAD cliticized verb} \\ \text{COMPS } \langle \dots, 1, \text{affix}, \dots \rangle \\ \text{SLASH-gap } \langle \dots \rangle \\ \text{SLASH-aff } \langle \dots \rangle \end{array} \right] \Rightarrow \left[\begin{array}{l} \text{COMPS } \langle \dots \rangle \\ \text{SLASH-gap } \{1\} \\ \text{SLASH-aff } \{3^{\text{rd}}, \text{sg}, \text{nom}\} \end{array} \right]$$

The formulation of this rule requires that both the clitic and the extracted element be removed from the COMPS list of the verb and be encoded in SLASH specification terms, so that the information is later percolated up through the SLASH feature to the filler. If we apply the rule in (14) to the Spanish experimental sentences, it is not clear how this rule can specify that the fronted phrase requires the presence of an upcoming clitic. Miller & Sag's (1993) rule does not seem to have the SLASH specification for the clitic and the extraction connected. Both the extraction and the clitic information are considered two independent SLASH encodings.

Finally, Balari (1998) examines clitics in long-distance dependencies and assumes that clitics are affix-like. Following Cinque (1990), he argues that the clitic in a CLLD construction acts as an overt variable rather than as a pronoun, because strong crossover effects can be observed.¹² He suggests that CLLD constructions should be considered weak unbounded dependencies.

⁹ This is done after the complement has been removed from the COMPS list of the verb; therefore, it is in complementary distribution with the cases where the phrasal complement of the clitic is present (although it doesn't prevent to have a clitic and a phrasal complement if they don't co-refer and it allows to have two clitics corresponding to different complements).

¹⁰ A later version in Abeillé et al. (1998) accounted for clitics co-occurring with extraction both in Italian and French.

¹¹ The rule (82) and its illustration (84c) in Miller & Sag (1993: 617, 619) have been simplified to explain the Complement Cliticization Lexical rule.

¹² These strong crossover effects can be observed in (i).

(i) *A Pedro_i, él_i dijo que no lo_i ayudarías.
To Pedro, he said that you would not help him

Balari's (1998) analysis of CLLD dependencies dispenses with the SLASH mechanism by extending binding theory in a way that the connection between a filler and a gap can be directly accounted for through binding principles. Balari (1998) considers that CLLD dependencies involve a co-indexation dependency rather than a sharing of SLASH features or a CLTS feature. Even if his account seems to be the most appropriate for the data in Pablos (2006) because it accounts for CLLD constructions, it is still not clear how accounting for this data in terms of binding principles can show the requirement for a clitic pronoun after the topic in these constructions. It seems that the factor that is left unspecified in the HPSG accounts that use clitic pronouns is the clitic requirement. A way to account for topic-clitic dependencies under SLASH terms is suggested in section 4.3.1.

4.3. Comparison of the Spanish study with different theories of long-distance processing

In what follows, I examine how the findings in the study by Pablos (2006) could be interpreted within the framework of other theories on the on-line interpretation of long-distance dependencies covered in section 2.3.

4.3.1. Comparison with HPSG Accounts

To account for topic-clitic dependencies in SLASH terms, I will combine it with the CLTS feature proposed for clitics in Romance. What I suggest that HPSG could propose for topic-clitic dependencies is a variant of the SLASH percolation. This variant would apply to cases where a topicalization is the filler, and where the only way to complete the dependency is by transferring the features of the clitic up to the topic. These features will be percolated in the tree so that this information is systematically registered on nodes that dominate the clitic. The new encoding is named SLASH | CLTS. The dependency will be completed once the SLASH | CLTS feature introduced at the clitic is bound off to the filler by identification with the local features of the filler.

The rule in (15) shows the HPSG rule I suggest for Topic-clitic dependencies in Spanish.

(15) Spanish Topic-Clitic Dependency Rule:

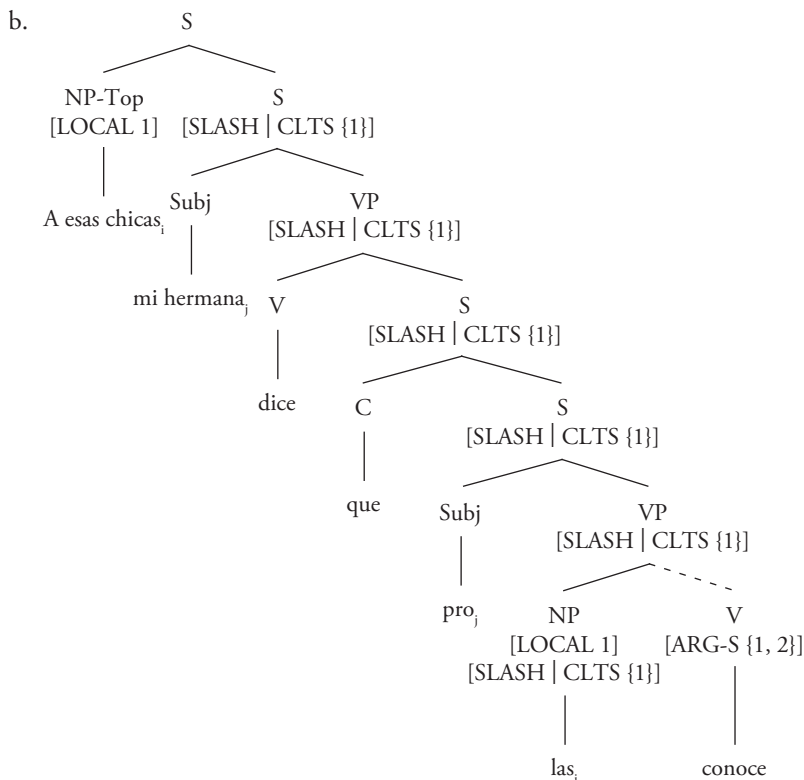
$$\left[\begin{array}{l} \text{HEAD verb with left-dislocated argument} \\ \text{COMPS } \langle \dots, 1, \text{clitic}, \dots \rangle \\ \text{SLASH} | \text{CLTS } \langle \dots \rangle \end{array} \right] \Rightarrow \left[\begin{array}{l} \text{COMPS } \langle \dots \rangle \\ \text{SLASH} | \text{CLTS} \\ \{1\} + \{3^{\text{rd}}, \text{sg}, \text{acc}/\text{dat}\} \end{array} \right]$$

This rule differs from Miller & Sag's (1993) French Complement Cliticization Lexical Rule reported in (14) in that both the information for the clitic and the filler's displacement is encoded under one single SLASH feature that is removed from the COMP list.

The sentence in (16) shows how this rule could be interpreted in SLASH terms.¹³

¹³ This sentence is a simplified version of one of the sentences used in experiment 1 in Pablos (2006).

- (16) a. A esas chicas,_i mi hermana,_j dice que las,_i conoce ____;



This account of the topic-clitic data under HPSG does not differ much from how an indirect association account would explain the processing of these dependencies, where the filler is interpreted through a mediated association with one of the underlying arguments of the subcategorizer. Both HPSG and indirect association accounts need to further specify what happens subsequently at the verb. At this point there is no evidence that addresses this question.

4.3.2. Comparison with accounts of Filler-Gap Effects

The experiment 1 in Pablos (2006) shows how dependencies that include overt elements can show dependency formation effects prior to the verb. In the processing of topic-clitic dependencies in Spanish, the reading time differences at the most deeply embedded clitic pronoun add evidence in favor of an incremental parser that uses every piece of available information to complete the unbounded dependency without the need to get to the main subcategorizer.

The distinction of the results in the Spanish experiment with respect to previous filled-gap experiments lays in the fact that the parser can interpret the dependency when it finds an overt element. The topic-clitic constructions do not involve the search for a gap. The question that this particular contrast between having an overt

element and a gap completing the dependencies raises is whether these two degrees of dependency completion can be considered the same, or whether they should be considered different since the amount of information provided by a null versus overt element is not the same. As discussed in section 3 for pre-verbal gap-effects, even if the dependency can be already interpreted at preverbal gap positions, there is still the need for subsequent confirmation at the verb so that the gap is completely interpreted with thematic information. Hence, the question is whether with clitic pronouns in Spanish the dependency can be completely interpreted at the clitic pronoun and the verb is just the piece that provides the lexical semantics information.

To try to address this last question it would be useful to break the on-line interpretation of an unbounded dependency into two different stages. The first stage consists of finding out which argument the fronted phrase corresponds to (dative or accusative); and the subsequent stage consists of finding out which subcategorizer the displaced argument belongs to. For the interpretation of topic-clitic dependencies, the question is whether the parser needs to get to the second stage to interpret the unbounded dependency, or whether finding an underlying argument such as the clitic is enough to interpret the fronted phrase. It is very likely that the parser needs to finally confirm at the verb the dependency that started to be interpreted at the clitic, but the crucial point is that the dependency can start to be interpreted before the verb. The difference with pre-verbal filled-gap effects rests in that the clitic pronoun in Spanish facilitates the interpretation before the main licenser (e.g. verb) even if this interpretation might not be complete. Even if the verb has not been encountered and its lexical semantic information is not available, the clitic pronoun can disambiguate the case of the fronted phrase and can help anticipating whether the verb will be ditransitive or transitive. Therefore, it can be concluded that clitic pronouns are used as cues to interpret topic-clitic dependencies before the verb.

4.3.3. *Comparison with the Direct Association approach*

The experimental results of the Spanish study in Pablos (2006) are incompatible with Pickering & Barry's (1991) direct association theory in that dependency formation effects occur before the subcategorizer is processed at the clitic pronoun. In the data that Pickering & Barry (1991) consider, the subcategorizer is necessary to establish a semantic link with the filler. In Pablos' (2006) study, the effect at the clitic shows that the presence of the subcategorizer is not required to interpret the filler. Therefore, it could be assumed that unbounded dependencies can be completed even before the subcategorizer is reached by using some of its underlying arguments such as clitic pronouns. The evidence that Pickering & Barry (1991) present has a bearing only on the existence of *wh*-traces and NP-traces in sentence processing. Since the dependency presented in the Spanish study is not bearing on *wh*-trace or NP-traces, it is hard to know whether their prediction holds in topic-clitic constructions if there are underlying arguments which can be linked semantically with the filler.

In addition, results from the study of clitic pronouns in Spanish lend support to Gibson & Hickok's (1993) proposal in that the clitic position can be predicted and associated to its filler before the position from which the fronted phrase moved is reached. Nevertheless, the evidence also differs from Gibson & Hickok (1993) in

that the element that can interpret the filler is not a subcategorizer, but an underlying argument.

5. General Discussion

The goal of this paper was to look at how long-distance dependencies, particularly those involving topic-clitic dependencies, are interpreted on-line and to look at different accounts that have been considered for explaining filled-gap effects to examine if they could account for the data on topic-clitic dependencies in Pablos (2006). Guided by results of previous research on both head-initial and head-final languages like English and Japanese respectively, the aim was to show how effects of dependency formation prior to the subcategorizer (e.g. the verb) can be found in languages with a head-initial configuration and to demonstrate that these effects are not uniquely dependent on the verb.

The experimental results of the study in Pablos (2006) lend support to the use of underlying argument positions such as clitic pronouns in processing long-distance dependencies. This entails that the parser can start interpreting the fronted phrase through clitic pronouns which are available to the reader before they encounter the main subcategorizer. Moreover, this evidence supports an incremental parsing where the parser uses all the information at hand at every moment to complete an unbounded dependency.

It has been shown how a theory that requires the subcategorizer to interpret the filler can hardly explain the effects at the clitic pronoun in Spanish. As discussed in section 4.3, Pickering & Barry's (1991) argument would have to be adapted to the data considered for Spanish to see how they could account for topic-clitic dependencies. On the other hand, HPSG could account for the data if a new type of SLASH encoding such as the one suggested in section 4.3.1. was introduced for topic-clitic dependencies.

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