Wh-questions in Catalan Sign Language

Les preguntes-qu en Llengua de Signes Catalana

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To Oriol, my favorite *who*

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Abstract

This dissertation offers a characterization and an analysis of wh-questions in Catalan Sign Language, which show the particularity of placing wh-expressions canonically in sentence final position. This feature, specific to Sign Languages, has been difficult to deal with from traditional models, which have often considered that wh-movement is universally to the left and which have also often assumed that syntactic structure encodes information about the linear order of linguistic elements. The dissertation also argues that syntactic hierarchy and linear order are two different objects with a limited impact over one another, and that the latter is mainly dependent on the mechanisms of linguistic processing and, specifically, on Working Memory. In that sense, the hypothesis that the difference in the placing of wh-elements between Sign Languages and Spoken Languages is due to differences in Working Memory is put forwards. To explore it, the results of two experiments with Deaf and hearing participants are discussed.

Resum

S'ofereix una caracterització i una anàlisi de les preguntes-que en Llengua de Signes Catalana, que presenten la particularitat d'ubicar preferentment les expressions-qu al final de l'oració. Aquesta característica, pròpia de les llengües de signes, ha estat difícil de tractar des de models tradicionals, que sovint han considerat que el moviment-qu és universalment cap a l'esquerra i que sovint han assumit que l'estructura sintàctica codifica informació respecte de l'ordre lineal dels elements lingüístics. Es proposa que la jerarquia sintàctica i l'ordre lineal són dos objectes diferents i amb un impacte limitat l'un sobre l'altre i que el segon depèn principalment de mecanismes de processament lingüístic i, específicament, de la Memòria de Treball. En aquest sentit, s'hipotetitza que la diferència en la ubicació dels elements-qu entre llengües de signes i llengües orals respon a diferències en la Memòria de Treball. Per a explorar aquesta hipòtesi, s'exposen els resultats de dos experiments amb participants Sords i oients.

PREFACE

Many years later, as he faced his interpreter, the linguist was to remember that distant afternoon when his professor took him to discover language. These are the words that could begin the novel of many linguists who once decided to study human language in the visual modality. The path they took was one of no return. Once they chose to explore this version of language they took on a commitment to rigor and, in a certain sense, to justice. Once they chose this path, they would not be able to look at language in such a narrow way again.

What these linguists did not know was perhaps the solitude in which they would have to work. At best, their colleagues would look at them with fascination from a safe distance. That solitude would only be mitigated at some specific conferences, where they could exchange experiences and knowledge with others like them, who also once chose to belong to a minority within a minority. I do not know whether such solitude will exist for one hundred years. If we take Stokoe (1960) as the beginning, it has already lasted half of those hundred.

Sign Languages (SL) have recently been studied in comparison with spoken languages. Achieving the recognition of SL as natural languages has been hard, because signed modality is a minority in most of the societies and because many major league linguists have neglected visual modality in their analyses, and accounted for linguistic facts from a modality-centric point of view. This work aims to contribute to a fairer and more global view of human language.

Since we already know that SL are natural languages, we linguists have the intellectual obligation to consider them whenever we make our claims. Looking at it in a more positive light, SL give us the opportunity to discover more about all languages, as we can draw a more unified blueprint of what the glottospace looks like.

That same linguist, when starting his journey through the dissertation, does it with a very naive thought in mind: that he is going to learn a lot about some specific academic aspect. However, as the journey advances, he will realize that is only a part of the whole process. Over this time, he will learn a lot of other things, about himself and about those around him, that are really valuable lessons for life after the dissertation. He will learn to know himself better and to value what he does fairly. He will learn to forgive himself and to respect his work just enough as to develope it further, and just enough as to throwing it away and start from scratch when it is necessary. This is a message for the future PhD student: the sooner you realize that you can do it and that you are qualified to do it,

the better.

The other big teaching from this long journey is respect for the work of other people. A dissertation has to serve to open up the mind of the scientist, so he is able to listen to the proposals of his colleagues without dogmatic filters intervening. Making that leap allows to appreciate the work of everybody, regardless of the theory they adscribe to. That has been the case with all the authors cited in this work, and specially of the two big groups of formal syntax whose ideas are in opposition. From their disagreeing positions, and I want this to serve as an acknowledgement, they have been a very important point of reference. Because, in the end, we were not so lonely.

Contents

Chapter 1

INTRODUCTION

The aim of this dissertation is twofold. On the one hand, it wants to provide a characterization of wh-questions in Catalan Sign Language (LSC). Therefore, the first part of the work is devoted to the overview of the literature on the topic of wh-questions in Sign Languages (SLs), and to a description and an analysis of these constructions in that language. On the other hand, it wants to shed some light on the explanation of an exceptional fact that has been observed in sign language wh-questions, namely the possibility and, indeed, the preference for locating wh-expressions in sentence final position. Up to now, formal approaches have been unable to satisfactorily account for this difference between modalities. While some approaches have focused on showing that there is nothing new in wh-questions in SLs, some others have focused on highlighting the particular structures that underlie SLs and the flaws of the general syntactic theory for not including those structures as possible. However, apart from the discrepancies between them at a formal level, none has addressed the differential fact between modalities, namely the possibility of and preference for final location of wh-expressions in SLs.[1]

In the present work, I defend the unity of syntax across modalities. In line with the works that pursue a line of work in which it is not necessary to posit special syntactic particularities for SLs (Petronio and Lillo-Martin 1997), I claim that the hierarchical structure underlying wh-sentences is common to SLs and SpLs.

However, the vision of syntax I have is different from that of those other works. I defend a model in which syntax only has information relating to dominance, and does not encode (almost) any kind of information relating to order. Under this vision, there is no left or right (preceding-following) in the hierarchical structures built by syntax, but just only up and down (dominating-dominated). The information about order is post-syntactical, and it is visible not in Logical Form (LF), but rather in Phonetic Form (PF).

Under this framework, I claim that the differential fact in wh-questions between modalities is not due to a syntactic reason but to a reason of performance, to how SLs and SpLs are externalized. The differential fact is

[1]With the exception of Cecchetto et al. (2009), which I will present in chapter 2, who try to give an explanation based on the possibility to mark syntactic dependencies through non manual markers (NMMs) that SLs have.

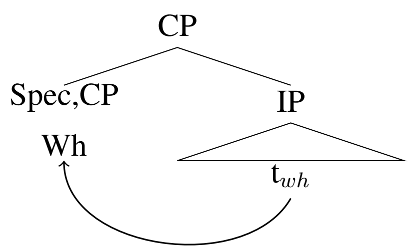
tightly bound to modality itself. This explanation is based on some differences observed in perception and storing of visual and auditory information between modalities. For this reason, two experiments have been designed and carried out to compare differential processing in terms of short term memory (STM), which I claim have important bearings on the issue.

1.1 A differential phenomenon

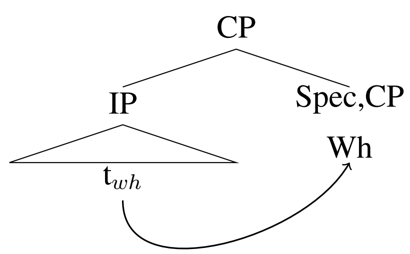
In the study of wh-questions in SLs there is a phenomenon which has not been observed in spoken languages (SpLs) and which has strongly attracted the attention of researchers: the placement of wh-expression at the end of the sentence. The literature on this subject has mainly been devoted to determine the situation of wh-expressions in phrase structure. That is not surprising, since the answer an author gives to that puzzle may have direct and strong bearings on the situation of the specifier of CP in phrase structure. In this regard, it is interesting to compare the main analyses on this topic (leftward and rightward approaches) in the same language, which I will do for ASL in chapter 2.

The consequences each of these approaches has are not trivial. In the case of the approaches supporting leftward movement (1a), that is, those which claim that the underlying derivation involves regular wh-movement to a higher node situated in the left periphery of the sentence, it is possible to preserve the standard view on wh-movement, which is assumed to be universally to the left. These approaches are obviously pursuing the aim of any scientific explanation: to account for the widest amount of possible cases of a phenomenon (in natural language in this case) with the smallest theoretical apparatus possible. Nonetheless, this kind of explanation is weakened if it is put forward at the expense of increasing the complexity of the derivations specific to the languages under study, either through remnant movement operations or through the addition of empty categories. In a mirror image, on the other hand, in the proposals that support rightward movement (1b), it is possible to explain a feature which is specific to sign languages in a simpler manner, at the expense of adding complexity to standard syntactic theory, which should then be allowed to accept movement to the right in some situations.

(1) a.



b.



Nevertheless, it is impossible to find among the analyses an explanation that tackles a fundamental issue rigorously: why are wh-questions constructed this way in many SLs? While SLs have been reported to show a tendency to place wh-expressions at the end of wh-questions (Cecchetto, 2012), this pattern is almost never found in SpLs.[2] Therefore, it seems evident that the difference in the way wh-questions are made has something to do with the fact that we are dealing with different modalities.

The issue of different patterns for different modalities is never the central question in the debate of wh-movement in SLs, but rather a secondary aspect at most. In this regard, a mention must be made of the reflections in Cecchetto et al. (2009) and their proposal of a macrotypological classification of languages based on prosody and the marking of wh-dependencies, which includes an aspect intrinsic to signed modality: multi-dimensionality. Multi-dimensionality is the feature by which signs and non manual markers (NMMs) are articulated simultaneously using different articulators, allowing them to operate in an independent manner to convey different grammatical information.

[2] In the corresponding chapter in the World Atlas of Linguistic Structures (WALS), Dryer mentions two languages that seem to break the rule: Tennet, which places wh-expressions in sentence final position, and Noni, which places wh-expressions in an immediately postverbal position (Dryer, 2013).

1.2 The main topic behind: linearization

The issue about the possible effect of modality in the patterns of distribution of wh-elements (initial or final) hides strong ramifications affecting one of the hottest topics in the study of formal syntactic theory: whether linear order is part of syntax, or rather it is the result of an algorithm of linearization that comes into play later on, to flatten structures out and turn hierarchical trees into strings of words. Explaining facts like the initial or final position of wh-elements necessarily puts the researcher in the position of having to commit either to one view or the other.[3]

Within the first point of view, by which linear order is part of syntax, Kayne's theory (Kayne, 1994) offers an exhaustive vision of how hierarchy and order relate to each other. According to his view, hierarchy totally determines linear order. This relation is univocal: it entails that a given hierarchical structure may only give rise to one linear order and that, therefore, two different linear orders must necessarily be the outcome of different phrase structures.[4]

In this line, cartographic approaches also imply a similar relation between structure and linear order. That is to say, they also imply that the

[3]For instance, in previous generativist frameworks like Principles and Parameters, the head directionality parameter accounted for head-initial and head-final languages. This parameter corresponded to left or right branching in the derivations of each language.

[4]Notice, though, that the relation is not biunivocal. There are cases where a particular linear order could be analyzed as the outcome of two different phrase structures.

structure has an impact on linear order. Under the cartographic view, functional syntactic projections conform a fix template of positions that can be occupied by a limited set of syntactic-semantic elements (Cinque, 1999). It is assumed that this template of functional projections is universal and that those projections are shared by all languages, although not all languages fill them with overt material, and that the specifiers of these projections are landing sites for internal and external merge (Van Craenenbroeck, 2009). The variation in word order is explained, then, by the presence or absence of some of those move and merge operations and by the overt or covert spell-out of some of those projections. This way, around the 80s and 90s of the 20th century, a number of proposals of such templates arose, like the split IP by Pollock (1989), the shell-analysis of VP by Larson (1998) or the CP structure (3) by Rizzi (1997), to cite just a few.

The view that a universal structure can account for the sequential order in all languages has some problems that have been already described (for a general critical overview, see Van Craenenbroeck (2009)). For the concerns of this dissertation, it is specially remarkable that some empirical data show that the relative order between some sets of elements is not always reflected on an absolute ordering between them. That is, the transitivity principle is not always respected, as the Norwegian examples in (2) show (Nilsen, 2003).

(2) a. ***muligens* 'possibly' $<$ *ikke* 'not'**

Ståle har <*ikke> muligens <ikke> spist hvetekanekene
S. has not possibly not eaten the.wheaties
sine.
his

Stanley possibly hasn’t eaten his weathies.

b. ***ikke* ‘not’ < *alltid* ‘always’**

Ståle har <*alltid> ikke <alltid> spist hvetekanekene
S. has always not always eaten the.wheaties
sine.
his

Stanley hasn’t always eaten his weathies.

c. ***alltid* ‘always’ < *muligens* ‘possibly’**

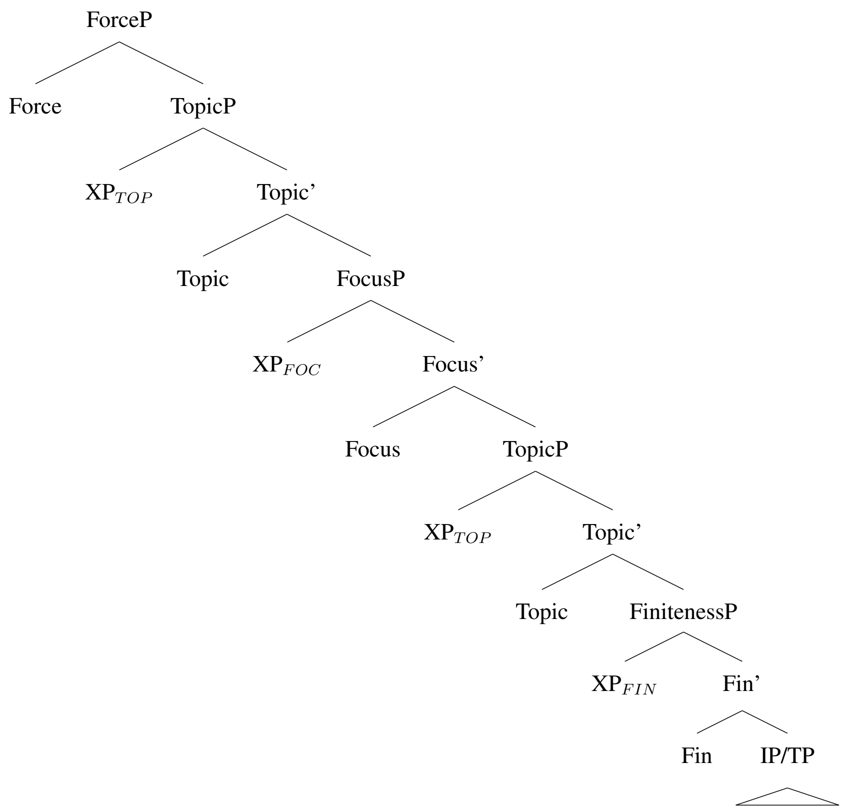
Dette er et morsomt gratis spill hvor spillerne alltid
this is a fun free game where the.players always
mulligens er et klikk fra å vine $1000!
possibly are one click from to win $1000

This is a fun, free game where your’re always possibly a click away from winning $1000!

The examples in (2) show that *muligens* (‘possibly’) must precede *ikke* (‘not’) in (2a), and that *ikke* must precede *alltid* (‘always’) in (2b). However, this does not yield that *muligens* must precede *alltid*, since in fact it is the other way around (2c).

Within the second point of view, by which linearization is a post-syntactic event, Chomsky (1995) conceives syntactic structures as the product of a recursive merge operation, without including specifications

(3)



on linear order. The information about linear order is part of the post-syntactic phonetic interface, so there is no need for it to be repeated in syntax as well. Contrary to Kayne's model, this perspective allows that two different linear orders share the same underlying syntactic structure.

According to these perspectives, it makes no sense talking about left and right in syntactic trees, since they only encode information about dominance relations and not about precedence. This means that syntactic movement is non-directional, it only builds up the tree vertically (Alphonce and Davis, 1997). Trees should be seen as three-dimensional structures. They would behave like Calder mobiles, in which, regardless of the position of the watcher, what matters are the relations of dominance between higher nodes and embedded nodes (1.1). These relations do have a linear correlate after all, for peripheral elements occupy only the edges of the line (either initial or final) while embedded elements can occupy either medial positions or edge positions. It makes no sense to say that a given terminal node precedes another one in such a tridimensional mobile structure.

At this point, it is worth wondering why the trees in the syntactic literature (the ones in the models that do not follow Kayne’s approach) seem to contain information relating to order so often. In fact, some accidental circumstances of syntactic notation have added confusion to some theoretical aspects of order and hierarchy. For instance, in the classic tree depicting wh-movement in English (4), the wh-expression is located “on its left”. The reason is that reading the tree is easier this way, because the nodes of the tree can coincide with the words of the sentence written below it. Nevertheless, that should not imply that syntactic structures have left and right. If we carry out an analysis of a wh-question in Arabic (5), also a wh-fronting language, we could draw the mirror image of that tree, so the nodes coincide again with the sentence written from right to left below it. But the two structures are equivalent. We are forced to write

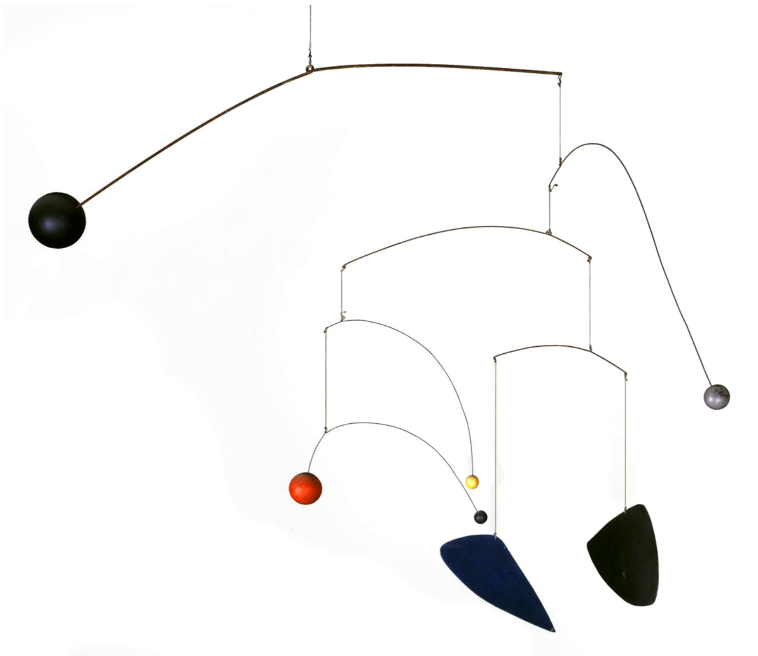


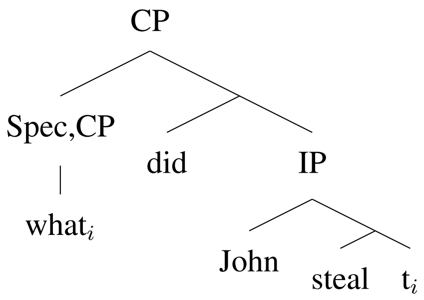
Figure 1.1: Trees are 3D structures.

down trees in flat, two-dimensional surfaces, but the trees themselves are not necessarily two-dimensional.[5]

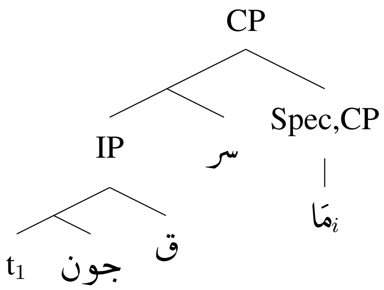
Maybe the bias caused by western writing has influenced us to see right and left in syntactic structures, and, consequently, to see direction in wh-movement. If we accept this line of reasoning and acknowledge the fact that trees like 4 and 5 are equivalent, the irony arises that, ac-

[5]This is a hypothetical case, because, actually, Arabic examples are normally represented on trees or glosses using a romanized version of the Arabic writting system, which uses the latin alphabet and which is written from left to right.

(4)



(5)

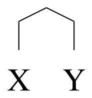


tually, the structures proposed by leftward approaches (1a) and by rightward approaches (1b), which have lighted a hot debate, are in many ways the same. The basic phrase markers proposed by leftward and rightward approaches have the same underlying structure, namely a wh-expression located in a high node called Spec,CP which c-commands the rest of the sentence. For both views, location of Spec,CP to the left or to the right of the structure serves as an explanation for the location of wh-expressions at the beginning or at the end of the sentence. According to these approaches, an initial wh-expression is accounted for by its being placed in a Spec,CP 'to the left' of the tree and a final wh-expression is final because it is located in a Spec,CP ‘to the right’ of the structure. However, as I have already pointed out, these behaviors should actually be explained in terms of ‘before’ and ‘after’, since they are tied to linearization. In other words, the initial or final location of a given peripheral element has a post-syntactic cause, at the phonetic interface, because left and right information is not encoded in the syntactic structure.

Maybe all these considerations do not have serious bearings in some of the works about wh-questions in SpLs. But the moment when SLs appear under the spotlight, it is crucial to be clear about them. Notice, for instance, that years of study and literature on SpLs have left us speaking about concepts like *left periphery*. The implicit claim in that expression has undoubtedly affected the way we approach the formal study of SLs.

In other words, in the relation between hierarchy and linear order it can only be assumed that more peripheral structural elements will be closer to the margins of the word string (beginning and end) while more embedded elements can appear either in the margins or in medial positions of the utterance. Hierarchy prevents, for instance that a higher constituent linearly intervenes between the nodes of a hierarchically lower constituent of the tree. In this sense, some linearizations will never correspond to some hierarchies. Let us illustrate it with a simple example: if we merge two nodes, X and Y, we can draw the resulting structure either like in (6) or in (7). These two representations are completely equivalent in structural terms. They have no difference in terms of hierarchy and none of them gives any differential information about how the linear order will be. Then, as said, it is wrong to assume that the first structure will correspond to the linear order X>Y and the second one to Y>X. At this point, we only know that X and Y are sister nodes, which means that they will be adjacent in the utterance unless some additional operations were applied.

(6)



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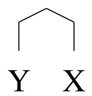
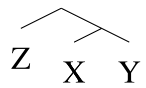


The next merge (Z) yields this structure (8). In the same way shown for the first merge between X and Y, the structure represented in (8) is the same as the one in the three equivalent representations of the trees in (9-11).

(8)



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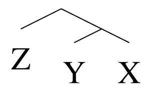

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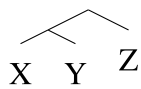

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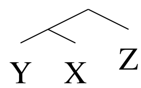


As for linearization, on the other hand, adding Z, four possible linear orders result, namely ZXY, ZYX, XYZ, YXZ. However, as said, hierarchy forbids something from happening. The node Z, which asymmetrically c-commands X and Y, cannot linearly intervene between the nodes of the constituent formed by them (the structure in (8) will never yield *XZY nor *YZX). That is to say, hierarchy prevents a higher node to break a lower constituent in the linearization. When this happens in the linearization (apparently), when we obtain XZY or YZX, it is necessary to postulate a movement at the derivation to promote either X or Y to a higher node. In sum, what matters in hierarchical structure are vertical configurations and not horizontal notions. What matters are dominance and c-command notions.

In this line, in a study about blending constructions by bimodal bilinguals, Donati and Branchini (2013) also suggest that syntactic structure is devoid of information about linear order. Different linear orders that apply to a given phrase marker are the product of different PF linearization algorithms which apply on a single, abstract, purely hierarchical syntactic structure which is shared between both modalities.

It is true that, looking at linear order, operators tend to be linearized preceding the variables they bind, like in wh-fronting sentences. This has been accounted for based on the idea that the syntactic parser does not look for a variable until it finds an operator. From this point of view, the data about final wh-expressions in SLs pose a challenge, since the operator does not precede but follow the variable. In chapter 5 I will present an account for this challenge and I will also present an explanation that has been provided to the processing of non-fronting languages.

As I already pointed out, it seems that the phenomenon of non-*in-situ* final wh-expressions in SLs has to be related to modality in some way, since spoken languages never show this kind of behavior. We could discuss the structures underlying these constructions at a formal level, avoiding the aforementioned misunderstandings, and we probably should do so. But no matter how long or how deep we discuss the issue, we will not be able to escape the question that is haunting us persistently: why does this linearization come up only in SLs? This question forces us to direct the spotlight to another level of analysis: in particular, to how are sign and spoken languages externalized.

1.3 A big leap to modality

This leap to the study of externalization is indeed a big one for the formal linguist writing a dissertation, and probably also for the linguist reading it. It is a huge leap, a change in the framework, which moves away from the study of the underlying hierarchical structures of a language to the study of the articulated expression of that language. Nevertheless, and I must stress this, it is a necessary step because it allows for the connection of some syntactic and phonological facts to some particular differences on perception and storing that have been found between auditory and visual modality. To solve that puzzle, we have to study the particularities of modality which, in turn, will help us shape and define I-language.

For the linguist who studies SLs, looking for differences between modalities is something somewhat uncomfortable, bearing in mind the recent history of the research on this field. As is well known, SLs have not always been considered natural languages, but rather byproducts of the spoken modality or rudimentary communication systems. The acknowledgement that SLs are natural languages is an achievement that has been hard to conquer, step by step, from the middle of the 20th century. During these decades, work has been done carefully and many important discoveries have been put forward that have placed SLs in the place they belong to: full-fledged manifestations of the human faculty of language. During all these years it has become clear that both modalities are comparable in terms of the timing of processing and acquisition timing, in terms of the specific neural mechanisms that underlie language, in terms of sublexical structure (phonology), lexical productivity and syntactic structure and productivity, to cite just a few aspects. In effect, in the study of SLs, the second half of the 20th century is characterized by the fight on linguistic prejudices against signed modality. Still nowadays the SL linguist has to face these prejudices on a daily basis, since the discoveries permeate society really slowly.

Nevertheless, in spite of the permanent (and sometimes exhausting) defense of the equality of SLs, the linguist cannot overlook the fact that both modalities show differences, and that the differences can sometimes explain some phenomena under study. In this sense, identifying said differences is a healthy exercise for the field, because nailing down which aspects are dependent on modality allows us to redefine some issues whose consideration has been biased in the past towards audio-vocal modality. It is not surprising that some differences have been suggested to be the product of particularities of each modality: in the articulators, in the perceptual systems, or in the greater potential of signed modality to make use of iconicity and indexicality (Meier, 2002).

Going back to wh-questions, I reject the idea that we are facing pure parametrical variation. The placement of wh-elements at the end of the sentence in SLs is not just a typological issue, unless we wanted to consider modality a macro-parameter: too conservative a solution which does poorly in explaining a phenomenon with such a clearly defined distribution tied to externalization. The idea in this dissertation is that we are facing a particularity of modality that we have been unsuccessfully trying so far to fit in the frame of some overspecified theories on the hierarchical structures of languages. Precisely because we want to find what both modalities share, we have to be able to identify what makes them different. This way, we keep the integrity of syntax untouched for both modalities.

In the search for the differences, I turn my eyes to an aspect that has an unquestionable role in how sentences are processed: short term memory (STM). The study of STM in signed modality, and the comparison to spoken modality, is not new. For the last two decades, a considerable amount of literature has been produced on this topic. Some differences have been observed in STM between modalities: more specifically, it appears STM span is shorter in signed modality, as we will see in chapter 4. All these studies have led to important theoretical and methodological debates.

1.4 On uniformity: differences between modalities

Modality effects have been alluded to on many occasions in several levels of analysis to account for a variety of phenomena. On some of these occasions there is a tacit assumption that the signed modality is somehow uniform. There is even the hypothesis that SLs might exhibit a smaller degree of variation among them than SpLs (Newport and Supalla, 2000), probably because of some characteristics specific to the signed modality. In line with this, there are several lines of research that try to account for the differing findings between modalities.

One such finding is the preference of SLs for non-concatenative, simultaneous morphology, in contrast with SpLs' preference for linear affixation. This difference, widely known in the field, is attributed to the restrictions imposed by the signed modality. In this sense, these restrictions should be seen rather as the use of a dimension which is unavailable to SpLs (the spatial dimension), instead of as a limitation *per se*. Somehow, this spatial dimension is an element the visual modality cannot overlook. In line with this idea, there are reports of the difficulties of deaf children to acquire Manually Coded English (MCE) (Supalla, 1991). MCE is a visual-gestural transcription of spoken English that has been used in the United States' educational system. Supalla (1991) wanted to test if the structure of a spoken language can be incorporated into the signed modality satisfactorily or if, on the contrary, there are restrictions tied to modality that condition the way a language can be structured. In effect, Supalla observes how deaf children exposed to MCE (and not previously exposed to ASL or any other SL) transform this language (spoken English encoded manually) into another one with a spatially-based structure, more similar to ASL. The author concludes that, although both modalities share the same componential system, the way the components are formed and combined is different. Children create their own linguistic structure to "meet general modality constraints on signed (versus spoken) languages".

Another line of research is based on the study of unrelated sign languages in contact (Supalla and Webb, 1995). In a cross-linguistic study of case marking in 15 signed languages, the authors observed many differences among them. Nevertheless, they also report a very strong common tendency to use space to mark verbal agreement with the subject and the object. This kind of similarities is what make SLs capable of developing a signed pidgin ("International Sign") 'that retains these morphological structures and that is unexpectedly more complex than spoken pidgins'. It has also been suggested that visual-gestural modality has a lot more structure even in non-linguistic uses (regardless of its users being deaf or hearing). That could account for the uniformity of SLs in the grammaticalization of this type of non-linguistic source.

Of course, the idea that restrictions on modality are the source of the low rate of variation in SLs is still controversial. There are two main objections that one could raise to it. First, we do not currently have a representative enough pool of described SLs to prove that the relation between variation and restrictions goes in one sense or the other, or if it is even relevant or not. In fact, the statement itself that there is a lower degree of variation is still to be demonstrated beyond all doubts. Doing so is not easy, because many SLs are threatened by the big prestigious SLs like ASL or LSF. These big languages have had a big impact in communities where there was already an established, autochthonous SL. In this respect,Meier (2002) mentions the case of the indigenous SLs in Southeast Asia, which are being 'substantially influenced' by ASL and LSF.

The second objection to the alleged uniformity between SLs comes from the fact that SLs are young languages and that this is the feature that is in the roots of their huge similarities, and not modality. Creoles are reported to have a greater structural uniformity (Bickerton, 1981). From this point of view, the origin of differences would not be in modality, but in some features that are inherent to any creole. Nevertheless, Meier (2002) points out that existing creole languages in spoken modality do not need to be structurally similar to signed creole languages, because the latter can have as their superstratum homesign gestures or other gestures shared by the hearing and deaf communities. The fact that these ‘non-linguistic’ gestures are at the basis of some SLs has been proposed as a source of differences in the structure of signed modality. According to Meier, these gestures may have a higher degree of motivation and, therefore, a different internal structure. With these words, Meier is referring to a higher degree of iconicity in these items which would cause that, sometimes, the arbitrary relationship between form and sense be missing, resulting in different paradigmatic regularities in the system.

However, this line of reasoning is not devoid of problems. The signs deriving from homesigns or emblems are also the result of convention, since they are elements shared by two or more speakers. In the end, for a native signer acquiring his first language, the motivation of a sign will surely be opaque. All lexical items in any SL must pass, as in any other case, through the filter of grammar and phonology.

Before discussing the state of the art, let us quickly review the standard view on wh-questions in spoken languages.

1.5 Wh-questions in spoken languages

Before reviewing what has been said for SL wh-questions, which will be done in the next chapter, let us see what has been said for the spoken modality.

Wh-questions constitute a paradigmatic instance of the displacement property in language. Displacement in language means that a given constituent, the wh-expression in this case, is pronounced in a place other than the one it is thematically interpreted in. This can be seen in (12), where the wh-expression, an object in this case, is pronounced at the front but interpreted as a verbal object, which normally appears following the verb.

(12) What$_i$ did John buy t$_i$?

When the wh-expression is complex, this operation may break the wh-constituent, taking only the wh-element and leaving the rest of the constituent, the restrictor, in its base position. This is illustrated in the Polish example (13)[6] where *jaki* (which) has been extracted from the wh-phrase *jaki numer* (which number), and fronted. Some other times, the restrictor is pied piped (i.e. dragged along) by the wh-element and they both end up located on the front, like in (14).

(13) Jaki wykrecilés numer?
what dial.PAST number

[6]Extracted from Van Kampen (1994).

What number did you dial?

(14) Which car have you bought?

In all these cases, this displacement can be seen as a distance dependency between two syntactic positions. Wh-expressions in (12 to 14) are pronounced in a position, at the front, but they are interpreted in another, the object position, where we would expect them to appear. These two positions are in a dependency relation and they are subject to some constraints which have been richly studied.

It is extensively assumed that this displacement can be explained through the operation *move*, or *internal merge*,[7] which extracts elements from constituents and locates them in different places. Wh-movement is described differently according to each theory, but a widely accepted view is that wh-elements move to check their [+wh] features with the C head's own features. To do so, they move to Spec,CP, located in the periphery of the tree.

There are languages in which wh-movement is carried out covertly. They are called *wh-in-situ languages*. These languages, like Chinese, show the wh-expressions *in situ*, as if no movement had taken place. This

[7]The operations *move* and *merge* have been unified in a single one, *merge*. Under this unified view, the operation *move* is thought of as *internal merge* (internal to the derivation, since targeted constituents are taken from the object formed along the derivation). The term *external merge* would be applied to elements which are taken from the numeration, that is, from outside this object.

can be seen in (15)[8] where the wh-object *shei* (who) is pronounced in the object position, its base location since Chinese is an SVO language.

(15) Ni xihuan shei?
you like who.OBJ
Who do you like?

Some languages show both patterns, wh-fronting and wh-*in-situ*, for conveying different meanings, such as the presence of presupposed information or a demand for repetition. This is the case of English *echo* questions (16), for instance. Some other languages, like Portuguese, show both patterns with no particular meaning associated to each option (17-18). In these languages the choice of one or the other does not seem to have any impact on the semantic interpretation of the sentence.

(16) You bought what?

(17) Você viu quem?
you saw whoOBJ
Who did you see?

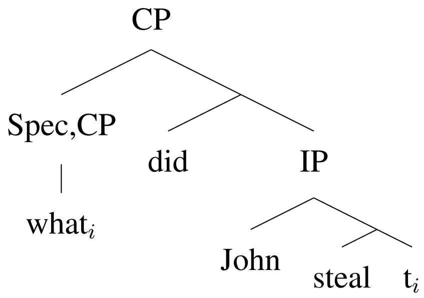
(18) Quem viu você?
who.OBJ saw you
Who did you see?

Both in wh-fronting cases and in wh-*in-situ* cases, wh-expressions are assumed to have moved to a designated position on a higher layer

[8] Example extracted from Huang et al. (2009)

of the clause structure. This designated layer is the Complementizer Phrase (CP), a functional layer outside the VP domain, in the periphery of the sentence (or *left periphery*). From this position, Spec,CP, the wh-expression can bind its variable, the trace it left in its original position, it occupies a scope position, and it can check its wh-features with C, which hosts the sentence illocutionary force (19). As said, the difference between wh-fronting instances and wh-*in-situ* instances is that the movement is overt (and thus visible to PF) in the former, while covert (it is produced at the level of LF) in the latter.

(19)



1.6 Summary

In this chapter I have introduced some basic aspects that justify some of the basic questions this dissertation aims to address. In the characterization of wh-questions in LSC, there is a fact that cannot be disregarded, namely the final location of wh-expressions. While the SLs studied so far not only allow but in fact prefer this final location for these expressions, SpLs never exhibit this pattern. In the debate on wh-questions in

SLs, the main focus has been put precisely on determining the right or left location of Spec,CP in the syntactic structure. In this regard, I have introduced some ideas against some views of the syntactic hierarchy, specially in what concerns its relation with the sequential order of the elements in the utterance. In line with Chomsky (1995), in this dissertation I hold a view of hierarchy that is free of information dealing with linear order, since linear order is something that happens later; it is postsyntactic.

In general, in the debate on wh-questions in SLs, a question has been neglected that deserves to be formulated: why do SLs exhibit this pattern while SpLs do not? This question motivates the second part of this work: an experimental study that is based on the idea that the difference between modalities comes from a difference in how we perceive and store visual and auditory information. In this psycholinguistic approach, I study specifically the differences in Short Term Memory (STM) between modalities.

The dissertation is structured as follows: in chapter 2 I present the state of the art of wh-questions in SLs. In 3 I present a description of wh-questions in LSC and a proposal for their analysis bearing in mind the caveats I have mentioned above. In chapter 4, I present a state of the art of the topic of STM in spoken and signed modalities, and two experiments carried out with Catalan speakers and LSC signers. Chapter 5 is devoted to the role of WM differences in the differential pattern of wh-questions between modalities. Chapter 6 presents conclusions.

Chapter 2

WH-QUESTIONS IN SIGN LANGUAGES

2.1 A challenge for standard syntactic models

In this chapter I present a state of the art on the research about wh-questions in sign languages. I develop the key points for each view and the main aspects of disagreement among them, which, in the case of ASL, sometimes are not limited to the analysis of the relevant data but to the acceptability of those data themselves.

It is not surprising that sign language wh-questions have sparkled important debates among researchers. Like in the spoken language field, some of the assumptions one holds with regard to those structures involve very important assumptions about syntactic theory and about human language. As already mentioned, in the sign language literature, in this regard, the main topic discussed so far is the structural location of Spec,CP, namely whether it is located to the left or to the right with respect to the sentence. For those approaches that assume that wh-questions involve an internal merge operation (movement operation), the location of Spec,CP in the structure usually implies an assumption on the direction of wh-movement, leftwards or rightwards.

In chapter 1 I have reviewed some misunderstandings and some uses of the notions of left and right in syntax that I consider inadequate when applied to hierarchical structures. However, for the sake of simplicity in the discussion of the argumentations to be reviewed in this chapter, I will sometimes use the notions of left and right in the same way the authors I am discussing do.

Although we do not have as many data from sign languages as we have from spoken languages, the sign languages described so far seem to follow a specific, differential pattern, which spoken languages never follow: they tend to place wh-expressions at the end of the sentence as the default option (2.1). The only sign language that seems to follow the opposite pattern is Austrian Sign Language (ÖSG) (Schalber 2006; Cecchetto 2012).

However, in signed modality, word order is not the only piece of evidence we use to make claims about the structural location of certain syn-

American Sign Language (ASL) Brazilian Sign Language (*Língua de Sinais Brasileira*, LSB) Wh-items may occur at the left periphery, at the right periphery and *in situ*. The extent to which these options are available in ASL remains controversial.
Croatian Sign Language (*Hrvatski Znakovni Jezik*, HZJ), cf. Šarac/Wilbur (2006) Finnish Sign Language (FinSL), cf. Savoilanen (2006) New Zealand Sign Language (NZSL), cf. McKee (2006) Wh-items can appear sentence initially, sentence finally or doubled in both positions.
Australian Sign Language (Auslan), cf. Johnston/Schembri (2007) Wh-items can appear *in situ*, in sentence initial position or doubled in sentence initial and in sentence final position.
Austrian Sign Language (*Österreichische Gebärdensprache*, ÖGS), cf. Šarac/Schalber/Alibašić/Wilbur (2007) The most "neutral" position for wh-items is at the left edge.
Israeli Sign Language (ISL), cf. Meir (2004) Sign Language of the Netherlands (*Nederlandse Gebarentaal*, NGT), cf. Aboh/Pfau (to appear) Catalan Sign Language(*Llengua de Signes Catalana*, LSC), cf. Quer et al. (2005) Spanish Sign Language (*Lengua de Signos Española*, LSE), cf. Herrero (2009) The natural position of wh-phrases is at the right edge.
Japanese Sign Language (*Nihon Shuwa*, NS), cf. Morgan (2006) Wh-signs are typically, but not necessarily clause final. Wh-phrases can also occur *in situ* and on the left, in which case placement of a copy at the end of the sentence is not unusual.
Hong Kong Sign Language (HKSL), cf. Tang (2006). The wh-signs for argument questions are either *in situ* or in clause final position. Wh-signs for adjuncts are generally clause final. Movement of the wh-sign in clause initial position is not allowed.
Italian Sign Language (*Lingua dei Segni Italiana*, LIS) Indo-Pakistani Sign Language (IPSL) Wh-phrases move to the right periphery, while movement to the left periphery is altogether banned.

Table 2.1: Position of wh-signs in different sign languages, from Cecchetto (2012).

tactic objects. Another very important source of information to bear in mind when analyzing syntactic structures in general and wh-questions in particular is the observation of NMMs behavior, specifically the observation of their kind and spreading patterns. NMMs are crucial to gain insights into syntactic phenomena and any approach has to address them and fit them in its explanations. As a matter of fact, NMMs encode information at different linguistic levels, such as phonology, morphology, syntax and pragmatics. Prosodic functions have also been described for NMMs, distinguishing between edge markers and domain markers (Pfau and Quer, 2010). NMMs seem to work in a left-to-right way and they generally tend to match with syntactic constituents. Some aspects about how syntax and NMMs are related are still not clear, as it happens to prosody in general. It is not clear whether syntax feeds the realization of NMMs (this is the main view of it) or, in a more innovative way, whether NMMs feed syntax (Cecchetto et al. 2009, following Richards 2006). In other words, it is not clear whether syntactic structure determines prosodic behavior or whether it is the other way around. This aspect is only one more example of how wh-questions claims can have implications for high level assumptions and can configure the main views of syntax and even of the human faculty of language. That is why wh-questions constitute such a central topic in linguistics.

Before going into Catalan Sign Language, let us have a look at what has been said for wh-questions in other sign languages. This will help us to figure out what the crucial points of the discussion are, and how each approach deals with them. In the following sections I describe some proposals that have been made for different SLs, mainly for American

Sign Language (ASL) and Italian Sign Language (LIS).

2.2 Leftward analysis in ASL

2.2.1 Petronio and Lillo-Martin's perspective

ASL is an SVO language that seems to show wh-expressions either at the beginning of the clause (20), *in situ* (21) and at the end of it (22)[1].

(20) $\overline{\text{WHAT JOHN BUY}}^{\text{whq}}$

What did John buy?

(21) $\overline{\text{JOHN BUY WHAT}}^{\text{whq}}$

What did John buy?

(22) $\overline{\text{BUY CAR WHO}}^{\text{whq}}$

Who bought the car?

In this respect, the information available in the literature is not always consistent, and sometimes conflicting. As a matter of fact, the discrepancies between the leftward and rightward analyses are not only based on the structures they propose, but also on part of the data, on what is canonical and what is not, and even on what is grammatical and what is not. For instance, (22) has obtained mixed judgments sometimes and directly rejecting judgments some other times.

[1] Examples from Petronio and Lillo-Martin (1997)

Leftward movement approaches posit there is nothing particular in ASL wh-movement. Specifically, they claim there is a standard leftward movement with some particularities in the derivation that yield a right-location of some wh-expressions that is only apparent. The most remarkable contribution to this point of view is the one by Petronio and Lillo-Martin (1997). In this section I briefly present their approach. All the examples of this section belong to ASL and their grammaticality judgments are the ones provided by the authors. As it will be shown in the next section, the characterization of the data is not completely coincident with other works on ASL wh-questions.

Petronio and Lillo-Martin (1997) posit that in ASL Spec,CP is located on the left periphery as in any spoken language. Thus, wh-expressions in ASL would normally move in that direction. According to this work, the apparent rightward location of wh-expressions is something attributable to discourse factors and individual particularities of some speakers, which lead to the appearance of wh-expressions in final position. This proposal relies heavily on a construction that we can also find in LSC and in many sign languages studied so far, namely doubled constructions. Doubled constructions are those who show two coreferential wh-expressions, one at the beginning of the sentence and the other one at the end (23)[2]. The

[2]However, as I show later on, this is not the only possible distribution, since Catalan Sign Language also exhibits doubled constructions with one wh-expression *in situ* and the other one in final position.

structure proposed for these constructions is central in their argumentation and it is claimed to reveal the structure of other constructions. In their view, doubled constructions allow us to see the actual structure of wh-questions, since it is overt, unlike other constructions which keep some structure parts hidden.

(23) $\overline{\text{WHAT NANCY BUY YESTERDAY WHAT}}^{\text{wh}}$

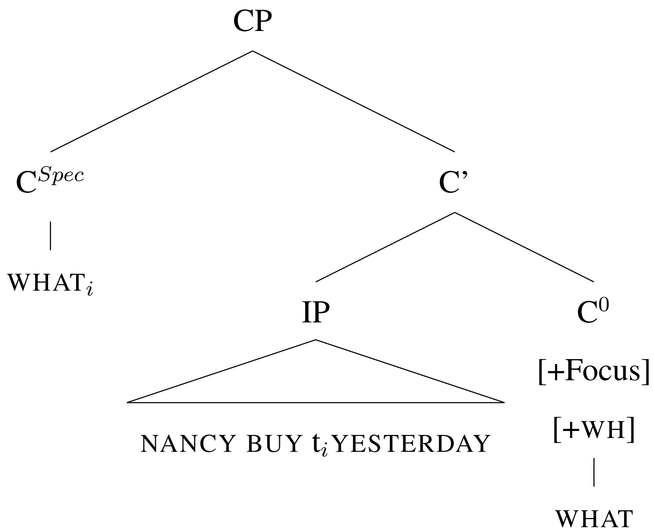
What did Nancy buy yesterday?

Petronio and Lillo-Martin (1997) propose an analysis of a double focus position for these structures. The wh-expression of the rightmost position is base-generated at the head C and has the features [+F(ocus), +Wh]. According to the authors, the other wh-expression, the one on the left, which has the same features, is the actual wh-expression of the sentence. This wh-expression moves overtly to Spec,CP, to the left periphery (24).

This analysis makes it possible to unify the ASL syntactic structure with the standard syntactic structure provided for spoken languages, since Spec,CP is on the left and wh-movement is leftwards.

In fact, the analysis of these doubled constructions, which would be subject to classic island conditions (Petronio, 1993), allows them to derive many other examples, which would share the same underlying structure. Since they posit a rightward CP head, the generation of a focalized element on the right is possible. This way, the authors can also account for non-wh-focused doubles like CANNOT in (25), which are present in

(24)



many sign languages.

(25) $\overline{\text{ANN CANNOT READ CANNOT}}^{\text{neg}}$

Ann can't read.

Crucially for their argumentation, Petronio and Lillo-Martin (1997) report that phrases cannot occupy this rightward position (26). As we will see later on, the rightward analysis for ASL by ABKN, turns out not to agree on this piece of data. I refer to the rightward movement group for ASL as ABKN (in the next section I detail its members). According to ABKN, the rightward position in ASL can be occupied by phrases and not only by heads.

(26) * $\overline{\text{ANN CANNOT READ CANNOT READ}}^{\text{neg}}$

In this respect, wh-doubles such of those in (23) would be comparable to non-wh-doubles (25) with only one difference: wh-doubles can move overtly while non-wh-doubles do so at LF. In example (23), the initial wh-expression (WHAT) is claimed to have moved overtly to Spec,CP while in (25) the first modal (CANNOT) is *in situ*.

This way, the analysis of double constructions by Petronio and Lillo-Martin (1997) is claimed to reveal the structure behind sentences with one final non-*in-situ* wh-expression (27), which could be a problem for leftward approaches at first glance[3]. The explanation is as follows: the authors resort to a well-known feature of ASL, namely the fact that ASL allows null arguments if it is possible to recover them from the context. These null arguments can also be wh-expressions, provided that the context is informative enough (28). Building on this property, Petronio and Lillo-Martin (1997) account for final wh-expressions by positing an initial null wh-expression plus the base-generated double focus element in final position, in the C head (29).[4] As said, for Petronio and Lillo-Martin (1997), wh-doubles are generally comparable to non-wh-doubles. Thus, the analysis provided by Petronio and Lillo-Martin (1997) for final wh-sentences is also applied to other final non-wh-expressions that participate in doubled constructions, like modals, which I just mentioned 26. Thus,

[3]Note that final wh-expressions are fully grammatical for ABKN, while Petronio and Lillo-Martin (1997) have found discrepancies between speakers.

[4]The bracketed representation is built from their analyses.

this analysis would apply to sentences with a final modal, which would also be a base generated focus with the twin null (30).

(27) $\overline{\text{BUY CAR WHO}}^{\text{wh}}$

Who bought the car?

(28) $\overline{\text{EARRINGS}}^{\text{t}}\ \overline{e\ \text{GIFT}_2}^{\text{wh}}$

Who gave you the earrings?

(29) $\overline{e\ \text{BUY CAR WHO}}^{\text{wh}}$

Who bought the car?

[e [[BUY CAR $]_{\text{IP}}$ WHO_{C^0} $]_{\text{C'}}$ $]_{\text{CP}}$

(30) $\overline{\text{ANN } e \text{ READ CANNOT}}^{\text{neg}}$

Ann can't read.

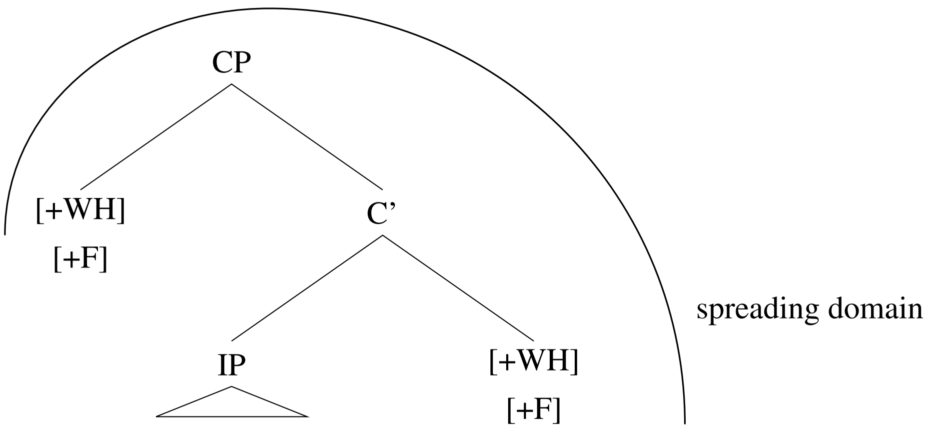
Sentences with initial wh-elements (31) are straightforwardly derived from Petronio and Lillo-Martin (1997)'s analysis. However, as the authors admit, these examples are not universally accepted. This is, again, another instance of discrepancy between Petronio and Lillo-Martin (1997) and ABKN about the data, since the latter directly mark these sentences as ungrammatical. Petronio and Lillo-Martin (1997) address this difference between signers resorting to an additional requirement some signers have: for some ASL signers, a head C marked with the features [+F, +Wh] must be associated to lexical material, i.e. it cannot be null. In contrast, cases like (29) represent the judgments of those signers that do not have such requirement. This way, the authors provide an additional explanation for the discrepancies observed between speakers, which the rightward approach does not even recognize.

(31) $\overline{\text{WHAT JOHN BUY}}^{\text{wh}}$

What did John buy?

As for NMMs, Petronio and Lillo-Martin (1997) claim that wh-NMMs reflect syntactic structure, but their account of the their spreading is rather more general than the one by ABKN, as we will see next. According to Petronio and Lillo-Martin (1997), NMMs are the realization of the [+F, +Wh] features of an interrogative head C, which are shared by its specifier through Spec-head agreement. From this point of view, the spreading of NMMs is obligatory over the whole sentence, as shown in (32).

(32)



However, as I will show later on, in ASL some sentences involving final wh-expressions do not show spreading over the whole utterance.

Petronio and Lillo-Martin (1997) provide an alternative analysis for these cases. These sentences are accounted for through a biclausal analysis. Sentences like (33), which are reported as grammatical by ABKN, would involve a wh-question which is a separate clause, like (34). In fact, the material that precedes the wh-expression is reported to allow a head nodding NMM (35). According to the authors, this material is a sentence by its own and presents some presupposed information.

(33) $\overline{\text{BUY CAR}}^{\text{hn}}\ \overline{\text{WHO}}^{\text{wh}}$

Some did buy a car. Who?

(34) SOMEONE BUY CAR $\overline{\text{WHO}}^{\text{wh}}$

Someone bought a car. Who?

(35) $\overline{\text{SOMEONE BUY CAR}}^{\text{hn}}\ \overline{\text{WHO}}^{\text{wh}}$

Some did buy a car. Who?

Another structure provided by Petronio and Lillo-Martin (1997) to give support to the leftward analysis are indirect questions. The data presented to provide support for their proposal are: i) left-located wh-expressions in the indirect question are preferred, ii) indirect questions are marked with a different NMM, and iii) indirect questions cannot have a double.

Petronio and Lillo-Martin (1997) report a strong preference for wh-expressions to appear on the left in the indirect question (36), although they can also appear *in situ* (37).

(36) $\overline{\text{I DON'T-KNOW WHAT HE BUY}}^{\text{hs/ponder}}$

I don't know what he bought.

(37) $\overline{\text{I KNOW YOU LIKE WHO}}^{\text{hn}}$

I know who you like.

Since Petronio and Lillo-Martin (1997) claimed the wh-NMMs to be the realization of [+Wh, +F] C, they expect indirect questions not to be marked with the NMMs typically found in direct questions. This is derived from the fact that they stipulate indirect questions are not marked [+F, +WH]. This stipulation reflects the idea that there is one focus per sentence and that it is a root phenomenon (Sandler and Lillo-Martin, 2006). In fact, they report that indirect questions allow different NMMs from regular wh-questions, like head nods, side-to-side headshakes and pondering or puzzling facial expression.

Moreover, the authors report the impossibility of doubling wh-expressions in indirect questions. Recall that they proposed a double focus analysis for doublings. Therefore, since indirect questions have no [+F] feature, the authors expect them not to show doublings (38).[5]

[5] Nevertheless, the ungrammaticality of 38 could be due to the matrix verb constraints. The authors do not provide doubling examples in indirect questions with verbs like *wonder*. They interpret cases like JOHN WONDER $\overline{\text{MY MOTHER BOUGHT WHAT}}^{\text{whq}}$, with grammatical object clauses containing final wh-expressions with the matrix verb

(38) * $\overline{\text{I KNOW WHO WIN WHO}}^{\text{hn}}$

Another interesting piece of data Petronio and Lillo-Martin (1997) provide is the judgment inconsistencies in wh-long-distance movement instances. Lillo-Martin (1990) reported this impossibility already. Leftward wh-extractions from an embedded clause seem not to be fully accepted (39), since some informants require a second identical wh-expression at the end of the sentence (40).

(39) $\overline{\text{WHO JOHN THINK MARY LIKE}}^{\text{whq}}$

Who does John think Mary likes?

(40) $\overline{\text{WHO JOHN THINK MARY LIKE WHO}}^{\text{whq}}$

Who does John think Mary likes?

The explanation for that is the same one provided for simple sentences, namely that some informants require a head C with [+Wh, +F] features to be filled with lexical material. That is why the final wh-expression is required for the sentence to be grammatical.

However, some informants do not even accept (40) as grammatical. The explanation they give to this fact is that for some informants verbs like THINK are bridge verbs, which allow long-distance wh-extraction, while for some others they are not.

wonder, as direct root questions.

The leftward analysis by Petronio and Lillo-Martin (1997) can be summarized this way: A double focus structure is posited to underlie wh-questions. In this structure, the actual wh-expression standardly moves leftwards from its *in situ* position in the clause to Spec,CP. On the other hand, there is a right-located focus double, which is base-generated in the C head, on the right. This structure is presented to be fully overt in doubled constructions. Doubled constructions have an initial and a coreferential final wh-expression. The former is the actual wh-expression, and the latter is the double. In the case of wh-questions with a single wh-non-*in-situ*-final element, this analysis is also posited. The only difference is the presence of a left-located null element, in Spec,CP. The rejection of examples with only one fronted wh-object by some informants is seen as a requirement of filling the C head with lexical material when it is [+F]. That is to say, a [+F] C head must be explicit for some ASL signers. Wh-NMMs are the realization of [+F, +Wh] features of the interrogative head C, shared by its specifier by Spec-head agreement. This means NMMs must appear over the whole sentence. Leftward-wh-long extraction from embedded clauses is not well accepted in ASL, since some informants require another final-wh-expression for it to be grammatical. According to Petronio and Lillo-Martin (1997), the requirement of an explicit C head when it is [+F] may account for that. In the cases where not even the final doubling makes them acceptable, they suggest that, for some informants, verbs like THINK are bridge verbs, while for others they are not.

2.2.2 Wilbur's perspective

Wilbur (2011) contributes to the debate of wh-movement in ASL from a different point of view, in a broader study on the behavior of NMMs in ASL. According to this author, the behavior of brow raise and brow lowering in ASL is motivated by the presence of some semantic operator, which allows her to connect different NMMs to their semantic functions. More specifically, she classifies the semantic operators associated to NMMs into monadic operators and dyadic operators. She argues that the presence of a given operator corresponds to the presence of a given related NMM, and that the category of the semantic operator determines the different spreading scopes of NMMs (Wilbur, 2011). One of the main consequences of this analysis is that it allows her to make a proposal in support of the leftward location of CP in ASL.[6]

Monadic operators (like [+wh] or [+neg]) apply to a single argument. In the case of [+wh] operators, for instance, they delimit a set from which one element must be identified (*who[m]* for people, *what* for inanimates, *where* for places, etc.). In the case of [+neg] operators, a constituent is selected to change its polarity. The NMMs associated to monadic operators, in this case brow lowering and negative headshake, must spread over

[6] Wilbur and Patschke (1999) had already accepted the left position of Spec,CP in a study of brow raise in ASL, which they linked not to semantic considerations, but to syntactic ones. Specifically, they claim that brow raise occurs in the A'-positions of structures headed by restrictive [-wh] operators.

their c-command domain.

Dyadic operators, on the other hand, apply to two arguments, in the sense that they establish relations between two semantic constituents. For instance, a dyadic operator is involved in a conditional structure (*If X, then Y*) or in topics (*As for X, Y*). In (41) X (*she does not join us*) and Y (*I will go to the dinner*) are the two semantic constituents, and they are linked by the fact that Y is only true if the conditions on X are met. In this case, the conditional is the dyadic operator. Something similar is true for topic constructions like (42), with the difference that in this case the topic is the dyadic operator. In both cases, the restriction in the antecedent clause is what must be accomplished for Y (the matrix clause) to happen/be true. Unlike in the case of monadic operators, the NMMs associated to dyadic operators, in this case brow raise, spread over the semantic restriction (the Y constituent), and not over the c-command domain (the X constituent).

(41) If she does not join us, I will go to the dinner.

(42) As for John, he will come.

In sum, in ASL, NMMs associated to monadic operators spread over their c-command domain and NMMs associated to dyadic operators spread over their semantic restriction. For instance, in (43), the negative headshake associated to the negative operator spreads over its c-command domain, namely the VP.[7][8]

[7]ASL examples in this section are from Wilbur (2011)

[8]This example shows that ASL allows the omission of the negative lexical sign NOT.

(43) JOHN $\overline{[_{\text{NEGP}}[_{\text{NEG}}\text{+NEG}][_{\text{VP}}\text{BUY HOUSE}]]}^{\text{hs}}$

John does not buy a house.

By contrast, the NMMs associated to dyadic operators spread over their semantic restriction. For, instance, (44) shows a conditional structure in ASL, which, as said, involves a dyadic operator, the conditional. The NMM associated to the semantic operator, in this case brow raise, spreads over the semantic restriction, (IF) RAIN TOMORROW, that is to say, over the conditions necessary for the second event to be true.

(44) $\overline{\text{(IF) RAIN TOMORROW}}^{\text{br}}$, PICNIC CANCEL

If it rains tomorrow, the picnic will be cancelled/is cancelled.

Although it is not the main point of her paper, Wilbur provides some evidence to support the idea that the structure of the sentence has a left-located Spec,CP, and that wh-movement is leftwards. Examples like (45) are provided to support the position of Spec,CP to the left of the sentence, as standard views assume. Since the head C is on the right in ASL, it is concluded that, in (45), WHAT can only be in Spec,CP. That is to say, WHAT has been fronted to Spec,CP, as in standard fronting languages. When fronting to Spec,CP, the brow lowering NMM must spread.

When this happens, the NMM must spread over the c-command domain of the operator. When the sign NOT is present, the NMM can affect only the lexical sign without spreading.

(45) $\text{CARY } [_{\text{VP}} \text{ WONDER } [_{\text{CP}} \overline{\text{WHAT } [_{\text{TP}} \text{ SUSAN BUY } t_{\text{WH}} \text{ YESTERDAY}}^{\text{bl}} \; [_{\text{C}}[\text{+WH}]]]]$

However, it has to be said that the mirror image of WHAT in (45) is also possible in ASL. It is possible for WHAT to appear in final position, after the adverbial. These examples are in fact provided in Wilbur (2011) as well (46). The explanation for the position of WHAT in these instances is that it has moved to the head C, which is right-located, since the subordinate clause is the complement of WONDER and its head C contains [+wh]. Precisely because the wh-expression is in the head C in (46) the NMM may spread over the embedded clause or remain only affecting the wh-sign. I will come back to wh-final-location examples and show a different account for them in the rightward movement proposals.

(46) a. $\text{CARY } [_{\text{VP}} \text{ WONDER } [_{\text{CP}} [_{\text{TP}} \overline{\text{SUSAN BUY } t_{\text{WH}} \text{ YESTERDAY}][_{\text{C}}\text{WHAT } [\text{+WH}]]]]}^{\text{bl}}$

b. $\text{CARY } [_{\text{VP}} \text{ WONDER } [_{\text{CP}} [_{\text{TP}} \text{ SUSAN BUY } t_{\text{WH}} \text{ YESTERDAY}][_{\text{C}} \overline{\text{WHAT } [\text{+WH}]}^{\text{bl}}]]]$

Under this view, it is still necessary to account for the ungrammaticality of examples like (47). Such ungrammaticality is explained by taking into account the nature and structural location of the NMM brow lowering. Wilbur claims that it is not lexically associated to the wh-expression but rather associated to the [+wh] feature in C, which is on the right. If brow lowering was lexically associated to the wh-expression, one would expect the absence of spreading of NMMs in (47) to be grammatical.

(47) $^{*}\text{ JOHN BUY } \overline{\text{WHAT}}^{\text{bl}} \text{ YESTERDAY}$

Summing up, Wilbur (2011) provides an account for the differential behavior of some NMMs, among which there is the brow lowering associated with wh-questions. She suggests these differences are semantically motivated. Specifically, she observes two differential spreading domains, namely the c-command domain and the semantic restriction domain, which correspond to two kinds of semantic operators. In the case of wh-questions, since the operator is monadic, the spreading scope is over the c-command domain of the [+wh] feature in C. With regard to the location of Spec,CP and the direction of wh-movement, Wilbur (2011) aligns with leftward analyses and standard views on the spoken literature. In her approach, Spec,CP is on the left and wh-movement is towards this direction. With regard to the nature and syntactic location of brow lowering NMMs, they are associated with C and not lexically associated.

2.2.3 Multi-dominance perspective

Within the leftward approaches, Churng (2006, 2011) defends that not only Spec,CP is on the left, but also the head C. Her analysis puts the stress in differentiating focus movement and wh-movement. More specifically, Churng (2011) analyzes multiple wh-questions in ASL. She proposes a derivation in the theoretical framework known as Parallel Merge or Multi-dominance perspective. Before we go into her vision of multiple wh-questions, I will present her proposal for regular wh-questions.

Regular wh-questions are derived by standard leftward movement to Spec,CP as (48) shows. In (48), the wh-subject has moved to Spec,CP from inside the VP. In ASL, wh-questions with initial wh-expressions show a spreading of the wh-NMMs to the end of the sentence. To account for this behavior, the author adds the abstract non-manual lexical item for the wh-marking in a higher projection, namely CP2. This way, the spreading over the c-command domain of the wh-expression is accounted for.

(48) $\overline{[_{\text{CP}_2} \text{ (WH) } [_{\text{CP}_1} \text{ WHO } [_{\text{TP}}\ t_{who}\ [_{\text{VP}}\ t_{who} \text{ LOVE JOHN }]]]]}^{\text{wh}}$

Who loves John?

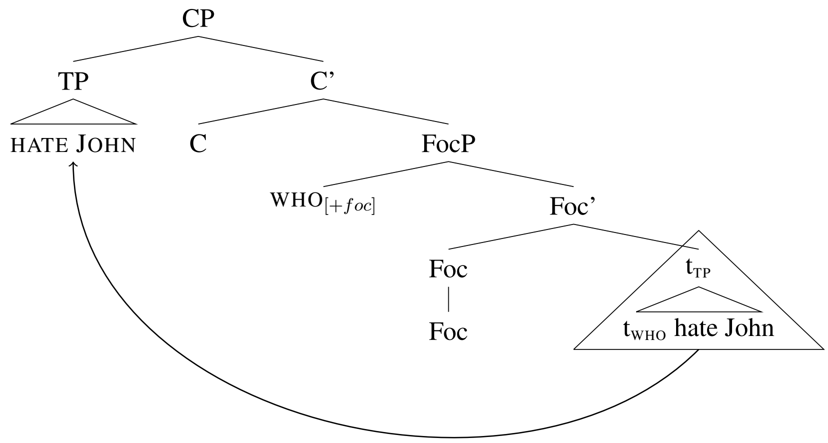
However, as mentioned in previous sections, ASL has final wh-expressions as well, like in example (49), taken from Neidle et al. (1998a). Churng (2011) accounts for these instances by resorting to a leftward movement to FocP of the wh-expression plus a remnant movement of the lower TP (50).

(49) HATE JOHN $\overline{\text{WHO}}^{\text{WH+FOC}}$

Who does John hate?

Like Petronio and Lillo-Martin (1997), the author also aims to parallel the analysis of regular wh-questions to doubled wh-questions (51). This way, she applies the analysis for examples like (50) to doubled wh-

(50)



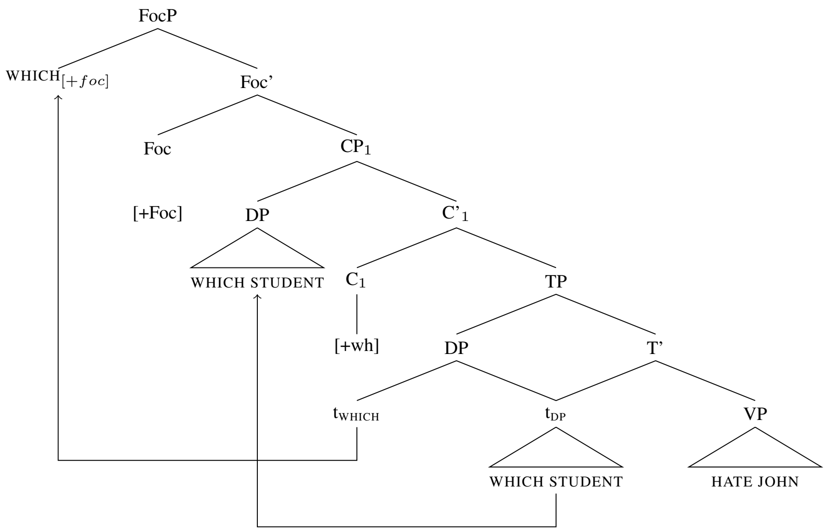
questions, as illustrated by the two steps in (52) and (53). In (52)[9] there is a complex DP formed by two copies of the wh-head, one of them having its restrictor present. The wh-phrase moves to Spec,CP via regular wh-movement. Then, the other wh-head moves higher to Spec,FocP via focus movement. The second step (53), triggered by the focus movement operation, is a remnant movement of the already projected CP (CP1), to a second CP (CP2).

(51) $\overline{\text{[WHICH STUDENT]}}^{\text{wh}}$ HATE JOHN $\overline{\text{[WHICH]}}^{\text{foc+wh}}_{foc}$

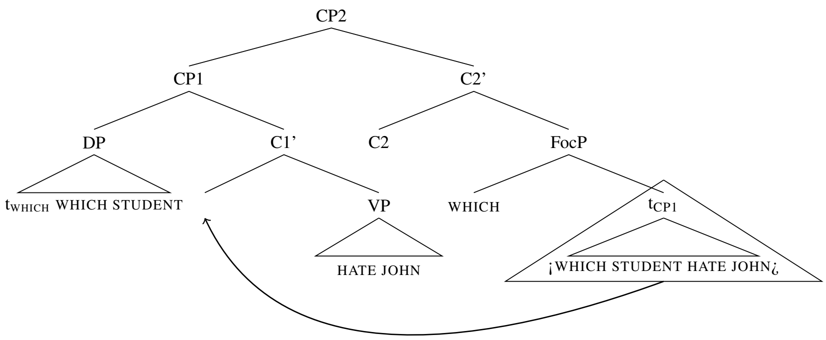
[9]Notice that 52 shows two nodes immediately dominating the same node. This is due to the Parallel Merge paradigm in which the proposal is inscribed. At this point, this detail is not crucial for the understanding of the example. I shortly introduce the basics of this framework next.

Which student hates John?

(52)



(53)



This way, left-branching is assumed and the final-located wh-head, which is focused, is accounted for. Churng (2011) considers focus operations to be independently motivated and different from regular wh-operations. In her view, therefore, focus movement in ASL is a two-step operation: movement to check the focus feature and remnant movement of the lower projections. This analysis allows her to prevent non-focused elements to end up in final position, since only focus movement would trigger the subsequent remnant movement. This is relevant to the discussion on final complex wh-expressions in ASL given by Neidle et al. (2000) where it is assumed that these elements are inherently focused. Churng (2011) notes that in doubled-constructions, this final focus position can only be filled with a head, and that only the final head can be focused (54). This analysis allows Churng to preserve the higher wh-expression unfocused, in accordance with what her data show.

(54) a. (Petronio & Lillo-Martin 1997:46)
PASS TEST $\overline{\text{[WHICH STUDENT]}}^{\text{foc+wh}}{}_{foc}$

Which student passed the test?

b. * $\overline{\text{[WHICH STUDENT]}}^{\text{foc+wh}}$ PASS TEST $\overline{\text{[WHICH]}}^{\text{foc+wh}}{}_{foc}$

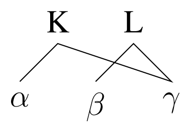
Which student passed the test?

c. * $\overline{\text{[WHICH STUDENT]}}^{\text{foc+wh}}$ PASS TEST $\overline{\text{[WHICH STUDENT]}}^{\text{foc+wh}}{}_{foc}$

Which student passed the test?

As I have already said, Churng (2011) proposes an explanation to multiple wh-questions (those with two non-corefering wh-expressions) within the framework of the Multi-dominance perspective. Although the aim of this section is not to thoroughly explain Multi-dominance approaches, let us sketch some of their basics for the reader to follow Churng (2011)'s analysis. Multi-dominance (Citko 2005, 2011;Gračanin-Yuksek 2007, 2013), also known as Parallel Merge or Sharing Structures, revisits some basic notions of merge and phrase structure. This line of research defends the symmetric nature of some syntactic mechanisms. Specifically, the approaches within this line of analysis review the mechanism of recursion, the mechanism of displacement and the mechanism of determining the category of the resulting constituent after merge. In other words, they review the operations merge, move and labeling. One main modification of the standard theory by Parallel Merge is that it allows a node to be simultaneously dominated by two nodes yielding a multi-dominant structure (55), thence the name.

(55)



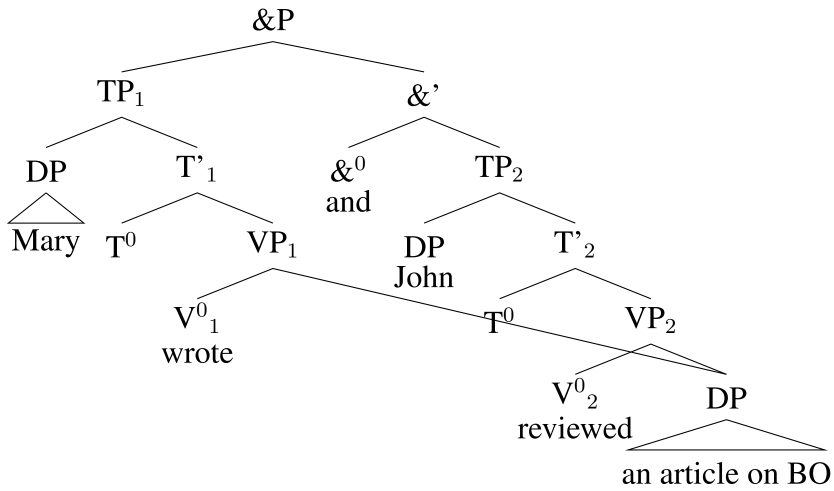
This modification is used, for example, to account for coordinated structures like the one in (56) (Gračanin-Yuksek, 2013).

In (57), the phrase *an article on Barack Obama* is immediately dominated by the two VPs simultaneously. This DP is shared by these two VPs and by all the nodes that dominate them, thus accounting for the fact that a single DP is acting as the object of two verbs simultaneously.

Coming back to ASL, Churng (2011) classifies ASL multiple wh-questions into three different kinds according to three different interpretations: stacked wh-questions, coordinated wh-questions with an at-all reading and coordinated wh-questions with an it-reading.

(56) Mary wrote and John reviewed an article on Barak Obama.

(57)



Stacked wh-questions. This type of multiple questions asks for a pair-list answer. That is to say, they ask for a list of coupled answers (58).[10][11]

(58) What did you eat when?

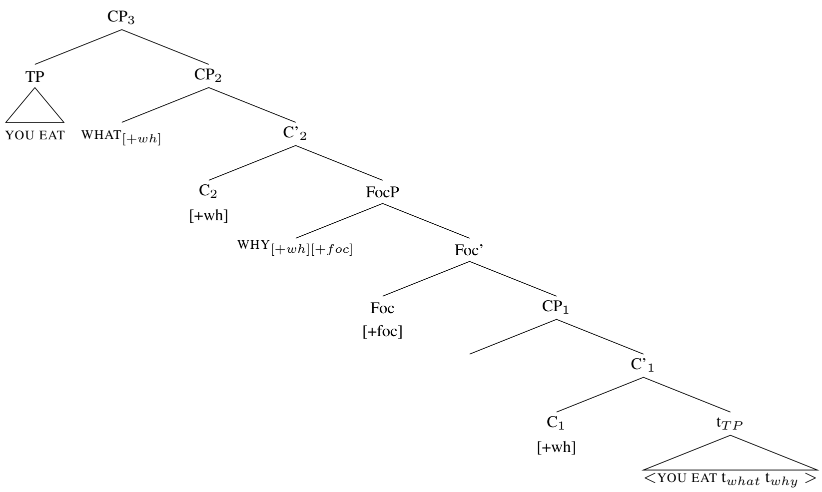
Answer: I ate oatmeal in the morning, veggie wraps at noon and braised pork for dinner./*I ate oatmeal in the morning.

(59) $\overline{\text{YOU EAT WHAT,}}^{\text{wh}}$ $\overline{\text{WHY}}^{\text{foc}}$

What foods did you eat for what reasons?

[10]English and ASL examples are taken from Churng (2011).

[11]For questions like (58) to allow a single pair answer, a pause before the wh-adjunct WHEN is required. The contrast between questions that ask for pair-list answers and single-pair answers has been analyzed in Croatian by Bošković (2002).

(60) 

Churng (2011) derives stacked wh-questions like (59) through a standard leftward movement of the wh-argument *what* to Spec,CP1 first and to CP2 later on. The wh-adjunct WHY undergoes a focus movement to Spec,FocP. Finally, a remnant movement of the lower TP to Spec,CP3 is carried out (60). This analysis is essentially the same as the one proposed for doubled wh-questions.

Coordinated wh-questions. This kind of sentences have a coordinator, *and*, which is overt in English (61,63) and null in ASL (62,64). There are two subtypes, namely the at-all-reading and the it-reading.

(61) What and why did you eat? [At-all reading: *What did you eat and why did you eat at all?*]
Answer: I ate oatmeal, and I ate because I was ravenous.

(62) $\overline{\text{YOU EAT,}}^{\text{wh}}$ $\overline{\text{WHAT,}}^{\text{foc}}$ $\overline{\text{WHY}}^{\text{foc}}$

What foods did you eat, and why did you eat at all?

(63) What and why did you eat? [It reading: *What did you eat and why did you eat it?*]

Answer: I ate oatmeal, and I ate because it smelled good.

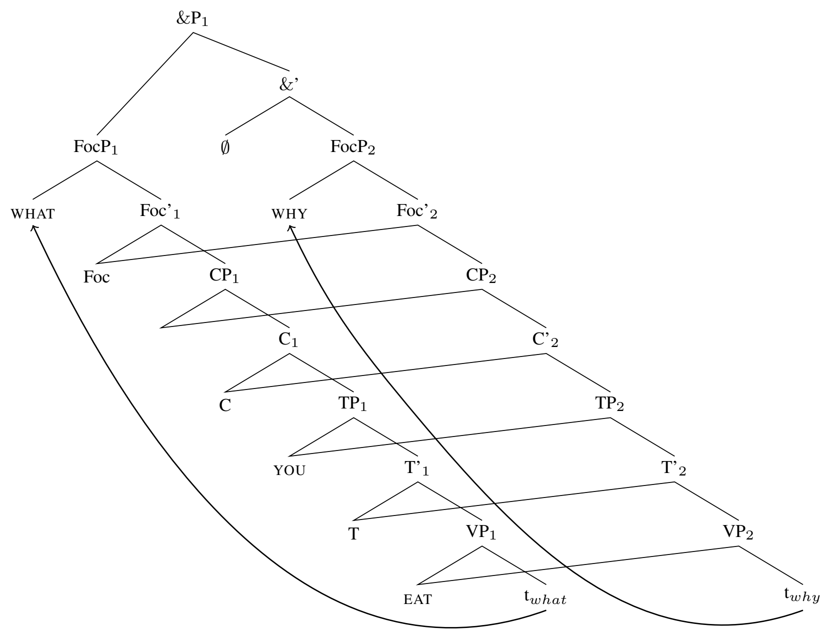
(64) $\overline{\text{YOU EAT,}}^{\text{wh}}$ $\overline{\text{WHAT}}^{\text{foc}}$ $\overline{\text{WHY}}^{\text{foc}}$

What foods did you eat, and why did you eat it?

In the at-all-reading (61), only a single pair answer is acceptable. The question asks for what was eaten and why the answerer ate, thus adjoining the adjunct *why* to the absolute reading of the verb *eat*. In the it-reading in (63) also a single pair answer is required. This time, though, the adjunct *why* adjoins to the transitive interpretation of *eat* and the question asks for what was eaten and why the answerer ate that particular food and none other.

Both types of coordinated wh-questions are analyzed under the Multidominance approach, backing each particular analysis in some prosodic data. In the case of the “at-all reading” type (62), the derivation involves parallel merge plus remnant movement (65). In example (65), multiple sharing operations apply except in the case of wh-expressions, WHAT and WHY, which undergo separate focus movements to the two parallel Spec,FocP. In other words, all terminal nodes in the sentence are immediately dominated by two elements except for the wh-expressions and their traces.

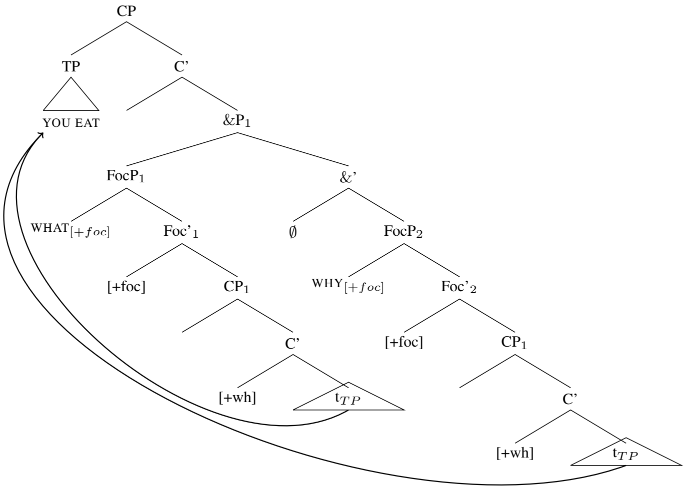
(65)



After that, the remnant TP moves to a higher Spec,CP, as shown by (66) in a traditional representation.

As for coordinated wh-questions with the it-reading (67), also Parallel Merge and remnant movement operations are proposed. In this case, the two wh-expressions undergo separate focus movements from a single TP to two parallel Spec,FocPs. The TP moves afterwards to a higher Spec,CP via remnant movement (68). The fact that there is a single TP involved in all the steps, instead of the two in (65-66) has the desired consequence that the reading of the verb in both FocP clauses must be the same in

(66)

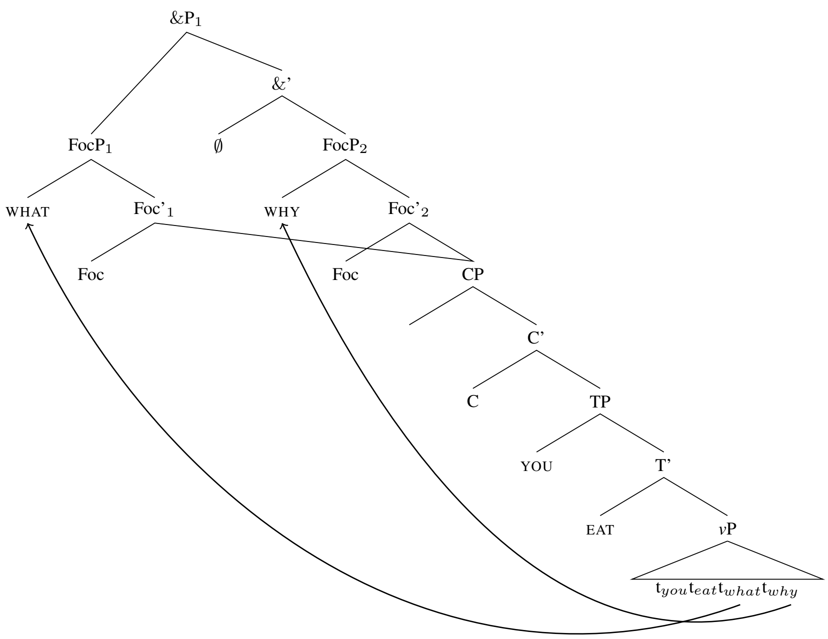


argumental terms, that is, transitive (in this case).

To summarize, Churng's vision proposes not only a left located Spec,CP, but a left located head C too. Wh-questions with a fronted wh-expression derive directly from that assumption. To account for questions with final wh-expressions, Churng puts forward an analysis based on leftward focus movement followed by a leftward remnant movement of the lower TP. The analysis of doubled wh-questions follows this line of reasoning: a first, standard leftward wh-movement to Spec,CP of one of the wh-expressions would take place, followed by a focus movement of the other wh-expression to a higher projection, Spec,FocP; finally, a remnant movement of the lower CP to a higher, second CP would take place.

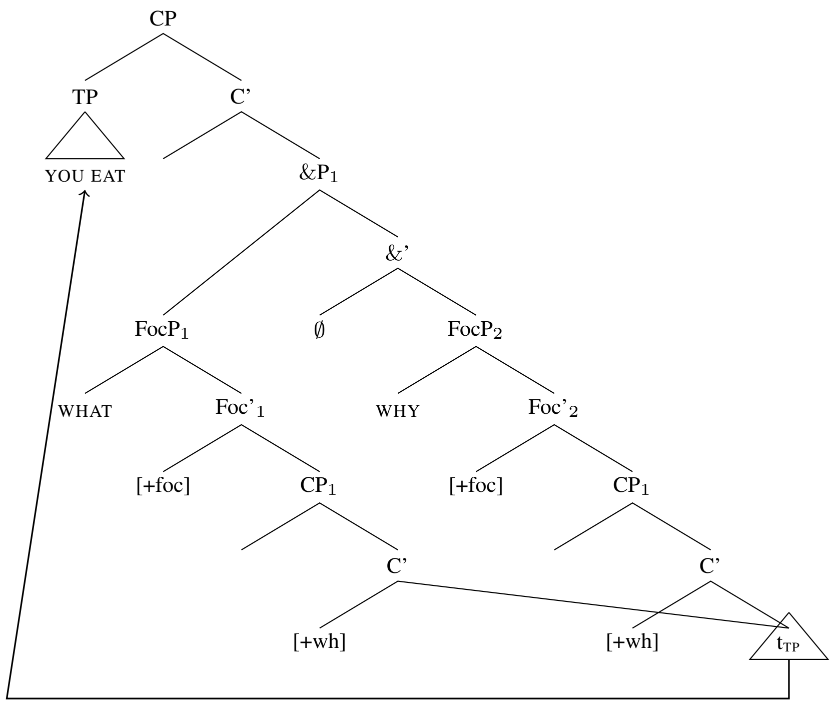
Finally, Churng provides a characterization and an analysis of ASL

(67)



multiple questions within the Parallel Merge framework. Regarding stacked multiple wh-questions, similarly to doubled constructions, she proposes a standard leftward movement of one of the two wh-expressions first to Spec,CP1 and then to Spec,CP2 later on. Then, the other wh-expression undergoes a focus movement to FocP and finally a remnant movement of the lower TP happens. Regarding coordinated multiple wh-questions, she differentiates those with an at-all-reading from those with an it-reading, according to their interpretation. Wh-questions with an at-all-reading are claimed to be the product of structures which have multiple sharing oper-

(68)



ations in all of the nodes except for the wh-expressions themselves. Each of the two wh-expressions would undergo focus movement to a different Spec,FocP. After that, the TP undergoes remnant movement to the higher Spec,CP. Wh-questions with an it-reading, on the other hand, are the product of structures without multiple sharing operations in all the nodes. The two wh-expressions are generated within TP, as usual, and undergo separate focus movements from this single TP to two parallel Spec,FocPs, both dominating CP. The TP moves afterwards to a higher Spec,CP via remnant movement.

2.2.4 Aboh and Pfau's perspective

Aboh and Pfau (2011)[12] offer an interesting, unifying view on wh-questions in spoken languages and sign languages. Their approach is unifying, in fact, in two senses. First, it puts forward an analysis that can equally be applied to both modalities and, second, it proposes a unified vision of the structure that underlies total interrogatives and partial interrogatives. The authors base their explanations in the hypothesis in Cheng (1991, 30), the so called Clause Typing Hypothesis.

> CLAUSE TYPING HYPOTHESIS: Every clause needs to be typed. In the case of typing a wh-question, either a wh-particle in C^0 is used or else fronting of a wh-word to the Spec of C^0 is used, thereby typing a clause through C^0 by Spec-head agreement.

According to this idea, all sentences must be typed. Interrogatives, in particular, involve an Inter projection, regardless of whether they are total questions or partial questions. This position can be overtly expressed, for instance through interrogative particles, through subject-verb inversion, or through the intonational patterns of some questions (69a, 69b). In Gungbe, the high tone on the verb in (69a), which has a declarative interpretation, contrasts with the high-low tone in (69b), which has an interrogative interpretation. In the case of content questions, there can be a null

[12] All the examples in this section are taken from this reference.

morpheme that targets this position or there can be some other element that is overtly expressed. Wh-expressions do not contribute an interrogative meaning *per se*. They are not interrogative elements by themselves. They just act as operators that delimit the set over which the question is being asked, and they target Spec,FocP, where they check the [+focus/wh] feature.

(69) a. Sɛ́tɔ̀ kò wá
Seto already come
Seto arrived already

b. Sɛ́tɔ̀ kò wâ?
Seto already come.INTER
Has Seto arrived yet?

The authors present two sign languages to complete the puzzle, Indian Sign Language (IndSL) and Sign Language of the Netherlands (NGT). In the case of IndSL, it shows a generic question sign that appears in wh-questions (G-WH). Additionally, a NMM is associated to the sentence that consists of raised brows and backward head position with the chin raised. This generic wh-sign by itself covers all the question-signs that other languages exhibit. Usually, the interpretation of the content of these questions depends on the context.

The generic wh-sign of IndSL is interpreted by the authors as the member of a paradigm, a closed class of morphemes that clause-type sentences and that appear in final position. The other members of the set are imperative, negative and existential signs (70a to 70c). These clause-typing morphemes express properties of the different functional projections of the C-system.

(70) a. INDEX$_2$ STUDY IMP
You have to study!

b. INDEX$_1$ WORK NEG
As for me, I am not working.

c. STUDY USEFUL EXIST
Education is really useful!

This sign, combined with an associate phrase, forms wh-questions. This associate can be null, as seen in (71a) or a generic or indefinite associate, like FACE G-WH (*who*), PLACE G-WH (*where*), TIME G-WH (*when*) and NUMBER G-WH (*how many*) (71b, 71c). These associates can occur *in situ* or *ex situ*. In this regard, when the two options are available (overt associate or null associate), the difference between the presence or absence of said associate phrase is tied to focus requirements. These combinations are not present for expressing *what*, *why* and *how*, which must be recovered from the context. They analize examples like (71b) as can be seen in (72).

(71) a. CHILD ANGRY $\overline{\text{G-WH}}^{\text{wh}}$
Why is the child angry?

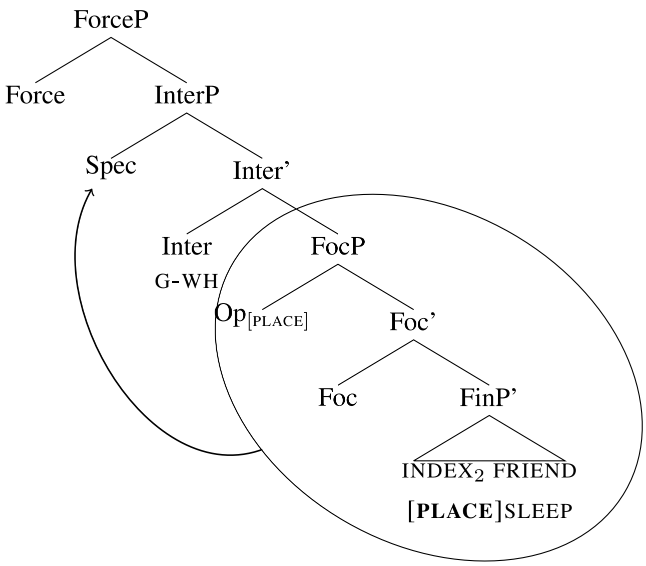
b. INDEX$_2$ FRIEND PLACE SLEEP G-WH

Where does your friend sleep?

c. INDEX$_3$ TRAIN GO TIME G-WH

When is the train leaving?

(72)



In (72) the G-WH merges in Inter and attracts FocP which contains the focus binder of the associate into its specifier. This way, the G-WH ends up in final position, through a derivation involving remnant movement.

What is important of this analysis is that i) it offers a unified analysis for all interrogatives (total and partial) by separating the clause type projection, Inter in this case, from the focus projection, which hosts the wh-expression (which is not interrogative *per se*); and ii) it offers a leftward movement analysis, which is shared both by signed and by spoken languages.

In NGT, on the other hand, there is a full set of wh-expressions. These wh-expressions can occur in initial position and can be doubled. Their most frequent position is, nevertheless, the end of the sentence (73).

(73) $\overline{\text{BOOK STEAL WHO}}^{\text{wh}}$

Who steals the book?

Interestingly, the authors remark that there are some features comparable to those described for IndSL. In some occasions, in wh-questions, the wh-expression is followed by an interrogative particle glossed as PU (palms up), as can be seen in (74a). This particle can also appear in total questions (74b)

(74) a. $\overline{\text{INDEX}_2\text{ BIKE STEAL WHO PU}}^{\text{wh}}$

Who stole your bike?

b. $\overline{\text{INDEX}_1\text{ OFTEN USE PU}}^{\text{yn}}$

Do I use it often?

Examples like (74a) seem parallel to examples like (75) in Lele, in which the wh-question has a question particle and also a wh-phrase moved to focus. These data, again, support the claim that wh-movement and clause-typing are not directly related. Under this perspective, wh-movement seems to be more tied to focus. The authors conclude that the role of a wh-expression in a wh-question is more dependent on the meaning (information structure) than on the syntax of the sentence.

(75) Wéy ba é gà?
who FOC go INTER
Who went away?

Another proof that the authors provide to support this idea is the fact that wh-expressions can be dropped when an interrogative particle occurs. In these cases, the information is retrieved from the context and there is no need to modify anything for the interpretation. However, if the interrogative particle is also dropped, the interrogative interpretation is expressed only with non-manual intonation.

To summarize, regarding this section, it is relevant from the analysis in Aboh and Pfau (2011) is that i) they propose a unified analysis for total and partial questions, by positing an Inter projection that is shared by both kinds of sentences; ii) additionally, wh-expressions in partial questions provide a restriction to meaning and focus, and do not have an interrogative interpretation by themselves; iii) the final location of wh-expressions in SLs is due to a specific derivation, using remnant movement. Their proposal is then inscribed in the group of models I have called leftward approaches.

In this line, the approach in Goksel and Kelepir (2013) about Turkish Sign Language (TID) is worth mentioning here. Their proposal, based on the analysis of NMMs, follows Aboh and Pfau's idea in the sense that they too posit the existence of a projection which is specifically associated to the illocutionary force of the sentence. In a bit more detail, they hold that, in TID, the head tilt NMM marks the interrogative mood. The absence of this NMM yields a declarative interpretation. This NMM would encompass two values (head forward and head backward) which would correspond, respectively, to polar question reading and to content question reading.

In the next section I review some approaches that claim that some SL wh-questions involve rightward movement.

2.3 Rightward analysis in ASL

The other main group of approaches to wh-movement in sign languages are the ones that defend a rightward movement analysis. This goes against what has been generally assumed for syntactic movement, since backward dependencies have been claimed to be extremely constrained (Ross 1967;Kayne 1994). A very important group of researchers that gives support to this analysis is the one formed by Debrah Aarons, Benjamin Bahan, Judy Kegl, Robert Lee, Dawn McLaughlin, and Carol Neidle (Aarons et al. 1992, Aarons 1994, Neidle et al. 1994a, Neidle et al. 1994b, Neidle et al. 1997, Neidle et al. 1998a, Neidle et al. 1998b, and Neidle et al. 2000). I will refer to this group as ABKN when I present proposals they agree on. I will only specify particular papers when a given contribution is highlighted.

This group proposes that wh-movement in ASL is rightwards, to the final sentence position, where Spec,CP is located. As already mentioned, rightward movement has been banned by many models in the syntactic literature, since it has been shown it is very constrained in the spoken languages (Ross 1967;Kayne 1994). However, ABKN maintain this is the analysis which accounts for the ASL data they provide, and they ask for a revision of the general theory in order to fit their findings in this language. The main evidence to support this analysis is based on i) word order, ii) distribution of wh-NMMs, and iii) intensity of wh-NMMs.

As mentioned above, the ASL data provided by ABKN are not completely coincident with the data provided by Petronio and Lillo-Martin (1997). All examples in this section are from ASL and the grammaticality judgments are the ones provided by ABKN.

Regarding word order, wh-expressions in ASL may appear *in situ* (76) or in final position (77), according to ABKN. Example (76) displays a subject *in situ*, while (77) displays a right-moved subject. In other words, a wh-expression can only appear on the left of the clause if it is a subject in its base position. Otherwise it would yield an ungrammatical result, like the left-located wh-object in (78). From the rightward movement perspective, the final wh-object in (79) could be either *in situ* or in a peripheral position. In fact, sentences containing TP-final adverbials show they may move to the periphery (80).

(76) $\overline{\text{WHO LOVE JOHN}}^{\text{wh}}$

Who loves John?

(77) $\overline{t_i \text{ LOVE JOHN WHO}_i}^{\text{wh}}$

Who loves John?

(78) * $\overline{\text{WHO JOHN LOVE}}^{\text{wh}}$

(79) $\overline{\text{JOHN LOVE WHO}}^{\text{wh}}$

Who does John love?

(80) $\overline{\text{TEACHER LIPREAD } t_i \text{ YESTERDAY WHO}_i}^{\text{wh}}$

Who did the teacher lipread yesterday?

Still in word-order-related data, whithin ABKN's examples, also some other instances seem to indicate that wh-expressions can move to a peripheral location at the right margin of the sentence, namely the examples of wh-extraction from embedded clauses that go to final position (81). In this example, the extraction of a wh-subject from the embedded clause shows that the final wh-expression cannot be *in situ*. Recall that this was different in data in Petronio and Lillo-Martin (1997), since they presented long-distance wh-movement as ungrammatical. They presented left-extracted wh-expressions as rejected (though some informants accepted them when adding a final wh-double). Anyway, single wh-extractions from an embedded clause in final position, as in (81), were not present in data in Petronio and Lillo-Martin (1997).

(81) $\overline{[[\text{TEACHER EXPECT } [[t_i \text{ PASS TEST}]_{\text{IP}_2}\ t_i]_{\text{CP}_2}]_{\text{IP}_1} \text{ WHO}_i]_{\text{CP}_1}}^{\text{wh}}$

Who does the teacher expect to pass the test?

Specific patterns of wh-NMMs are the second main aspect on which ABKN's proposal is based. In this sense, ABKN give a more detailed description of how NMMs behave than Petronio and Lillo-Martin (1997) do. According to them, in ASL wh-NMMs co-occur obligatorily with the wh-expression, probably for lexical reasons. They are associated with the [+Wh] feature and that is why they can be found over wh-expressions even when they appear in isolation[13]. Wh-NMMs may also spread over other material in the sentence. The pattern described by ABKN shows that wherever a wh-expression appears, NMMs must spread from there till the end of the clause. This means that when a wh-expression appears in a non-final position, such as an *in situ* subject, the wh-NMMs must obligatorily spread from that point till the end of the sentence. This is interpreted as a spreading over its c-command domain. In (82), the *in situ* wh-subject makes the spreading of wh-NMMs compulsory. If not, the sentence is ungrammatical, as (83) shows. In contrast, when a wh-expression appears in final position, wh-NMMs spreading is not compulsory, like in (84), which shows a right-located wh-expression with its NMMs limited to it.

(82) $\overline{\text{WHO LOVE JOHN}}^{\text{wh}}$

[13]Recall that Petronio and Lillo-Martin (1997) observed differential NMMs in indirect wh-questions like head nods, side-to-side headshakes and pondering or puzzling facial expression. They attributed this to the fact that wh-expressions in these sentences do not have [+F] features.

Who loves John?

(83) * $\overline{\text{WHO}}^{\text{wh}}$ LOVE JOHN

(84) JOHN LOVE $\overline{\text{WHO}}^{\text{wh}}$

Who loves John?

However, when wh-expressions are in final position, NMMs may optionally spread over the rest of the elements in the sentence (elements that precede the wh-expression), like in (85). In this example, the optional spreading has been realized over all the IP domain.

(85) $\overline{\text{JOHN LOVE WHO}}^{\text{wh}}$

Who loves John?

This distributional pattern of wh-NMMs is thought of as a function of the availability of manual material in Spec,CP. If there is manual material in Spec,CP, the wh-NMM must be coarticulated with that material. If there is no manual material available in Spec,CP, the wh-NMM must spread till it reaches this position from wherever they are in the sentence, as shown in (82).

The third main source of data for ABKN's argumentation comes from a study of the intensity of wh-NMMs. The authors report that the wh-NMMs intensity is greatest nearest the source of the [+Wh] feature with which the marking is associated, and decreases as distance from that point increases (Bahan, 1996). Example (86)[14] shows this gradual decreasing of intensity as we go away from the wh-expression towards the beginning of the sentence.

(86) [[JOHN SEE WHO YESTERDAY]$_{TP}$[+wh]$_{C}$]$_{CP}$
Who saw John yesterday?

Also, they appeal to an additional articulatory phenomenon to account for intensity behavior, namely perseveration. Perseveration means that when the same articulatory configuration is used multiple times within a certain proximity, it tends to be kept between those articulations. Perseveration is claimed to happen between the two wh-sources. This means the wh-NMMs will be maintained between both wh-sources, namely between the *in situ* wh-expression and the C head. But not only is the NMM type kept between these two points: also the intensity, which is maintained at the maximum level. In (86), the NMMs of the *in situ* wh-object are maintained at the maximum level of intensity from that point to the C head, covering the adverbial in the middle. Another example of perseveration can be seen in (87), where an *in situ* wh-subject triggers the

[14] Although Neidle et al. (2000) state that the intensity of NMM between two [+wh] sources has to be maximal, they offer the following example, in which that is not true.

[[JOHN SEE WHO YESTERDAY]$_{TP}$[+wh]$_{C}$]$_{CP}$
Who did John see yesterday?

Since the example does not match their argumentation, I offer it here in a footnote, leaving the representation that does match above, in the main text.

spreading of the wh-NMMs, and the maximum intensity is maintained between the two wh-sources, again the wh-expression and C.

(87) [[WHO LOVE JOHN]$_{TP}$[+wh]$_{C}$]$_{CP}$

Who loves John?

The fact that intensity does not decrease from the wh-expression on but, instead, does so in the opposite direction would be the proof that there is no node with [+Wh] at the beginning of the clause, at the left periphery.

In sum, with regard to NMMs behavior, ABKN provide support for the rightward analysis by relying on two facts about NMMs intensity: on the one hand, the intensity is highest in the [+Wh] source and it decreases as we move away from it, and on the other hand, when two wh-sources are in a certain proximity in the sentence, the NMMs will be maintained between them and it will do so at the maximum level of intensity. Thus, the intensity behavior of wh-NMMs is taken as another piece of evidence in favor of a right-located Spec,CP. Concretely, the fact that one cannot see a decrease intensity of in wh-NMMs as one gets close to the end of the sentence, while one can observe that towards the beginning (86), would be taken as the crucial piece of evidence.

Double constructions

ABKN also address the so-called double constructions. The authors refer to them as 'wh-questions with more than one wh-phrase' because they think there are two different structures behind this category: 'final tags including a wh-phrase' and 'initial wh-topics'.

As shown in the previous section, double constructions constituted a challenge for Petronio and Lillo-Martin (1997) because they show final non-*in-situ* wh-expressions. In the case of ABKN, double constructions are a challenge precisely because of the opposite fact: they show initial non-*in-situ* wh-elements.

Final tags

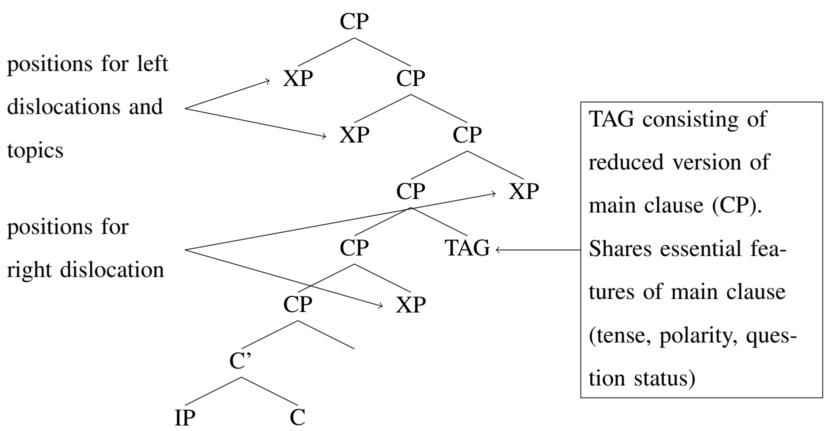
One of the structures behind double constructions is claimed to be a final tag with a wh-phrase. A tag is a repeated and reduced version of the matrix clause. As other tags, these ones are reported to have the characteristic head movement associated with them (an affirmative head nod or a negative head shake).

(88) $\overline{\text{WHO LIKE JOHN}}^{\text{wh}}$, $\overline{\text{WHO}}^{\text{wh+hs}}$

Who likes John, who (does)?

Under this analysis, (88) is seen as an example of an *in situ* wh-subject plus the wh-tag, which is in final position, in a node higher than CP-internal material and lower than left dislocations and topics, as (89) depicts.

(89)



Initial wh-topics

The second structure behind the so called double constructions is that of an initial wh-topic.

(90) $\overline{\text{WHAT, JOHN BUY WHAT}}^{\text{wh}}$

What did John buy?

The initial wh-expression in these examples would be a base-generated topic and the final wh-expresion would be the regular one, which may appear either *in situ* or overtly moved to the right (this would be the preferred option). The evidence they provide to give support to the idea that these initial wh-expressions are topics is: i) the NMMs associated to them, ii) their position in relation to other topics, and iii) the relation with the final wh-expression.

Wh-topics are claimed to have a differential NMM from regular wh-expressions and also from other topics. These NMMs would be in some sense difficult to detect because they are a combination of topic-NMMs and wh-NMMs (Aarons, 1994). Since topic marking is generally realized by brow raise and wh-marking is realized by brow furrowing, a conflict is expected from this combination. The result would be a brow raise plus a narrowing of the eyes and a backward head tilt. NMMs of wh-topics are admittedly variable, though, and not always distinguishable from non-topic wh-expressions. Also, although other topics are normally followed by a pause, the wh-topics posited by ABKN generally are not (91) (Neidle et al., 2000), which makes it more difficult to distinguish them from regular wh-expressions.

In terms of NMMs, also the intensity of NMMs and perseveration are appealed to to account for the existence of wh-topics in ASL. Double constructions containing an initial wh-topic plus the actual wh-expression show spreading till the end of the sentence, irrespective of whether the actual wh-expression has moved to the right or has remained *in situ*. In addition, these examples show the perseveration phenomenon, since the intensity is maintained at the maximum level between the two syntactic locations where [+Wh] occurs, as (91) shows.

(91) $\overline{\text{WHAT JOHN BUY } t_i \text{ YESTERDAY WHAT}_i}^{\text{wh}}$

What did John buy yesterday?

However, perseveration is not only observable in the spreading or the intensity of NMMs, but also using the manual channel. In these cases, when two instances of the same bimanual sign occur close to each other, the non-dominant hand may keep the articulation between the two occurences.

ABKN claim that the perseveration of the non-dominant hand may have been disregarded in some analyses. This can be observed, for instance, in the perseveration of the non-dominant hand that signs WHAT in the doubled construction in (92), a wh-question with two coreferential wh-occurrences. In (92), the non-dominant hand articulates the bimanual sign WHAT from the beginning and keeps the handshape for the duration of the whole sentence. In fact, the final WHAT can be articulated only with the non-dominant hand and without a differentiate onset for the sign. That is to say, the first wh-sign would be kept during the whole sentence using the non-dominant hand, and the second wh-sign would be joined with it without the participation of the dominant hand.[15]

(92) $\overline{\text{WHAT JOHN BUY } t_i \text{ YESTERDAY (WHAT}_i)}^{\text{wh}}$ [dominant hand]
WHAT ____________________________ [non-dominant hand]

[15]The simultaneity that SLs allows makes it difficult to decide whether these cases are instances of two wh-signs or just one sign. It makes it difficult even to decide whether the nature of these elements is segmental or suprasegmental. According to the authors, they are two joined wh-signs.

According to ABKN, the perseveration of the non-dominant hand may have been neglected in some analyses yielding the gloss in (93), with a single initial wh-expression, which could be presented as support for leftward movement. However (94) could have been the realization in these cases where a final wh-occurrence is articulated by the non-dominant hand.

(93) * WHAT JOHN LIKE

(94) WHAT JOHN LIKE [dominant hand]
WHAT __________ (WHAT) [non-dominant hand]

With respect to the distribution of wh-topics in relation to other topics, ABKN observe that wh-topics behave as other base-generated topics do. In ASL, a maximum of two topics can be adjoined to CP. Sentences with more than two topic-marked items are judged as ungrammatical; with the only exception of listing constructions (Aarons, 1994). In addition, if the wh-topic co-occurs with a moved topic, it must precede it, as other base-generated topics and if it co-occurs with a base-generated topic, may precede or follow it.

With regard to the occurrence of wh-topics in doubling constructions, the authors report that they can appear either with an *in situ* or a rightwards moved wh-expression. In examples (95a-95d),[16] the two possibilities are illustrated: an initial wh-topic with the second wh-expression

[16] From Aarons (1994, 65a-65d)

(the regular one) *in situ* and an initial wh-topic one with the second wh-expression moved to Spec,CP via rightward movement. The examples (95a-95b) illustrate it with a wh-subject and (95c to 95d) with a wh-object.

(95) a. $\overline{\text{WHO,}}^{\text{wh}}$ $[_{CP}$ $\overline{\text{WHO BUY BOOK YESTERDAY}}^{\text{wh}}]_{CP}$

Who, who bought a book yesterday?

b. $\overline{\text{WHO,}}^{\text{wh}}$ $[_{CP}$ $\overline{\text{BUY BOOK YESTERDAY WHO}}^{\text{wh}}]_{CP}$

Who, who bought a book yesterday?

c. $\overline{\text{WHO,}}^{\text{wh}}$ $[_{CP}$ $\overline{\text{MARY SEE WHO YESTERDAY}}^{\text{wh}}]_{CP}$

Who, who did Mary see yesterday?

d. $\overline{\text{WHO,}}^{\text{wh}}$ $[_{CP}$ $\overline{\text{MARY SEE YESTERDAY WHO}}^{\text{wh}}]_{CP}$

Who, who did Mary see yesterday?

2.4 Rightward analysis in LIS

Another contribution to the sign language wh-questions debate is the one provided by Cecchetto et al. (2009) for Italian Sign Language (LIS), an SOV language. The description of LIS adds new interesting data because not only wh-subjects but also wh-objects are reported to be right-located. Cecchetto et al. (2009) propose that wh-expressions undergo rightward movement and land in Spec,CP, which is located to the right. According to these authors, this option, constrained for spoken languages, is available in sign languages because they have an additional way to mark syntactic dependencies, namely wh-NMMs marking. This approach, then, provides a modality-dependent explanation, and it also addresses the elephant in the room for this topic, namely why only sign languages can locate their wh-expressions in final position. According to these authors, sign languages allow this because they are multidimensional. Let us see what their arguments are.

The first piece of data in support of the rightward analysis for LIS is that wh-expressions appear in final position, be they subjects (96) or objects (97). In LIS, sentences with a fronted wh-expression are not allowed. Remember that this was not the case in ASL, which showed initial wh-expressions that gave way to the two different analyses just presented.

(96) HOUSE BUY $\overline{\text{WHO}}^{\text{wh}}$

Who bought a house?

(97) GIANNI BUY $\overline{\text{WHAT}}^{\text{wh}}$

What did Gianni buy?

These final wh-expressions are claimed to be in a peripheral position, since they follow adverbs (98), negation (99) and the postverbal perfective marker DONE (100).

(98) ARRIVE IN-TIME $\overline{\text{WHO}}^{\text{wh}}$

Who arrived in time?

(99) CAKE EAT NOT $\overline{\text{WHO}}^{\text{wh}}$

Who did not eat the cake?

(100) HOUSE BUILD DONE $\overline{\text{WHO}}^{\text{wh}}$

Who built the house?

Moreover, crucially for their claim, not only heads but also phrases appear in final position (101). This gives support to the existence of a final Spec,CP, and not just a right-located C head.

(101) PAOLO STEAL $\overline{\text{[BOOK WHICH]}}^{\text{wh}}$

Which book did Paolo steal?

Wh-expressions in LIS can also appear *in situ*, whether they are heads (102) or phrases (103).

(102) GIANNI $\overline{\text{WHO KISS}}^{\text{wh}}$

Which of them did Gianni kiss?

(103) PAOLO $\overline{\text{[BOOK WHICH] STEAL}}^{\text{wh}}$

Which book did Paolo steal?

Wh-NMMs patterns when wh-expressions are *in situ* are a key aspect in this analysis. The description of LIS NMMs' behavior reminds us of the one provided by ABKN of ASL because both groups provide an explanation based on rightward movement, though the data and the analyses are not exactly the same.

Wh-NMMs are obligatorily coarticulated with the wh-expression. However, these NMMs may spread over other material in the sentence. The spreading depends on where the wh-expression is. When the wh-expression is *in situ*, the NMMs must spread from the wh-expression to the end of the sentence, whether the wh-expression is a subject (104) or an object (105). When the wh-expression is in final position (106-107), the NMM does not need to spread. The left-to-right spreading from the *in situ* element to the end of the sentence is interpreted by the authors as a particular strategy n the signed modality to mark a syntactic dependency, from the Probe-Goal theory view (Chomsky, 2001). This spreading would mark the wh-dependency between the probe (a wh-feature in the head of CP in this case) and the goal (the position of the wh-expression that moves to Spec,CP). On the other hand, the non-necessity of spreading when the wh-expression is in final-position, is interpreted as a proof of the non-necessity of marking the wh-dependency, since the wh-expression has reached the goal node (Spec,CP), to the right of the sentence.

(104) $\overline{\text{BOY WHICH BOOK STEAL}}^{\,wh}$

Which boy stole the book?

(105) PAOLO $\overline{\text{BOOK WHICH STEAL}}^{\,wh}$

Which book did Paolo steal?

(106) BOOK STEAL $\overline{\text{BOY WHICH}}^{wh}$

Which boy stole the book?

(107) PAOLO STEAL $\overline{\text{BOOK WHICH}}^{wh}$

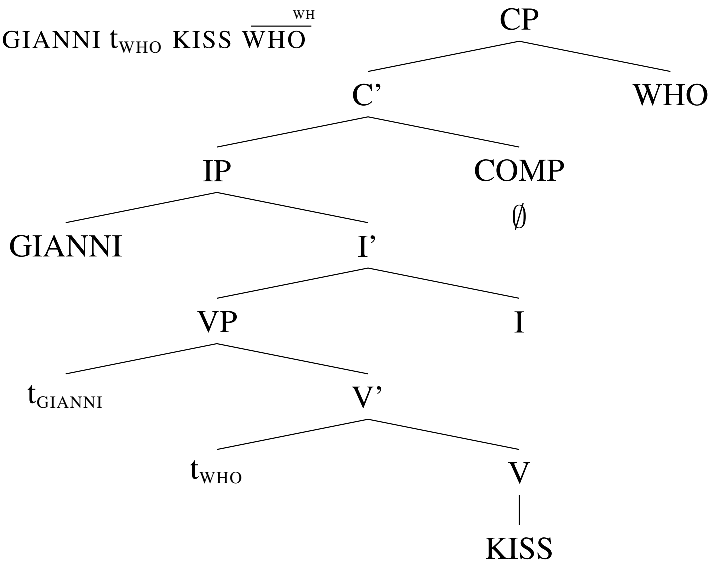
Which book did Paolo steal?

In addition to the obligatory spreading just presented, there are also optional spreading instances when wh-expressions are in final position. The way this optional spreading proceeds is also presented to support the proposal of the wh-chain marking. When a final wh-subject appears, the wh-NMMs optionally spread over verb and object. On the other hand, when a final wh-object appears, wh-NMMs can only spread over the verb and cannot affect the subject. This is seen as a proof of the left-to-right marking of the wh-dependency, from probe to goal.

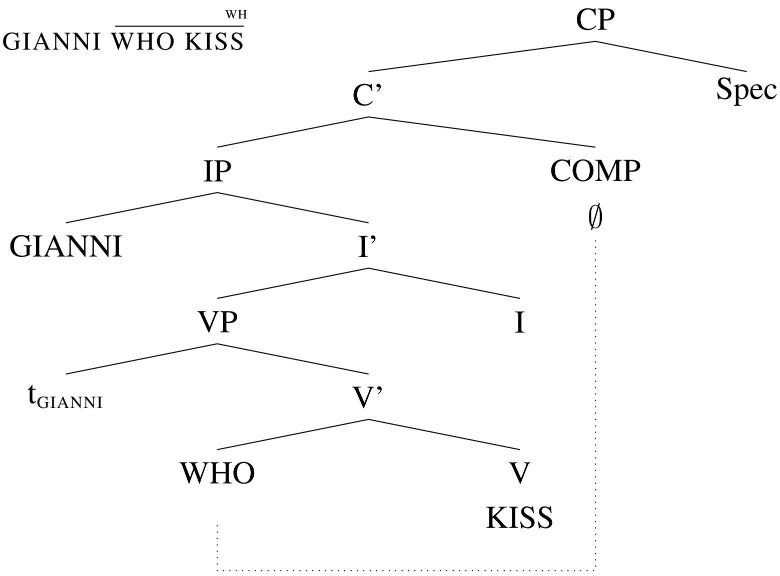
Interestingly, when a wh-object remains *in situ*, spreading over the subject is neither possible. This modality-specific way of marking syntactic dependencies is presented in favor of the claim that in LIS wh-movement is rightwards and that Spec,CP is right-located. If it were leftwards, as standardly assumed for SpLs, this chain marking could not take place. In (108a), the chain has been marked by movement, in (108b) by the spreading of wh-NMMs and in (108c) by both strategies.[17]

[17]The authors present the counterfactual cases for leftward movement. That is to

(108) a. GIANNI t_{WHO} KISS $\overline{\text{WHO}}^{\text{WH}}$

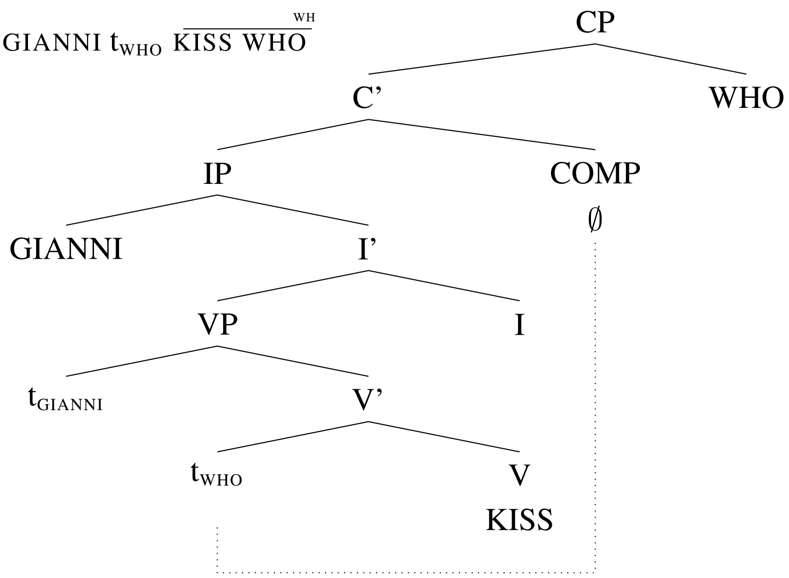


b. GIANNI $\overline{\text{WHO KISS}}^{\text{WH}}$



say, they try to see whether the chain marking could be done in a leftward movement scenario. They conclude it is not possible.

c. GIANNI t_{WHO} $\overline{\text{KISS WHO}}^{\text{wh}}$



As for doubled wh-constructions in LIS, based on the different duration of the two copies, Branchini et al. (2013) propose that the initial wh-expression is located in Spec,FocP, on the left, while the final one is in Spec,CP, on the right, as Cecchetto et al. (2009) propose.

Summing up, Spec,CP is on the right and wh-movement is rightwards in LIS, according to Cecchetto et al. (2009). Wh-NMMs spreading is seen as an alternative way to mark syntactic dependencies in sign languages, which spoken languages would lack. Specifically, wh-NMMs would link the probe position, be it a trace or an overt *in situ* wh-expression, with the goal position. This link would proceed linearly, from left to right, and would exclude material not intervening between these two nodes, namely the subject in a question involving a wh-object. The non-necessity of NMMs' spreading when the wh-expression is in final position is seen as a proof of the non-necessity of marking the wh-chain, since the wh-expression is assumed to have reached the goal node already. The availability for hosting wh-expressions at the right edge of the sentence in sign languages is presented as a result of a macrotypological difference between signed and spoken modality, since only sign languages can use NMMs to mark syntactic dependencies.

2.5 Summary

In this chapter I have reviewed the main approaches to the study of wh-questions in different SLs, grouping them around two main lines: leftwards approaches and rightwards approaches. Obviously, the denomination shows that the two views are cosidering the notions of right and left to be present already in the syntax. I have already put forwards in chapter 1 the reasons why I believe this point is not relevant: syntax does not understand right and left, it only understands up and down.

Within the leftwards approaches, I have presented Petronio and Lillo-Martin (1997)'s proposal. It aims at explaining some phenomena observed in ASL under the scope of unifying the analysis for both modalities. That is, the analysis they put forward in their model is based on the standard view of the syntax of wh-questions that has been so far used for spoken languages. But the proposal is unifying also at a secondary level, because it parallels the structures proposed both for doubled wh-questions and simple wh-questions. In both cases, the underlying structure is essentially the same: a focused base-generated element is present in sentence final position (at the head C) in final wh-questions, which may occur alone or with a copy in sentence initial position, and a wh-expression standardly moved to Spec,CP is present in initial wh-questions which, again, may occur alone or with another copy in sentence final position.

Wilbur (2011)'s analysis for ASL, in turn, aims at studying the nature of NMMs and, among them, the typical NMM of wh-questions: brow lowering. Her analysis is semantically motivated, identifying two different spreading domains that correspond to two different semantic operators. In the case of wh-questions, they show spreading over the c-command of the [+wh] feature in C, since the operator is monadic. Wilbur (2011) does not have as one of her main objectives to determine the nature of wh-movement, nor the situation of Spec,CP, but she accepts the leftwards approaches, since she assumes a left located Spec,CP and leftward wh-movement.

Churng (2006, 2011)'s works not only proposes a left located Spec,CP, but also a left located head C. Her proposal wants to characterize and analyze multiple wh-questions in ASL, and follows the Parallel Merge framework, in which the operations merge, move and label are revisited. In this proposal, multiple sharing operations are combined with remnant movement to explain the surface form of wh-questions in ASL and the different readings that are obtained.

Aboh and Pfau (2011) also make a unifying proposal, in two senses. On the one hand, they equate the syntactic analysis of wh-questions in IndSL and NGT to the analyses provided for spoken languages. On the other hand, they want to bring together the structure underlying wh-questions with the structure underlying yes-no questions. In their model, there is an Inter projection shared by both kinds of question. In addition, wh-expressions in partial questions provide a restriction to meaning and focus, and do not have an interrogative interpretation *per se*. As in other leftwards approaches, final wh-expressions are accounted for by remnant movement operations.

In the group of rightwards approaches, I have presented the work of the group formed by Debrah Aarons, Benjamin Bahan, Judy Kegl, Robert Lee, Dawn McLaughlin and Carol Neidle. According to these authors, ASL shows not only the head C to the right, but also Spec,CP and wh-movement, therefore, has to be rightwards. Final wh-expressions in ASL are adduced as the proof of this statement and, crucially, the authors report that not only heads, but also phrases can be found in final position. According to the authors, it is not possible to find initial wh-expressions in ASL unless they are *in-situ* subjects. The only case in which one could find a non-*in-situ* initial wh-expression (an object, for instance) is what they call an initial topic. Initial topics are base generated wh-topics, normally accompanied by a prosodic pause like regular topics (but not necessarily). This group of authors also provide a characterization and an analysis of wh-NMMs. They show that when a wh-expression appears in a position other than the end of the sentence, the spreading of NMMs to the end is obligatory, while it is optional when the wh-expression appears in sentence final position. They also analyze the intensity of wh-NMMs, reporting that it is greatest the nearest to the source of the [+wh] feature with which the marking is associated, and decreases as distance from that point increases. They also mention perseveration, an articulatory phenomenon by which the same articulatory configuration is kept when it is used multiple times in a certain proximity, to explain the perseveration of NMMs and their intensity between two [+wh] sources.

Also within rightwards approaches, although different from the one just presented, I have reviewed Cecchetto et al. (2009)’s work regarding LIS. In that model, both the head C and Spec,CP are on the right, and movement is rightwards. The proofs the authors adduce to support their model are the distribution of wh-expressions and the behavior of NMMs. According to their proposal, the spreading of NMMs is a way to mark syntactic dependencies in sign languages. Specifically, wh-NMMs are a way to link the probe position, be it a trace or an overt *in situ* wh-expression, with the goal position.

As said, among the main contributions to the topic of wh-interrogatives in different SLs, the main point of controversy that articulates the debate is the situation of Spec,CP and, in consequence, the direction of wh-movement. Of all the visions presented here, Cecchetto et al. (2009)’s is the only one that regards SLs as different from SpLs in some aspect, namely in the possibility to use NMMs to mark syntactic dependencies, a strategy which SpLs would lack. According to the authors, this difference would account for the sharp difference in the behavior of wh-questions between modalities. The rest of models I have presented do not address this differential fact. Either they unify both modalities at the expense of adding complexity to the derivation to account for the examples of SLs, or at the expense of adding some complexity to general theory by allowing movements to the right in order to fit the differential patterns observed in SLs.

Chapter 3

WH-QUESTIONS IN LSC

3.1 Description

In this section I present a characterization of wh-questions in LSC. I will start by describing wh-questions in simple sentences (section 3.1.1). There are essentially three possibilities for this kind of sentences in LSC: sentences with just one wh-expression, or simple wh-questions (109a); sentences with two coreferential wh-expressions, or doubled wh-questions (109b), and sentences with two non-coreferential wh-expressions, or multiple wh-questions (109c).

(109) a. COOKIE STEAL $\overline{\text{WHO}}^{\text{wh}}$ *[simple wh-question]*

Who stole the cookie?

b. $\overline{\text{WHAT JOHN STEAL WHAT}}^{\text{wh}}$ *[doubled wh-question]*

What did John steal?

c. $\overline{\text{WHO BUY WHAT}}^{\text{wh}}$ *[multiple wh-question]*

Who bought what?

In all of these cases, the wh-expressions can be simple or complex, with a wh-word plus a restrictor, as in the English wh-phrase *which book*. As we will see, the relation between NMMs and wh-expression distribution will be of special interest. In the end of the section dedicated to simple sentences, I will briefly present self-questions, a canonical construction in LSC.

Next, I will describe wh-questions in complex sentences (section 3.1.2). I will first describe indirect wh-interrogatives (110a) and then move on to long distance wh-movement (110b), where I will present some interesting contrasts between sentence-initial and sentence-final wh-position and movement distance.

(110) a. GEMMA WRITE-DOWN SHIRT WANT $\overline{\text{WHO}}^{\text{wh}}$ *[indirect wh-question]*

Gemma wrote down who wants the shirt

b. MARY SAY JOHN BUY $\overline{\text{WHAT}}^{\text{wh}}$ *[long distance wh-movement]*

What did Mary say that John bought?

Before going into the description itself, let us note that although word order in LSC shows high sensitivity to discourse organization, the unmarked, canonical order for declarative sentences is SOV (111) (Quer, 2005), like in many other sign languages described so far. This basic word order can be modified in topic-comment structures, for instance, which are very common (112).

(111) JOHN COOKIE STEAL

John stole the cookie

(112) $\overline{\text{DOG,}}^{\,t}$ DANNY LOVE

As for dogs, Danny loves them.

All the data presented in these sections have been compiled using two methods. On the one hand, grammaticality judgments by the two LSC-native Deaf experts at the LSC-Lab at the Pompeu Fabra University. The experts were presented some glosses that were discussed and recorded. Later on, always after a week or more had passed, they were presented with the video recordings to validate the judgments using a more natural input. On the other hand, some tasks were designed to elicite semi-spontaneous signing by the two informants. In these activities, the informants had to either debate about a topic or collaborate to solve an enigma. Their conversations were videorecorded to observe how the relevant constructions were articulated in the discourse. As I present in the next sections, these tasks were specially informative with regard to NMMs.

3.1.1 Simple sentence

3.1.1.1 Simple wh-questions

In LSC, wh-expressions canonically appear at the end of the sentence (113-114). Notice that, as LSC is an SOV language, neither the subject WHO in (113) nor the object WHAT in (114) are located in their *in situ* position.

(113) COOKIE STEAL WHO

Who stole the cookie?

(114) JOHN STEAL WHAT

What did John steal?

However, the non-*in-situ* position of the wh-object can be seen even more clearly in (115), since a temporal adverbial intervenes between the verb and the object.

(115) JOHN STEAL YESTERDAY WHAT

What did John steal yesterday?

Wh-expressions have NMMs associated to them, usually consisting of furrowed eyebrows, forward head tilt, body lean and chin raise (Figure 3.1), and occasionally also accompanied by shoulder raise and squinted eyes. These NMMs can spread over some other signs (116) or even over the whole sentence (117).[1]

(116) JOHN $\overline{\text{STEAL WHAT}}^{\text{wh}}$

What did John steal?

(117) $\overline{\text{JOHN STEAL WHAT}}^{\text{wh}}$

What did John steal?

(118) $\overline{\text{JOHN COOKIE STEAL}}^{\text{y/n}}$

Did John steal the cookie?

The NMMs that accompany questions have been claimed to be mainly prosodic in nature, since they proceed linearly, they are simultaneous to manual signs, and they tend to match syntactic constituents. Wh-NMMs contrast with those usually associated to polar questions (118), which normally consist of raised brows, slight head nod and chin tuck on the last word (Figure 3.2).

When the wh-expression is in final position, the spreading of NMMs over the material preceding it is optional and seems to be related to presupposed information in the communicative context. More specifically, the spreading is linked to information that is not available in the context.

[1] Although wh-questions have more than one single NMM, I will gloss them separately only when it is crucial for the explanation. The rest of the times I will use the gloss *wh*, regardless of the combination of wh-NMMs involved. The same procedure is applied in polar questions, whose NMMs will be glossed *y/n* unless some distinction between the NMMS involved is necessary.

Figure 3.1: Wh-NMMs in LSC (manual sign: WHAT)

Figure 3.2: NMMs in polar questions in LSC (manual sign: COME)

The elements affected by it cannot be part of the background information. Elements unaffected by the spreading of wh-NMMs can be already available in the context, although it is not necessary. For instance, (119) could be uttered out of the blue, since it does not presuppose any information, while (120) would be uttered when the possibility of giving puppies away was already in the context (because, for instance, someone had explained that he had a pregnant bitch).

(119) $\overline{\text{PUPPY WANT WHO}}^{\text{wh}}$

Who wants a puppy?

(120) PUPPY WANT $\overline{\text{WHO}}^{\text{wh}}$

Who wants a/the puppy?

However, the patterns of optional wh-NMM spreading over preceding material, being tied to discourse and information structure, are bound to be more complex. They would surely deserve another dissertation on themselves. In this dissertation, I have focused on compulsory, regular wh-NMM spreading triggered by syntactic events, as we will see next.

Although it is not as frequent, wh-expressions can also appear in their *in situ* position, like the *in situ* wh-subject is in (121), and the *in situ* wh-object in (122). When the wh-expression appears in a place different from the final location, wh-NMMs must obligatorily spread from that point to the end of the sentence for it to be grammatical. This phenomenon has been described for other SLs as well (see chapter 2). In examples

(123) and (124) the lack of spreading of the wh-NMMs from the *in situ* wh-subject WHO and the *in situ* wh-object WHAT yields an ungrammatical result. As with final located wh-expressions, in the case of *in situ* wh-objects, which normally appear in a medial position between the subject and the verb, the spreading over the material on the left of the wh-expression, i.e. the subject, is optional (125).

(121) $\overline{\text{WHO COOKIE STEAL}}^{\text{wh}}$

Who stole the cookie?

(122) JOHN $\overline{\text{WHAT STEAL}}^{\text{wh}}$

What did John steal?

(123) * $\overline{\text{WHO}}^{\text{wh}}$ COOKIE STEAL

(124) * JOHN $\overline{\text{WHAT}}^{\text{wh}}$ STEAL

(125) $\overline{\text{JOHN WHAT STEAL}}^{\text{wh}}$

What did John steal?

Despite the general preference for placing wh-expressions in final position, and the possibility to keep them *in situ*, they can also sometimes appear in initial position not being *in situ*. This can be seen clearly with wh-objects appearing in initial position, like (126). This option is less frequent and, as with *in situ* wh-expressions, it also requires the spreading of the wh-NMMs from the wh-expression to the end of the sentence for it to be grammatical. The generalization is clear: wherever we find a wh-expression, the spreading of wh-NMM to the end of the sentence is compulsory (127). This principle can be seen to work with *in situ* wh-expressions and initially located wh-expression, and it holds also for final wh-expressions, although it applies vacuously.

(126) $\overline{\text{WHAT JOHN STEAL}}^{\text{wh}}$

What did John steal?

(127) * $\overline{\text{WHAT}}^{\text{wh}}$ JOHN STEAL

3.1.1.2 Doubled wh-questions

Doubled constructions are sentences in which some element is repeated in final position. That element might be a modal, a verb, an index, a negation or a wh-expression (128a - 128d). In the case of wh-questions, the result is a partial question with two equal, coreferential wh-expressions (128d). Observe that, differently from multiple wh-questions (129), doubled wh-questions require only a single element as their answer, not a pair list. Doubled constructions have been reported for other SLs too (Petronio and Lillo-Martin 1997 among others). Sandler and Lillo-Martin (2006), for instance, explain the doubling in final position as a means to receive prominence.

(128) a. $\overline{\text{WORRY NOT}}^{\text{neg}}$ JOHN CAN PEANUTS EAT CAN

Do not worry, John can eat peanuts.

b. IX1 SABADELL GO MANY-TIMES GO

I go to Sabadell many times.

c. $\overline{\text{INDEX}_2 \text{ MARRIED INDEX}_2}^{\text{rb}}$

Are you married?

d. $\overline{\text{WHAT JOHN STEAL WHAT}}^{\text{wh}}$

What did John steal?

(129) $\overline{\text{WHO BUY WHAT}}^{\text{wh}}$

Who bought what?

As we have seen in the previous section, there are three available slots for wh-expressions to appear in in LSC: initial, *in situ* and final. In principle, this would yield three possibilities for the distributional patterns of doubled wh-expressions. Nevertheless, the actual distribution of the wh-expressions in doubled constructions can only be either initial plus final position (130) or *in situ* plus final position (131a). I have used wh-objects in these examples for the sake of clarity and also to illustrate that, as we have observed in single wh-questions, the spreading of wh-NMMs over the material to the left of the first wh-expression is optional (131b).

(130) $\overline{\text{WHAT JOHN STEAL WHAT}}^{\text{wh}}$ *[initial+final]*

What did John steal?

(131) a. JOHN $\overline{\text{WHAT STEAL WHAT}}^{\text{wh}}$ *[in situ+final]*

b. $\overline{\text{JOHN WHAT STEAL WHAT}}^{\text{wh}}$

What did John steal?

It is interesting, then, that it is not possible to have one wh-expression in initial position and the other one *in situ*, leaving the final position empty (132). In this case, not even the spreading of the wh-NMMs, as in (132), can prevent the sentence from crashing. In the light of these patterns, the final position seems to be different in nature from the other positions of the sentence where wh-expressions can appear.

(132) * $\overline{\text{WHAT JOHN WHAT STEAL}}^{\text{wh}}$

[initial+in situ]

In the other two possibilities, the appearance of a wh-expression in an initial or medial (*in situ*) position triggers the obligatory spreading of wh-NMMs to the end of the sentence. Therefore, all the material between the two wh-expressions in doubled constructions is affected by it compulsorily. Some authors (Neidle et al., 2000) have attributed this behavior of NMMs to perseveration, a phonological process by which the NMMs (or other manual or non-manual articulatory feature) shared by two items are maintained between them if they are near.

3.1.1.3 Multiple wh-questions

Multiple wh-questions are questions with two non coreferential wh-expressions. They ask for pair list answers like in the English example (133).

(133) Who ate what?

Oriol ate pizza, Gemma ate spaghetti, and Berit ate lasagna.

This kind of sentences are possible in LSC, although not canonical, and they present some relevant asymmetries. First, there is a preference to overtly move just one of the two wh-expressions, leaving the other one *in situ*. Both (134), with a moved wh-object and an *in situ* wh-subject, and (135), with a moved wh-subject and an *in situ* wh-object, are equally acceptable.

(134) $\overline{\text{WHO BUY WHAT}}^{\text{wh}}$

Who bought what?

(135) $\overline{\text{WHAT BUY WHO}}^{\text{wh}}$

Who bought what?

Nevertheless, both wh-expressions can be moved, although the result is not as usual and is dispreferred, which gives raise to the second asymmetry. Both wh-expressions can be finally located (136-137). However, the fronting counterpart of this sentences are ungrammatical (138-139). That is to say, if the two wh-expressions move together, they can only be located at the end, and will never land at the beginning.

(136) $\overline{\text{BUY WHO WHAT}}^{\text{wh}}$

Who bought what?

(137) $\overline{\text{BUY WHAT WHO}}^{\text{wh}}$

Who bought what?

(138) * $\overline{\text{WHO WHAT BUY}}^{\text{wh}}$

(139) * $\overline{\text{WHAT WHO BUY}}^{\text{wh}}$

Finally, a superiority effect is observed when the two wh-expressions are in final position. When a wh-subject and a wh-object are moved to the end, the wh-object tends to appear in the more peripheral position, preceded by the wh-subject. So, although they are both accepted, example (136) is preferred over example (137).

3.1.1.4 Complex wh-expressions

Complex wh-expressions are formed by a wh-word plus a restrictor, like in the phrase *which boy*. In terms of their distribution, they follow the same patterns as simple wh-expressions in LSC. Again, their canonical location is also the end of the sentence, either if they are subjects, like BOY WHO in (140),[2] or objects, like BOOK WHICH in (141). The canonical order within complex wh-expressions is [restrictor+wh], although the reversed order is still accepted (141b).

(140) COOKIE STEAL $\overline{\text{BOY WHO}}^{\text{wh}}$

[2] In the case of complex wh-expressions involving human restrictors, WHO is a commonly used wh-head in LSC.

Which boy stole the cookie?

(141) a. JOHN STEAL $\overline{\text{BOOK WHICH}}^{\text{wh}}$

Which book did John steal?

b. ?? JOHN STEAL $\overline{\text{WHICH BOOK}}^{\text{wh}}$

Complex wh-expressions may also appear *in situ* (142a), although this is not a preferred option. Again, when the complex wh-expression occurs *in situ*, the spreading of the wh-NMMs from the wh-head to the end of the sentence is compulsory (142b). It is also possible to find only the restrictor *in situ* and subextract the wh-head to the final position (143). In this case, there is no requirement to spread the wh-NMMs over the material to the left of the wh-head. In fact, when the whole complex wh-expression is in final position, the restrictor can remain unaffected by the wh-NMM, since the only requirement is that the wh-head is accompanied by the wh-NMMs (144).

(142) a. JOHN $\overline{\text{BOOK WHICH STEAL}}^{\text{wh}}$

Which book did John steal?

b. * JOHN $\overline{\text{BOOK WHICH}}^{\text{wh}}$ STEAL

(143) JOHN BOOK STEAL $\overline{\text{WHICH}}^{\text{wh}}$

Which book did John steal?

(144) COOKIE STEAL BOY $\overline{\text{WHO}}^{\text{wh}}$

Which boy stole the cookie?

Complex wh-expressions can also participate in doubled wh-constructions. Regarding their distribution, the behavior is the same one observed in simple wh-expressions. At least one of the two wh-expressions must occupy the final position (145a). The other one may be in initial position or in medial position (wh-object). Also in these doublings, the wh-NMMs must cover all the material between the two wh-expressions (145b).

(145) a. $\overline{\text{WHISKY WHICH JOHN DRINK WHISKY WHICH}}^{\text{wh}}$

Which whisky does John drink?

b. * $\overline{\text{WHISKY WHICH}}^{\text{wh}}$ JOHN DRINK $\overline{\text{WHISKY WHICH}}^{\text{wh}}$

3.1.1.5 Non-argumental wh-expressions

Non-argumental wh-expressions follow the same behavior as argumental wh-expressions, namely that the canonical position for wh-expressions is on the right, and any non-final wh-expression triggers the spreading of NMMs to the end of the sentence (146-149b).

(146) JOHN COOKIE STEAL $\overline{\text{WHY}}^{\text{wh}}$

Why did John steal the cookie?

(147) a. $\overline{\text{WHY JOHN COOKIE STEAL}}^{\text{wh}}$

Why did John steal the cookie?

b. * $\overline{\text{WHY}}^{\text{wh}}$ JOHN COOKIE STEAL

(148) WHEEL CAR CHANGE $\overline{\text{HOW}}^{\text{wh}}$

How one changes the car wheel?

(149) a. $\overline{\text{HOW WHEEL CAR CHANGE}}^{\text{wh}}$

How one changes the car wheel?

b. * $\overline{\text{HOW}}^{\text{wh}}$ WHEEL CAR CHANGE

3.1.1.6 Self-questions

Self-questions are a common construction involving a wh-question that are used to make assertions in LSC. These constructions, also called *Question-Answer clauses*, have been described in other SLs too ((Wilbur, 1996); (Caponigro and Davidson, 2011)). Self-questions have two components: a question and its answer, which immediately follows it (150). The first element, the question, does not necessarily have to be a wh-question, but can also be a polar question (151). These constructions cannot be uttered out of the blue, since they need some foregrounded information preceding them in the discourse and instantiating the content of the question.

(150) $\overline{\text{MONTSE BUY WHAT,}}^{\text{rb}}$ CHINESE NOODLES

What Montse bought was Chinese noodles.

(151) $\overline{\text{CHRIS MEAT EAT,}}^{\text{rb}}$ $\overline{\text{NO}}^{\text{neg}}$

Chris does not eat meat.

These sentences have sometimes been called rhetorical questions. However, it is important to differentiate the two types of questions. Rhetorical questions are questions that do not ask to be answered by the addressee, and that are used to emphasize a given idea (152). Self-questions, on the other hand, are always followed by the answer uttered by the signer, which is new information.

(152) Who wants to pay more for the same product?

Again, in self-questions, the canonical place to locate the wh-expression is in final position, like in (150). However, as it happened with regular wh-questions, the wh-expression can also appear at the beginning (153) and *in situ* (154).

(153) $\overline{\text{MONTSE WHAT BUY}}^{\text{rb}}$, CHINESE NOODLES

What Montse bought was Chinese noodles.

(154) $\overline{\text{WHAT MONTSE BUY}}^{\text{rb}}$, CHINESE NOODLES

What Montse bought was Chinese noodles.

However, there is a difference from regular wh-questions. Self-questions can have a wh-NMM marker associated to them, or they can have raised brows instead, as in the previous examples.

3.1.2 Complex sentence

In this section I present some structures of LSC that involve subordination and wh-expressions. Nevertheless, as I will discuss now and again during the next pages, there is a strong tendency in LSC to avoid subordination. In the situations where a speaker of English or Catalan would typically use complex sentences, an LSC signer will prefer strategies involving two (or more) simple sentences, most frequently self-questions. Why include them in this study, then? First because, although most of these structures are not the default option in LSC, they are still acceptable. And second, and even more interesting, they can be highly informative about the syntax of wh-sentences in LSC.

3.1.2.1 Indirect questions

Wh-expressions are not always used to ask for information. Sometimes, their function is to make an assertion about a given propositional content. That is, for instance, the case of self-questions, and also the case of indirect questions, in which a subordinate wh-interrogative is the complement of the main declarative verb. Notice that in this kind of structures, the main clause can be either declarative (155a), or it can be interrogative, as in (155b), a polar question, and (155c), a wh-interrogative. Crucially, the wh-expression in the subordinate clause is never what is asked for in the main clause. It remains within the subordinate clause and only has scope over it.

(155) a. Mary said what John bought.

b. Did Mary say what John bought?

c. Who said what John bought?

In LSC, the distribution of the wh-expressions in indirect questions follows the same pattern described for simple wh-questions. That is to say, they can appear at the beginning of the subordinate (156a), *in situ* (156b) or at the end (156c). And, as in simple wh-questions, the wh-expression can be complex in all positions (157a-157b).

(156) a. MARY SAY $\overset{\text{wh}}{\overline{\text{WHAT}}}$ JOHN BUY

b. MARY SAY JOHN $\overset{\text{wh}}{\overline{\text{WHAT}}}$ BUY

c. MARY SAY JOHN BUY $\overset{\text{wh}}{\overline{\text{WHAT}}}$

Mary said what John bought.

(157) a. GEMMA WRITE NOTE-DOWN TEACHER $\overset{\text{wh}}{\overline{\text{WHO}}}$ COAT WANT

b. GEMMA WRITE NOTE-DOWN COAT WANT TEACHER $\overset{\text{wh}}{\overline{\text{WHO}}}$

However, regarding the distribution of wh-expressions, there is not a clear preference in this kind of structures for them to appear in final position. This could be seen as a strategy to prevent ambiguity with a long distance wh-movement (see section 3.1.2.2).

NMMs in indirect questions behave differently than in regular interrogatives. As (156a-156b) show, the NMMs do not spread to the end of the clause but rather remain associated just to the wh-expression. The wh-NMMs associated to indirect questions are normally articulated softer and quicker than wh-NMMs associated to main clauses. In fact, these

NMMs can be superseded by some other NMMs if they come into conflict with them. For example, in (158), the wh-expression WHAT has lost the typical furrowed brows associated to wh-elements, because it is in the antecedent clause of a conditional construction, which has a raised brows-NMM associated to it.

(158) $\overline{\text{IF JOHN }{}_{3}\text{ASK}_{2}\text{ IX}_{1}\text{ WHAT BUY}}^{\text{rb}}$ NO ${}_{2}$SAY$_{3}$

If John asks you what I bought, don't tell him.

Note that, as has already been said, indirect questions are not canonical constructions in LSC. The genuine and most widespread alternative is the use of a self-question. Therefore, the usual way to express (156) would be (159).

(159) JOHN BUY $\overline{\text{WHAT,}}^{\text{wh}}$ MARY SAY

Mary said what John bought.

3.1.2.2 Long-distance wh-questions

A long-distance wh-movement consist of extracting a wh-expression from a subordinate clause to the Spec,CP of its matrix clause, so it can scope over the whole sentence (160). Consequently, the matrix clause in this kind of constructions is always a wh-question.

(160) What did Mary say that John bought?

In LSC, the preferred landing site of the wh-expression in long-distance wh-questions is the ending of the sentence (161).

(161) WHO SAY COOKIE STEAL

Who said that (someone) stole the cookies?

In contrast, initial wh-expressions with long-extraction reading are very odd and they are usually interpreted as short-distance movements (162).

(162) SAY COOKIE STEAL WHO

Who did (someone) say that stole the cookies?

An interesting contrast between initial and final occurrences of wh-expressions is observed when we put an explicit argument in the object position and a wh-expression in one of the margins. In (163) the sentence crashes, since we do not have an available variable to link the operator WHAT to.

(163) * $\overline{\text{WHAT MARY SAY BOY COOKIE STEAL}}^{\text{wh}}$

However, a different pattern is seen when we put the wh-expression at the end (164). Interestingly, when the wh-expression is in that position, the sentence is saved with the reading of a wh-subextraction: WHAT is interpreted as extracted from a complex wh-expression, the wh-phrase 'which cookies'. This reading is impossible in the previous example.

(164) $\overline{\text{MARY SAY BOY COOKIE STEAL WHAT}}^{\text{wh}}$

Which cookies did Mary say that the boy stole?

Some more asymmetries between the margins arise when we look at non-canonical but possible sentences. Specifically, in the case of complex sentences with two non-coreferent wh-expressions. In (165) WHO is interpreted as a short-distance movement from the main clause, namely a dative from the main clause. The final wh-expression WHAT, on the other hand, is interpreted as a long wh-movement, a wh-object moved from the embedded clause.

(165) $\overline{\text{WHO MARY SAY STEAL WHAT}}^{\text{wh}}$

What did Mary say that was stolen to whom *(did she say it)*?

If the order of both wh-expressions is reversed, as in (166), the long distance reading for WHAT in the initial position is not possible. The informants accept this sentence by simply 'ignoring' the wh-expression at the beginning and assuming that the final located WHO is a long-distance movement from the subject position of the subordinate clause. In other words, this question is only answered with one element, the name of the possible thief, and not with a pair of elements.

(166) $\overline{\text{WHAT MARY SAY STEAL WHO}}^{\text{wh}}$

Who did Mary say that stole *(something)*?

This sentence reminds the so called 'what constructions' (WC) in languages like German, Hungarian or Hindi. In WC (167) there is an unmarked wh-element (*what*) in sentence-initial position, while the actual wh-expression is either *in situ* or has undergone partial movement to a position lower than the Spec,CP of the matrix clause, such as the Spec,CP of the subordinate clause.

(167) Was glaubst du wen Irina liebt?
what believe you who Irina loves
Who do you believe that Irina loves?

Strictly speaking, (166) cannot be considered an instance of a WC, because the second wh-element seems to be in a peripheral position instead of being *in situ* or in an intermediate position. Nevertheless, the asymmetry between (165) and (166) seems to point to a preference for the final location for long wh-extractions. On the other hand, initial wh-expressions in complex sentences tend to be interpreted as local wh-movements, from the main clause, and can even be devoid of argumental content, as in (166).

In this sense, the behavior of non-argumental wh-expressions in multiple complex sentences reinforces the idea that the initial location and the final location are different in nature. Regardless of the relative order of the wh-expressions, the initial one in (168) and (169) is always interpreted as a short distance movement. The final one, on the other hand, is ambiguous and can be interpreted both as a short or a long distance movement, although this last option is seen as more natural.

(168) $\overline{\text{WHERE MARY SAY JOHN STEAL HOW}}^{\text{wh}}$

Where was Mary when she said that John stole how?

(169) $\overline{\text{HOW MARY SAY JOHN STEAL WHERE}}^{\text{wh}}$

How did Mary say that John stole where?

3.2 Analysis

Having overviewed the relevant data concerning wh-questions in LSC, it is time to propose an adequately explanatory analysis that aims at integrating both the behavior of the manual wh-expressions and the behavior of wh-NMMs. In this sense, this analysis wants to explain mainly two questions: 1) in what position (or positions) do wh-expressions land when they move? and 2) why is the spreading of wh-NMMs obligatory when wh-expressions appear in a place different than the end of the sentence?

Regarding wh-NMMs, it seems that they operate linearly, without necessarily respecting phrasal boundaries. In this sense, they behave as if they where prosodic in nature: they tend to match constituency, but what really binds them is order and linearity. Nevertheless, they are not insensitive to syntax and, in fact, I will argue that they serve, among other things, to satisfy syntactic requirements.

I have also argued in chapter 1 for a view of syntax devoid of linear information. In my view, linearization is post-syntactic and mainly driven by processing and the constraints of performance. I will return to this point in more detail in chapter 5, but I must make a caveat before going into the analysis of the structure of wh-sentences in LSC. The general view of syntax encoding only dominance relations does not entail that order is underspecified or not-specified for particular languages. That would clearly go against empirical evidence.

In the particular case of LSC, we are dealing with a language with a high degree of freedom when ordering constituents. Although it is a predominantly SOV language, other orders are possible. That said, there are two types of elements that seem to be more rigid in this respect: topics and foci. As I will show when discussing the interactions of wh-expressions with other elements, topics (Topic Phrases, or TopP) appear systematically in sentence-initial position, while foci (Focus Phrases, or FocP) tend to appear in sentence-final position, although they can appear elsewhere if lexically marked by signs like MATEIX (Mosella, 2012). This pattern is also observed in other SLs (Rosenstein 2001 for topics across SLs; Wilbur 1991 for ASL). In fact, the final position of FocP will be crucial in the analysis to follow.

In previous works (Alba 2010; Mosella 2012), overtly moved wh-expressions in LSC were assumed to be located in Spec,CP, which was argued to be canonically linearized to the right. When appearing in sentence-initial position, an influence (calque) by the spoken language plus a repair strategy was suggested.[3] A more detailed examination of the data available right now shows that, although Spec,CP is one of the positions in which wh-expressions may appear in LSC, it is not the only one, nor the preferred one.

As we have seen when discussing the data, the canonical position of wh-expressions that move is the end of the sentence. To determine their final landing node in the syntactic tree let us present three examples.

(170) BRING NOTHING $\overline{\text{SAME BOOK BUY YESTERDAY}}^{\text{rel}}\ \overline{\text{WHO}}^{\text{wh}}$

Who has not brought the book that I bought yesterday?

(171) a. TODDLERS DREAM IX $\overline{\text{WHAT}}^{\text{wh}}$

What do toddlers dream?

b. TODDLERS DREAM $\overline{\text{WHAT IX}}^{\text{wh}}$

What do toddlers dream?

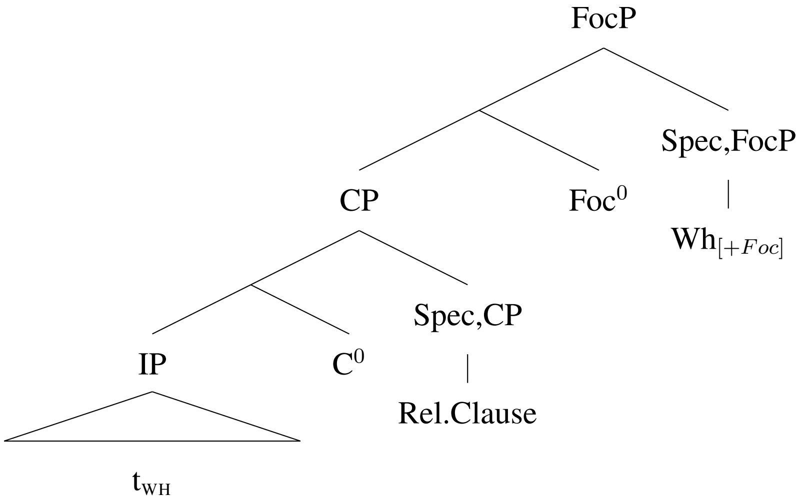
In (170), taken from Mosella (2012), the wh-expression coappears with a relative clause. According to the author's analysis, postposed relative clauses in LSC move to the right to Spec,CP and must precede the overtly moved wh-expression. Therefore the wh-expression, being

[3]Recall that the sociolinguistic situation of LSC, like that of most SLs, is such that most of its speakers are not native to it and learn it as a second language. Additionally, like many other signers, LSC signers live in a minorized language situation with respect to the SpLs of the environment, which means that the influence of these SpLs is very heavy.

more peripheral, must occupy a higher node (or at least Spec,CP if it was multiple). In (171) the wh-expression coappears with an IX index sign, which has been described as a focus marker (Crasborn and Kooij 2013, for NGT), with no particular preference as to which precedes which. Following the same reasoning, being unable to argue which is more peripheral, the pattern suggests that they are both under the same maximal projection, Spec,FocP, which is multiple.

Movement of the wh-expression to Spec,FocP is triggered by agreement by the necessity to check its [+Foc] features with the head Foc^0. The resulting structure is represented in (172).

(172)



The situation of FocP in sentence final position and the requirement of checking its [+Foc] feature is also on the basis of what we have seen as doubled constructions, whether they involve wh-elements or other kinds. In the case of wh-questions, we have seen they present essentially two patterns: *in-situ* plus sentence-final (173a) and sentence-initial plus sentence-final (173b). I believe the analysis of wh-doublings is extensive to the rest of cases of doublings we have presented.

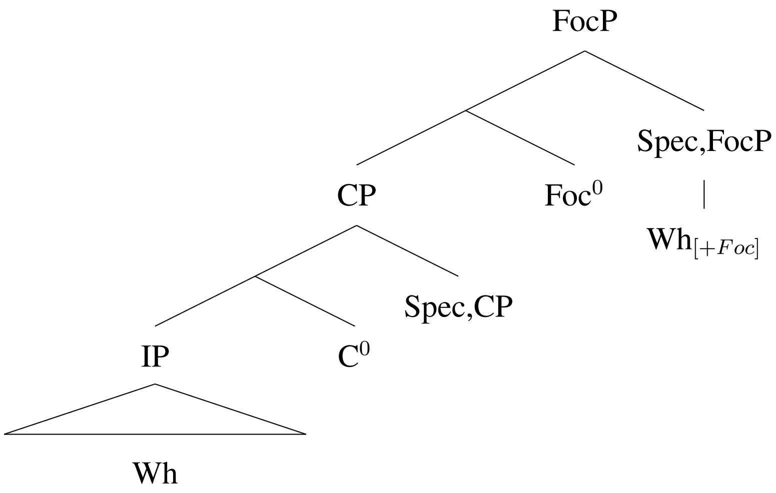
(173) a. JOHN $\overline{\text{WHAT STEAL WHAT}}^{\text{wh}}$

b. $\overline{\text{WHAT JOHN STEAL WHAT}}^{\text{wh}}$

In sentences like these, the second wh-expression is located in Spec,FocP. Since there is another coreferential wh-expression, we have to assume that it did not get there through movement, but was base-generated in that position through external merge. The first wh-expression remains inside the verb shell if it appears *in-situ* (174) or undergoes partial movement to Spec,CP if it appears in sentence-initial position (175), as I will discuss next. Spreading of the NMMs between both expressions is obligatory, but in this case it is a phenomenon of perseveration, articulatory in nature (Neidle et al., 1998a).

A consequence of this analysis is that wh-movement in LSC is carried out in two steps, and each one of the two steps is a possible final landing place for wh-expressions. First, the wh-expression moves to Spec,CP to check its [+Wh] features with the head C^0 and then it may continue to ascend the structure to Spec,FocP via [+Foc] agreement. In the case of final wh-expressions, the movement from Spec,CP to Spec,FocP can be considered vacuous if no other elements intervene (but see the *sandwitch constructions* next). In my previous work (Alba, 2010) I claimed that

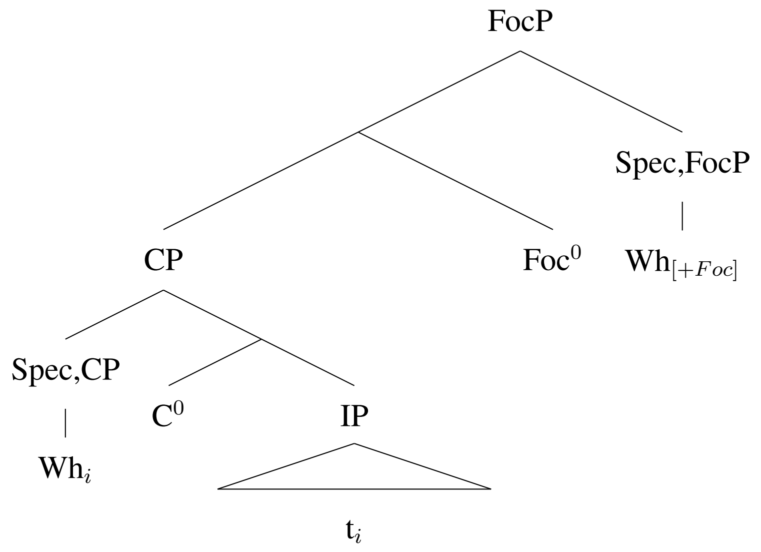
(174)



Spec,CP was linearized to the end of the sentence, while I am analyzing here initial wh-expressions as occupying that position. Under the light of the new, more complete data we currently have, and also consequently with a model of syntax that does not encode linear order, I claim that Spec,CP can be linearized either to the end or to the beginning of the sentence, depending essentially on post-syntactic operations (see chapter 5).

Perhaps the clearest instance of Spec,CP linearizing to the end of the sentence are what Mosella (2012) calls *sandwitch constructions* (176). In these constructions, which are a particular case of wh-doubling, the final periphery of the sentence is occupied by a combination of a wh-element followed by a relative clause followed by a second, coreferential wh-element.

(175)



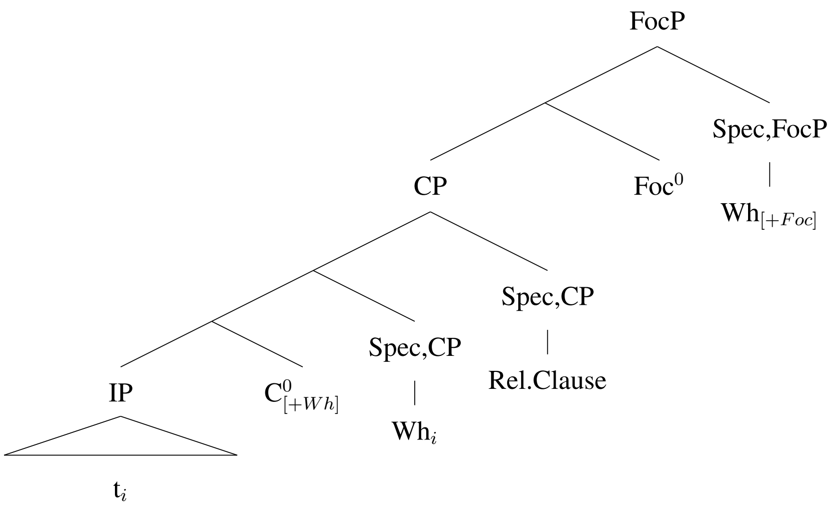
(176) FIND $\overline{\text{WHO}}^{\text{wh}}$ $\overline{\text{YESTERDAY IX}_1 \text{ KEY LEAVE}}^{\text{rel}}$ $\overline{\text{WHO}}^{\text{wh}}$

Who has found the key that I forgot yesterday?

I partially accept the analysis the author provides, in which the three elements are in a multiple Spec,CP, but disagree on the position of the final wh-element which, according to my own analysis, has to have moved to Spec,FocP (177). The first wh-element, being less peripheral than the relative clause, cannot be higher in the structure than the latter, and the arguments Mosella provides for placing the relative clause in Spec,CP are solid. The wh-element is not *in-situ* either. Therefore, these two elements must be together in that projection.

Other instances of partial movement to Spec,CP, apart from doublings,

(177)



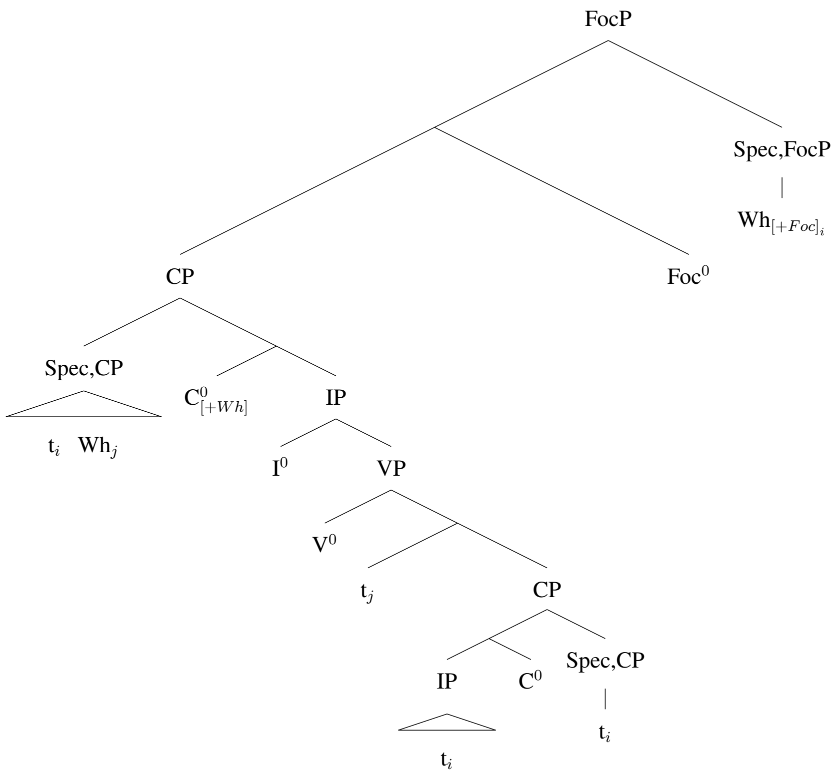
show linearization of the projection to the beginning of the sentence. Complex multiple wh-questions are illustrative of this pattern (178). In this case, the analysis is more complex, since there are superiority effects: the final wh-expression is always the one originated in the embedded clause, which has undergone a long extraction, and the initial one is always the one originated in the matrix clause, which undergoes short extraction. To account for this asymmetry in the linearization of these elements, some processing considerations have to be brought under attention. I will do so in chapter 5.

(178) $\overline{\text{WHO MARY SAY STEAL WHAT}}^{\text{wh}}$

What did Mary say that was stolen to whom *(did she say it)*?

In (178) the embedded wh-expression WHAT moves to Spec,CP of the embedded clause, then to Spec,CP of the matrix clause together with the matrix wh-expression WHO to check the [+Wh] feature of C^0, and finally continues on to Spec,FocP to check its own [+Foc] feature. Wh-NMM perseveration is compulsory between the two wh-expressions, the same way it was for doubled constructions, thus linking the first wh-expression with the [+Foc] position. The structural representation of this kind of sentence is given in (179). Although it shows some particularities on the restrictions of the distribution of the embedded and matrix wh-expressions, this pattern is consistent with the data about simple wh-doublings.

(179)



Having then established that Focus is sentence final and triggers wh-movement to check [+Foc] features and that Spec,CP can be linearized either to the beginning or to the end of the sentence and also triggers wh-movement, which proceeds therefore in two steps, to check [+Wh] features, we should turn to the cases where either Spec,FocP or both Spec,CP and Spec,FocP are empty of lexical material. This is the case of wh-*in-situ* and fronted wh-expressions (180).

(180) a. JOHN $\overline{\text{WHAT STEAL}}^{\text{wh}}$

What did John steal?

b. $\overline{\text{WHAT JOHN STEAL}}^{\text{wh}}$

What did John steal?

I have already explained how wh-expressions can undergo only partial movement or remain *in-situ* if a base generated focus is merged in Spec,FocP. In the cases we are discussing right now, there must be some other mechanism at work to satisfy the [+Foc] requirements of Foc^0. As we have seen during the presentation of the data, one of the most robust behaviors I have observed across all wh-sentences is the need of wh-NMMs to spread to the end of the sentence whenever a wh-element appears in a position other than sentence-final.

In the case of multiple wh-expressions and doubled constructions, I have argued that the spreading of wh-NMMs is articulatory, and can be explained as an instance of perseveration between two close elements that share that feature. But when there is only one wh-expression, that explanation is, of course, no longer available. In passing, I have also hinted at the possibility that, in fact, wh-NMMs can actually have syntactic bearings and satisfy syntactic requirements, just like some prosodic phenomena in SpLs. In fact, there are other instances of NMMs showing similar behaviors and fulfilling the agreement requirements of functional heads (see Pfau and Quer 2005 for negation).

In my view, that is what is happening in this cases. Spec,FocP, being devoid of a wh-element to check its features, triggers the spreading of wh-NMMs to do so. That spreading can be either from a partially moved wh-expression in Spec,CP in sentence initial position or, in the particular case of *in-situ* wh-expressions, it can also entail that the spreading satisfies the [+Wh] requirements of C^0 which, as we have seen, can be located close to FocP, in sentence final position. In both cases, [+Wh,+Foc] material reaches the relevant positions in the tree and the agreement requirements are duly satisified.

Before summarizing the proposed analysis, I will add a brief consideration about the position of Topics and their interaction with wh-expressions. As Mosella (2012) points out, fronted Relative Clauses precede initial wh-expressions, and reach TopicP which, in LSC, is linearized systematically in sentence initial position. Seeing that Relative Clauses in Spec,TopicP are more peripheral than sentence-initial wh-expressions, they must also be higher up the structure. That is in consonance with the claim that initial wh-expressions have moved as far as Spec,CP.

Summing up, after having presented the data to describe all the possible realizations of wh-questions in LSC, two systematic patterns emerge. First of all, wh-expressions tend to be located in sentence final position, which is a position related with [+Foc] information in many SLs, precisely to satisfy their [+Foc] features. This movement of wh-expressions to the end of the sentence is not restricted to short extractions, but can target also elements in embedded clauses, resulting in long-extraction readings. This is, in fact, the preferred landing site for long-extracted wh-expressions, while short-extracted ones tend to be kept in sentence initial position.

It is important to bear in mind that, when I talk about linearization to the left or to the right (or more specifically to the beginning or to the end of the sentence), I am not implying that order derives from any information encoded in the syntactic structural position. That is to say, in the tree, specifiers are not to the left or to the right of heads, for instance, although they are represented by left-branching or right-branching structures for ease of reading. Linearization is a post-syntactic event bound to externalization (see chapter 5). The analysis in this proposal accounts for the hierarchical (*vertical*) configuration of the constituents of the sentence.

Second, both the [+Wh] feature that triggers wh-movement to Spec,CP and, most importantly, the [+Foc] feature that triggers subsequent wh-movement to Spec,FocP can be satisfied either by filling these positions with lexical material (through movement or, in the case of doublings, through external merge) or by the spreading of wh-NMM whenever wh-elements are in a position other than Spec,FocP. That is why in the cases of inital wh-elements or *in situ* wh-elements the spreading of wh-NMM to the end of the sentence is compulsory.

According to the previous discussion, the hierarchy of nodes above IP in LSC is IP $<$ CP $<$ FocP $<$ TopicP. Wh-expressions can be found either below IP, within the verb shell, or moved inside the projections of CP or FocP. Wh-movement is carried out in two steps and can be partial or total. First, the wh-expression moves to Spec,CP to check its [+Wh] feature, and it can remain in that node (partial movement) and be linearized either to the beginning of the sentence or, under some circumstances, to the end in which case further movement is often vacuous both regarding the order of lexical signs and the compulsory spreading of wh-NMMs. In the second step, the wh-expression moves to Spec,FocP to check its [+Foc] feature and, in this case, will be linearized systematically to the end of the sentence. Nevertheless, overt movement is not compulsory, and [+Wh] and [+Foc] agreement can be satisfied by the spreading of wh-NMMs.

We have assumed that Foci are linearized to the end of the sentence (and Topics to the beginning) just as a conclusion of the observation of the data, again without implying that this is a consequence of the position of any particular node in the structure. In chapter 5 I will argue for a pattern of linearization that accounts for the possibility of having wh-expressions in LSC in any of the three positions available (initial, *in situ* and final) and also for the systematicity of placing Foci in sentence final position independent of hierarchy.

Chapter 4

WORKING MEMORY IN VISUAL AND AUDITORY MODALITY

In the first chapter I offered an introduction to one of the challenges wh-questions in signed modality pose to linguists: the differential behavior between modalities in allowing the location of wh-expressions at the end of the sentence. I also introduced some methodological issues found in the studies of the syntax of SLs, in particular some errors in the identification between order and hierarchy that might have derived in a vision biased by notions such as ‘left periphery’, coming from the study of languages with a writing system from left to right. In that chapter, I also pointed out the necessity of tackling the issue from the point of view of the processing of each modality. In chapter 2 I have reviewed the state of the art of wh-questions in SLs. In chapter 3 I have presented a characterization of wh-questions in LSC and I have offered a proposal for their formal analysis.

This chapter offers an experimental approach, a switch of the focus to some general capacities that underlie sentence processing, which I claim play a role in the different patterns of wh-questions between modalities. It is a turn in the traditional perspective of the study of syntax that might seem a bit radical. Nevertheless, and along some other formal linguists that have begun the exploration of this area (Geraci et al. 2008; Gozzi et al. 2011; Papagno et al. 2007; Cecchetto and Papagno 2011), it is a necessary leap to move forwards.

Specifically, the leap is based on the idea that underlies this dissertation: the differences in the linearization of wh-expressions between modalities are related to differences in how information is stored in working memory (WM) in each modality. In other words, the differences in how both modalities allow and disallow the wh-expressions to distribute along the sentence may be due to differences caused by modality itself and related to the differential WM processing in the visual and auditory modality. As a matter of fact, some of these differences in WM have already been observed in preceding studies. The goal now is to contribute some new data which, from this perspective, are the natural step to take in order to make progress in the solving of this puzzle.

In this scenario, by looking for the causes of linear differences in the processing patterns for each modality, the uniformity of syntax across modalities is preserved. Precisely because the hierarchical structure is shared by all natural languages, I posit that it is in externalization, in that which separates modalities, where we will be able to find the elements which will shed light on the debate on wh-questions in SLs and SpLs. According to my view, two major claims are put forward. First, as I have just said, that the differential patterns observed in each modality are a matter of linearization (and, therefore, post-syntactical); and, second, that the way each modality linearizes structures is related to the way information is stored in WM in that modality.

Before going into the relevant differences in WM for each modality, I offer a section with an overview of WM and some findings and debates about its role in sentence processing.

4.1 Working memory and sentence processing

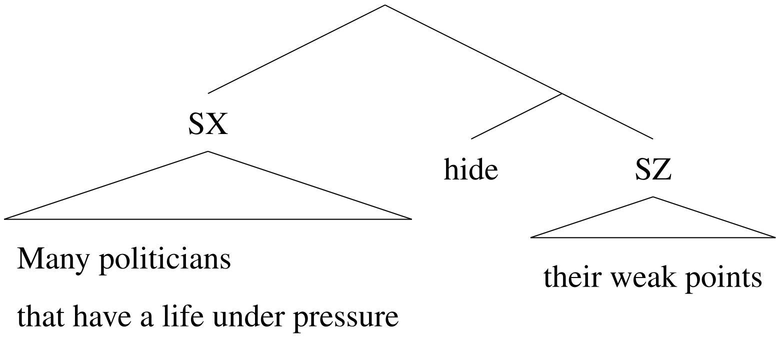
When we comprehend a sentence we must recognize the underlying hierarchical structure from a linear sequence of segments. This involves, on the one hand, identifying syntactic constituents, and, on the other hand, recognizing the configurational relations between them. It is generally assumed that, in this scenario, syntactic processing demands memory-based resources. One of the clearest instances of this is the necessity of linking together in the structure elements that are not adjacent in the utterance. Let us illustrate this with an example:

(181) Many politicians that have a life under pressure hide their weak points

In (181), the subject of the main clause, *many politicians*, appears separated from the verb by a center-embedded relative clause. Nevertheless, it must be kept active until the verb it must be linked to, *hide*, appears, and the corresponding argumental relation is established. That is to say, there is a dependence relation between two non-adjacent elements that cannot be solved immediately upon listening the first element, but has to wait, somehow active, until the second element is uttered.

To be fair, it should be noted that, at an adequate level of analysis, the subject and the main verb in (181) are adjacent. That is so because the subject is not only *many politicians*, but the whole phrase including the relative clause, *many politicians that have a life under pressure*. From this point of view, distance here would only be temporal (in the sequence), and not structural (in the tree). But, there is another case of a distant relation in this sentence: the relation between the pronoun *their* and its antecedent, the subject. In this case, there is linguistic material between the two elements not only in the sequence but also, crucially, in the tree. So this coreferent relation clearly cannot be solved immediately.

(182)



The fact that non-adjacent related elements demand memory resources is tied to the fact that languages are externalized in a temporal line. Structures have to be identified from a context in which the building blocks come either *before* or *after* each other, they are either *preceding* and *following*. In fact, as we will see later on, the notion of time plays an important role in the study of language processing.

Another paradigmatic case of non-adjacent relations is the instances of displacement, a defining property of natural languages by which some linguistic elements are interpreted with regard to their theta dimension in a place different from the one where they are uttered. The typical example of this property is wh-fronting (183).

(183) Which house did a friend of Tim sell to a guy with no morals?

In (183), the initial wh-expression *which house* is interpreted as the object of the verb *sell*, quite a distance away from the beginning of the sentence. Therefore, it must be kept somehow active in order for it to be related to the verb *sell* in said object position. From the linguistic tradition, it is said that the wh-expression and the object position, which hosts a co-indexed trace of that wh-expression, are involved in a dependency relation. Many studies, mainly in the fields of psycholinguistics and neurolinguistics, have pointed out that this gap is bridged through the intervention of Short Term Memory (STM) or, more specifically, WM (see Cecchetto and Papagno 2011 for an overview). That is to say, the resources necessary to process distance dependencies may rely on WM (Baddeley and Hitch, 1974; Baddeley, 2000). That makes WM the ideal candidate to begin searching for answers to the differences in the distributional linear patterns of wh-elements according to modality.

Working memory has been defined as a 'temporary storage system under attentional control that underpins our capacity for complex thought' (Baddeley, 2007). This storage allows us to do some tasks, like, for instance, mentally visualizing a map to plan the best route to drive from A to B, multiply carrying, or repeating sentences backwards. To put it simply, WM can be defined as a limited-capacity system which stores information for a short time and manipulates it.

The term WM is often used interchangeably with the term STM. In fact, the former evolved from the latter. However, some works make a difference between the two and use STM to refer only to the limited temporary storage of information, while leaving WM to refer to the additional combination and manipulation of such storage (Baddeley, 2012). When this difference is relevant, I will explicitly state it to avoid ambiguity. In sum, WM allows us to keep active fragments of information for short periods of time in order to carry out tasks that need that information to be used or manipulated in some way.

The most extended view on WM is the model by Baddeley and Hitch (1974). According to it, WM has three components:

Phonological loop A storage capable of holding speech-based information for a temporary lapse. Many studies make a distinction between two sub-components within the phonological loop: the Short Term Store (STS), which keeps memory traces for 2 seconds before they decay, and an articulatory processor of rehearse, normally called Rehearsal Process (RP),[1] which refreshes memory traces and prevents them from decaying (Baddeley, 1990).

Visual sketchpad A storage to hold and manipulate visual and spatial information.

Central executive An attentional controller devoid of storage properties that processes the information flow within WM and also interfacing with other systems, like Long Term Memory (LTM).[2]

[1]Rehearsal is assumed to involve either overt or covert vocalization.

[2]The idea of a separation between STM and LTM is an old one (Atkinson and Shiffrin, 1968) and is still controversial. The distinction between these two storages is supported specially by the existence of the anterograde amnesia, a specific memory

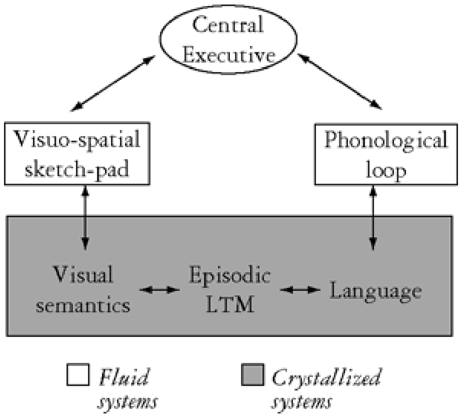


Figure 4.1: A sketch of the architecture of Working Memory (from Baddeley 2012)

Recently (Baddeley, 2000), another component has been added to the architecture of WM: the *episodic buffer*. This component consists of an interface between the three WM subsystems and other perceptual, memoristic or semantic components, that integrates information of different ‘codes’ (visual, auditory, semantic, etc.) into multi-modal, multi-dimensional episodes (or scenes), and that is accessible through conscious awareness. The WM architecture is shown in figure 4.1.

Two well-known effects in memory span provide evidence for the subdivision of the phonological loop into the Short Term Store (STS) and the

disorder that prevents the patient from creating new long-term memories, while leaving unaffected the ability to retain small pieces of information for a short time. But for a critical review about this partition of the storage, see: Brown et al. (2007); Nairne and Dutta (1992).

Rehearsal Process: the *phonological similarity effect* and the *word length effect*. On the one hand, the phonological similarity among the items of a list to be recalled affects the STS. STM span, the number of items that can be stored in STS, is higher when the items to recall are dissimilar (like *pit, day, cow, pen, sup*) and lower when they are similar (like *man, cat, cap, map, can*) (Conrad, 1964; Conrad and Hull, 1964). The explanation given to this fact is that the decay of phonologically distinctive features is more probable in the latter case, in which distinctive features are fewer, than in the former, in which the distinctive features are more numerous. This suggests that the information stored in the STS is, indeed, phonological.

On the other hand, the effect of word length gives support to the existence of a rehearsal process. Memory span is higher when the words to be recalled are shorter (like *wit, sum, pad, beg, top*) than when they are longer (like *university, refrigerator, hippopotamus, tuberculosis, auditorium*) (Baddeley et al., 1975). Since longer words take more time to be rehearsed, the decay of memory traces is more probable. In sum, memory span is affected by two variables: the rate at which the trace fades, and the speed at which items can be rehearsed (Baddeley, 2007).

4.1.1 Primacy and Recency effects

Besides similarity effect and word length effect, there are two more classic effects that have been attested in WM tasks: primacy and recency. The primacy effect makes items that are presented first in a list to be better remembered. On the other hand, the recency effect makes items that are presented last in a list to be remembered better. The side-effect of these two effects is that items in the central positions of lists tend to be forgotten more easily. The privileged status of the initial and final extremes of lists that these effects show is reminiscent of the initial and final position of wh-expressions in wh-sentences that motivated this dissertation. That is why the effects of primacy and recency were taken into account when conducting the experiments I present in this chapter, and specially when observing their results.

4.1.2 Recalling serial order

As can be observed, the effects of primacy and recency reveal a dimension to be considered in addition to STM span: serial order recall. There are two main visions on how the linear order of items is remembered, chaining models and contextual models. Chaining models consider that items are stored and retrieved according to chains of associations between them. What this means, essentially, is that items in a list are associated in chained pairs so when one item is cued, it calls up the next, and so on. Some objections have been made to this model, specially regarding the existence of some kinds of mistakes in recall that do not follow this pattern of organization. For instance, there are answers with transpositions, in which two items are reversed, leaving the rest of items unaffected. To cope with this, it has been suggested that the associations might go beyond pairs. Nevertheless, there are several other problems to the model that reformulations have not been able to answer (for a more detailed overview of the problems of chaining models see Baddeley 2007).

Contextual models associate items with a context which provides an ordinal clue. A classic example is the Slot Model, in which the storage of items is based on the number of slots from the order of presentation. Some contextual models have proposed that serial order is determined by taking into account the position of items regarding some specific markers, like the first item or the last one. In the Primacy Model (Page and Norris, 1998), for instance, the contextual cue is given by associations with the first item. To each item corresponds a node related to the first item in decreasing strength with respect to the preceding ones. In fact, error patterns seem to adjust to this model, since, for each item, there is a clear tendency of neighboring items to appear as intrusions.

The Start End Model (Henson, 1998), or SEM, adds recency as a point of reference to set the strength of the slots. By doing so, it can account for the mistakes made in chunks of triplets. It is a well-known fact that grouping digits in threes improves their recalling. The typical pattern of errors in triplets reproduces the one in longer lists, with the central digits concentrating most of the errors. Furthermore, switch mistakes between items tend to respect the position they occupy, and appear in the form of protrusions, in which an item is substituted by another item that appeared in the same position in another triplet.

4.1.3 On domain specificity for processing sentences

There is an open debate on whether there is a specialized module in the working memory system for identifying syntactic structure or whether it relies on memory resources that are used for other non-syntactic processes (Gordon et al., 2002), either within the Central Executive (CE) or within the Phonological Loop (PL). The first approach is held by supporters of the *Separate Sentence Interpretation Resource* (SSIR) (Caplan and Waters 1999, for a presentation of this view). This line of research defends that a separate subsystem is responsible for the syntactic and semantic operations in online performance when interpreting a sentence. According to them, the CE and/or the PL may only have a role (if any) in a post-interpretative stage. The second approach, the non-specific view of the role of WM in sentence processing is held by the supporters of the hypothesis of the *Single Resource* (SR) (Fedorenko et al. 2006 for a criticism of SSIR). This hypothesis supports a view in which the memory resources involved in sentence comprehension draw from a general pool common to other STM verbal and non-verbal processes (Just and Carpenter, 1992).

The data that support the SSIR theory come mainly from negative results. For instance, patients with a defective function of the PL do not necessarily show a deficit in sentence comprehension.[3] That would suggest that both processes are independent from each other in on-line processing.[4] However, when syntactically more complex sentences are considered, the data about performance in comprehension begins to show effects that strongly suggest that the PL is involved in sentence comprehension. Nevertheless, the co-occurrence of language comprehension deficits and damaged PL does not straightforwardly yield a causal relation: it is still possible that the neural correlates of both functions are adjacent and that, therefore, both regions are damaged by the same lesion (Romero et al.,

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[3]As for how sentence comprehension is measured, there are two main procedures used: the auditory moving-window technique (AWM) (Ferreira et al. 1996) and the sentence-to-picture matching tasks. The AWM is an auditory method analogous to the well known eye tracking task. In this case, a sentence is segmented and presented to the subject in the relevant constituents for the purposes of the study. It is the participant himself the one who presses a button in order to listen to the next segment. To make sure the participant has understood the sentence, when the sentence finishes, a yes-no question about it is asked. The reaction times (RT) that result from the pressing of the button to pass to the next segment are compared and can inform about points that are particularly demanding.

In the other method, sentence-to-picture matching tasks, the participant has to look at some pictures to choose the one that matches the sentence that he just has listened to.

[4]As I present in section 4.1.7, the way syntactic complexity is used in these studies is far from uncontroversial. For instance, some works have accounted for complexity effects in terms of the number of propositions involved in test sentences while some others have established a gradation considering the level of embedding or center-embedding as elements which add complexity.

2010).

Cecchetto and Papagno (2011) make quite a strong case for ruling out the possibility of a module within WM specialized in syntactic processing on the grounds of adequacy and economy. First, they argue, such a module is not necessary to explain the data currently available. These data can already be explained without resorting to any new and specific module, which is desirable from the point of view of economy and simplicity. Second, those very same data already point to the intervention of either the CE or the PL in assigning syntactic structure. Therefore, by positing a specialized module, the whole system increases greatly in complexity: not only because there would be one more (unnecessary) element within it, but also because that element would have to be integrated in the system by a set of mechanisms ruling its relation with the rest of subsystems, which should be explained as well.

So, the optimal candidate to measure the involvement of WM in syntactic processing should be either the CE or the PL, given the fact that there is no concluding proof that the Visual Sketchpad is involved in language processing at all. The involvement of the CE is controversial. Several tests using batteries of sentences on participants divided by WM span have been conducted (King and Just, 1991), criticized and replicated with differing results (Caplan and Waters, 1999), and criticized yet again (Miyake et al., 1999), leading to a situation in which it is difficult to tell methodological problems apart from, plainly, a lack of concluding results.

This situation would be problematic if it was not for the fact that the results obtained to argue for the involvement of the Phonological Loop are far more promising and robust, as we will see in the next sections.

There are three main approaches to test whether working memory is specialized in sentence comprehension. First, the study of individual differences in WM capacity and their possible correlation with sentence comprehension skills; second, the study of the possible disruption of sentence comprehension when concurrent verbal load in STS is caused; third, the study of STM specific disorders and their relation to sentence comprehension skills. Next sections present these three lines of research and provide more data from the SR and SSIR views.

4.1.4 Individual differences in WM

Within the individual-differences approach, the hypothesis of a SR would predict that having a low WM will reduce the resources for sentence processing efficiency. Under the hypothesis of the SSIR, WM tasks results do not predict sentence comprehension proficiency. The study of this possible correlation is normally carried out dividing participants in groups according to their WM span and then measuring their reading times and reading accuracy with increasing complexity sentence sets. In this line, some studies like King and Just (1991) have reported longer reading times in low span subjects. More specifically, they have reported that reading the verbs of an object relative sentence, such as *The reporter that the senator attacked admitted the error*, took more time for low WM span subjects, and their resulting comprehension was less accurate.

However, the results of this study and other subsequent experiments are not uncontroversial. Caplan and Waters (1999) reran them and found no significant correlation between WM span and performance. Specifically, in the case of relative clauses they compared object relatives (184) and subject relatives (185) on the basis that there is considerable evidence that the former are more demanding than the latter. This overburdening of the processing is supposed to be critical at or around the verbs, mostly the one in the relative itself but also the one in the matrix clause.

(184) The boy that the girl pushed kissed the baby.

(185) The girl that pushed the boy kissed the baby.

Caplan and Waters (1999) obtained a reading increase at the verbs, specially at the embedded verb, but no differences between WM span groups were found. In turn, their study was also questioned by Miyake et al. (1999). These authors claim that Caplan & Waters's arguments for separate working memory subsystems for sentence comprehension processes do not have a solid empirical basis because of the lack of statistical power from non optimal experimental designs and analyses. The only safe result that one can draw from this situation is that it is unclear that there is a relation between memory resources measured by WM span and sentence comprehension skills.

4.1.5 Concurrent verbal load

The mutual interference approach (also known as dual-task approach) tests whether verbal memory loads of WM result in a disruption of sentence comprehension proficiency. The disruption of sentence comprehension will always be stronger in complex sentences than in simple sentences. According to the SR hypothesis, a concurrent external verbal task (not related to syntactic processing, such as digit span tasks) will affect sentence processing, since both tasks, being verbal, depend on the same pool of resources. The SSIR, on the other hand, predicts that internal sentence interpretation (the process to extract the meaning of the sentence) and external interpretation (the process of using that meaning to perform other tasks) draw on different resource pools. According to this perspective, sentence processing would not be affected by this kind of concurrent tasks.

Baddeley and Hitch (1974) found that a concurrent digit load interfered more with comprehension of passive than active sentences. They presented a task in which subjects had to tell whether a statement about a sequence of letters was in accordance with a subsequent graphic display (for example, *A is not followed by B – BA*). However, Caplan and Waters (1999) criticized some aspects of the methodology of this study. They point out that some factors should have been considered, like the order of mention of the letters and the letter pair, presentation of letters in their alphabetical order in either the proposition or the pair, or proactive interference. According to them, some higher order interactions could have affected the results of the interaction between load and voice.

In their own studies, Caplan and Waters (1999) report that they did not find a correlation between WM load effects, syntactic complexity and performance in sentence comprehension. That is to say, a bigger external memory load (and/or a lower WM capacity) correlate to a decreased performance in sentence comprehension, but the effect on syntactically complex structures is not significant. Nevertheless, they point out another methodological issue that can be interfering with the data and that might have been wrongly analyzed. Throughout the literature, a pattern emerges. When the stimuli of the sentence task and of the recall task are presented sequentially, no effect is observed on syntactic complexity. But when the stimuli of both tasks interrupt each other during their presentation, the effects of a concurrent WM load on sentence comprehension correlate with syntactic complexity. So, if the digit span is presented before the sentence to be processed, the performance will not be decreased as a function of that sentence's syntactic complexity. If, on the other hand, the digit span is interspersed in the sentence, the performance will be affected in the case of syntactically complex sentences in a higher degree. They interpret that the reason for the effect of a concurrent WM load on syntactically complex sentences is that the attentional shifts associated with interrupting each task interfere with subjects' abilities to structure sentences syntactically or to use that structure to assign sentence meaning. In their words, that might be a secondary effect of disruptions of lexical access (Caplan and Waters, 1999), and not an effect of two tasks competing for a single pool of resources.

Both methodology and results in this area remain far from uncontroversial. Cecchetto and Papagno (2011) speculate that this lack of clarity might be due to a misunderstanding in the use of WM tests. They argue that this kind of tests, like reading span or digit span, measure conscious coordination of complex abilities, while language processing is based on automatic, unconscious processes. It might be the case, then, that the absence of a correlation is due to the mixing of conscious higher level cognitive abilities and unconscious lower level ones.

4.1.6 STM specific disorders

Perhaps a more promising and powerful venue of research to elucidate this debate lies in clinical studies with subjects presenting STM specific disorders. In this sense, some specific impairments in STM are informative about the existence of some components in the architecture of WM and also about their relation (for a review see Vallar and Papagno 2002).

Specifically, the lens has been put on subjects with a defective phonological STS. This kind of patients have a selective deficit of STS span, reflected on an impairment of serial recall of strings of unconnected auditory-verbal material (digits, letters or words). Their performance in visual modality –using written stimuli– is better than in auditory modality. This is unlike normal subjects, who have a better performance with auditory stimuli than with written input. This contrast supports the idea of two separate STSs, one auditory (phonological) and one visual (non-phonological). In fact, some studies have reported a high amount of errors based on shapes in some patients in visual modality (Warrington and Shallice 1972 in patient K.F.), like confusions between letters P and R.

The deficits of the defective Phonological STS do not arise from defective speech perception nor from impaired speech production. This kind of patients have obtained good general repetition scores of single stimuli (over 90%). In fact, a number of studies show normal performance in tasks that demand phonological analysis but that minimally demand immediate retention (like discrimination between syllables that only differ in one feature). The defective auditory verbal span disorder does not result either from speech production impairment. When a non-speech response is required, the results remain the same (patient P.V., Basso et al. 1982; patient K.F., Warrington and Shallice 1969). Moreover, the fact that oral speech is preserved in these patients also supports the idea that this deficit does not depend on speech production problems.

The other subcomponent of WM integrated in the PL, the rehearsal process, has been investigated in several patients who have lost the ability to speak, such as anarthric patients (Vallar and Cappa, 1987). It is interesting to determine the possible articulatory nature of the rehearsal process to, in turn, determine if it is indeed subvocal (inner speech) or it depends on the articulatory system. Anarthric patients had a normal auditory verbal span and were sensitive to phonological similarity effect and in some cases to word length effect. These data suggest that the rehearsal process can operate centrally on the plane of premotor planning, without feedback from the peripheral speech musculature (Vallar and Papagno, 2002).

4.1.7 Phonological STM disorder and sentence comprehension

Patients with a selective disorder of auditory-verbal span have an associate deficit of sentence comprehension. These patients tend to fail in comprehension tasks with sentences where word order is crucial, like the Token Test sentences such as *Touch the small green square and the large black circle* (De Renzi and Faglioni, 1978), or with semantically reversible sentences such as *The cat that the dog chased was white*, but not when lexical information constrains sentence interpretation (Vallar and Papagno, 2002).

These patients can nevertheless make correct grammaticality judgements on sentences that are longer than their impaired auditory verbal span. Although this casts some shadows on the precise role of STM in sentence processing, it is clear that there is indeed a relation. Different authors have proposed different functions for STM, all of them having in common the fact that STM provides temporary storage of phonological information that contributes to syntactic comprehension. In other words, sentence comprehension would be affected when the linear word order is crucial and lexical-semantic information does not constrain the meaning of the sentence.

Baddeley et al. (1987) and Baddeley and Wilson (1988) give support to the hypothesis that phonological STM is involved in sentence comprehension. They made a follow-up study in patient T.B., who had a defective auditory verbal span and sentence comprehension. In the moment that study was conducted, T.B.'s digit span had recovered from 2 to 9, within the limits of normality, and his performance in sentence comprehension tasks was consequently also back into normality. Crucially, the interpretation in terms of general and non-specific recovery is ruled out by the fact that his performance in tasks which required phonological judgements remained still defective (Wilson and Baddeley, 1993).

More recently, Papagno et al. (2007) examined a patient with a selective deficit of verbal STM to test whether sentence comprehension is limited by the number of propositions, as Rochon et al. (2000) had proposed, or by syntactic complexity. In their study, Rochon et al. (2000)

tested a group of patients with Alzheimer's disease and reported a two-proposition effect. According to this study, the subjects performed very poorly in picture matching and video verifying tasks when a single visual stimulus had to be matched to two propositions. They suggest that this was a postinterpretative effect.[5] Thus, performance would be affected by the number of propositions but not by syntactic complexity. Papagno et al. (2007) respond to this study with some objections. They point out that, in Rochon et al.'s study, the complexity of some two-proposition sentences was greater than others in which the patients performed better. They suggest that there could be in fact an effect of syntactic complexity hidden. To discriminate between these two possible factors, namely the two-proposition factor and the syntactic complexity factor, a task using two-proposition but structurally simple sentences is needed. Obviously, the candidate that better suits this requirements would be a coordination of simple sentences. However, this type of sentence was not in the set by Rochon et al. (2000). Following this line of argumentation, Papagno et al. (2007) tested their own patient, M.C., to verify whether sentence comprehension was impaired and whether sentence comprehension was constrained by syntactic complexity or by the number of propositions.

The results of their study show that the patient made errors when center-embedded structures, cleft objects, and object relative clauses in

[5] They suggest this postinterpretative effect could be caused by the difficulty in matching two propositions with a picture/video.

right peripheral position were involved. She performed at a normal level in the remaining sentence types. These results strongly suggest STM is in fact involved in complex sentences comprehension and go against the idea that the results correspond to a postinterpretative effect due to a difficulty in processing two propositions. Crucially, M.C. performed normally at simple coordination. Papagno et al. (2007) conclude that "a common verbal WM system supports verbal STM and complex sentence comprehension: one component of the phonological loop in particular -rehearsal- seems to be involved in the comprehension of syntactically complex sentences". More specifically, they suggest that rehearsal has a role in replaying the sentence, when comprehension cannot proceed online.

4.2 Working memory and SL

In the previous section, I have presented comparisons between auditory and visual modalities. Nevertheless, the area of spoken language has not been abandoned in any moment: in the general theory, the term *visual modality* has been traditionally applied to the written form of spoken language. We have seen, for example, that there is a phonological recoding component which can be damaged in some patients, yielding a deficit in the conversion of the visual stimuli in the input (written language) to the phonological output that should be stored to be rehearsed in the PL.

However, in the last few decades, another visual modality has been considered within the study of STM: sign language. Sign languages give us a unique tool to compare modalities within the domain of full-fledged, natural languages. They differ from written language in that the latter is an artificial system which requires an additional component to decode it. In this sense, it is relevant for the theory to elucidate whether language modality affects the way in which psycholinguistic mechanisms of production and comprehension use linguistic material, and if that is the case, to pin down which are those differences. This way, the study of WM in signed modality in particular is crucial to complete the general theories on the nature and functioning of WM.

Sign Languages and spoken languages have a similar internal organization of verbal short-term memory. Both modalities use phonological cues to store linguistic information. A proof of this is the fact that the phonological similarity effect (items from a list are better recalled if they are dissimilar) has also been attested in signed modality (Wilson and Emmorey, 1997b,a, 1998). In fact, older works like Bellugi et al. (1975) already showed that signs are phonologycally stored in STM. They studied the errors in serial recall of ASL signs and they showed that signers made phonollogically based mistakes, and not semantically based mistakes.

A rehearsal process has been posited for signed modality too, just like for spoken modality, since the effects that give support to this mechanism have been described in tasks using signs. For instance, Wilson and Emmorey (1997b), Wilson and Emmorey (1997a) and Wilson and Emmorey

(1998) found a *word lenght effect* in signed modality (the signs of a list are better recalled if they are short). This parallels the effect observed when using words, that longer items affect the rehearsal process because they take longer to rehearse. In the same direction, Wilson and Emmorey (1997b) also found an *articulatory suppression effect* in signed modality, which is present in spoken languages, too. The articulatory suppression effect happens when a subject has to produce some elements while doing a memory task. Concurrent irrelevant speech/sign can be very simple (like repeating a syllable) or more complex (like spelling a word). Wilson and Emmorey showed that, when using signs, just like in spoken languages with words, recall impoverishes when there is a competing activity of the articulators. Finally, these same studies have reported the presence of an *irrelevant speech (sign) effect*, which happens when some irrelevant stimuli are displayed when the subject is doing a recall task. As in spoken modality, competing inputs yield an impoverished recall.[6]

However, despite all these parallelisms, there are studies that show differences in STM between modalities. Specifically, several works have reported that STM span is lower in SL. Three main explanations can be found in the literature. First, sign length: signs are longer than words in articulatory terms, which would entail that it would take longer for them to be articulated (compared to words), negatively affecting articulatory

[6]It has been discussed whether this effect is attributable to a storage disruption or to a rehearsal disruption (for a review, see Baddeley 2012).

rehearsal in sign users. Second, the phonological complexity of signs versus spoken words: Signs would be heavier in phonological terms and this would affect memory span. Third, an effect of a temporal order demand: tasks used in measuring STM span which require the maintaining of serial order would favor speakers over signers.

4.2.1 Sign length

On average, signs are longer than words, in the sense that they take longer to be produced. This idea, already suggested by Klima and Bellugi (1979), has been used to explain the span differences between spoken and signed modality. In a recall task, although they controlled the rate of presentation by displaying one item per second, these authors acknowledged that signs were twice longer than words. They concluded that if signs take longer to rehearse, recall performance will be affected negatively.

Boutla et al. (2004) challenged this idea. They compared English speakers with ASL signers trying to control for the articulation rate of the stimuli and also for phonological similarity. They compared ASL Deaf native signers with English hearing native speakers in a span task using finger-spelled letters and digits respectively. In spite of the articulatory control of the items, their results still showed a significant difference in STM span between signers and speakers, with ASL signers scoring a mean span of 4.4, and English speakers scoring a mean of 7.2.

However, a more recent study by Wilson and Emmorey (2006) shows that Boutla et al.'s results have to be taken cautiously, since they used digits with the hearing group. According to Wilson and Emmorey, this difference can be attributed to the privileged status of digits in the oral modality. In their own study, the authors compared digit and letter span tasks for English speakers, and the digits still had a bigger span than letters. They explain that this privileged status of digits might be due to several reasons: we have more experience in number rehearsing tasks, digits form a smaller set than letters, and digits induce a representation of a magnitude (Knops et al., 2006). The advantage of digits over letters and words has also been reported in a study of a group of patients with selective deficits of STM (defective phonological STM) (Vallar and Papagno, 2002). These patients still showed a higher digit span (3.23) over letter span (1.79) and word span (2.00).

According to the results of these studies, it could be that, after all, the sign-length hypothesis is enough to explain the differences in STM span between signs and words. In fact, Wilson and Emmorey (2006) did not obtain a significant difference between auditorily presented letters and finger-spelled letters. That is, they obtained no significant difference when controlling the sign length (using letters in both modalities) and removing the digits from the stimuli set, which were posited to be the source of the difference found in the study by Boutla et al. (2004). Their study, though, was criticized in a response by Bavelier et al. (2006), who claimed that the result was due to a lack of control for phonological similarity in the case of spoken stimuli. They argue that the names of the letters in English (*bee*, *dee*, *gee*, etc) are more similar than the names of the digits. Therefore, there could be a phonological similarity effect causing the letter span to decrease, and affecting the performance of the English speakers group.

To test the hypothesis of the word length effect as the only cause for the differential span between modalities, it is relevant to use complete signs as items, and not fingerspelled letters, and confront them with words, not with letter names or digits. Geraci et al. (2008) did so. Including a control in the rate of articulation, they compared Italian word span to Italian Sign Language (LIS) sign span. They segmented signs in three parts: 1) the movement from the resting position to the location of the sign; 2) the articulation of the sign; and 3) the movement to come back to the resting position. 1 and 3 are transitional movements that increase the length of the sign. To match the duration of the sign with the duration of the word, transitional movements were excluded from the calculation of the articulation length. The results showed that even when articulation rate is controlled for, removing any possible advantage for words, hearing participants still have a significantly higher span than deaf participants in both the oral and signed modalities. They therefore excluded that articulation rate is responsible for the lower span in LIS.

An unlikely hypothesis would be that deafness condition was the cause of the shorter span. This was also ruled out in the study by Geraci et al. (2008). An experiment comparing hearing and deaf participants in an emblem span task was carried out. Emblems are symbolic gestures integrated in a community of speakers which refer to objects, concepts and actions. They are conventional (for instance, the ‘thumbs up’ gesture), and they can sometimes also be iconic (like the gesture of sending out a kiss). In the comparison between the deaf and hearing groups there was no significant difference in span.

4.2.2 Phonological complexity of signs

Another possible explanation to the lower span results in signed modality is the phonological complexity of signs. Geraci et al. (2008) point out that signed syllables are phonologically heavier than spoken syllables. These authors, based on other studies on sign language phonology (Brentari 1998; Sandler 1989), highlight two aspects of signed syllables: 1) signed syllables have a movement that works as the nucleus; and, 2) in signed syllables, the four formational parameters of the sign (movement, handshape, location and orientation) are always present. This means that syllables in sign language are always complex. In contrast, spoken syllables can be very simple, as simple as just the nucleus. These properties make signs phonologically heavier than words, and therefore not well suited for serial recall (Gozzi et al., 2011). The authors suggest that these two properties are responsible for the lower span in signed modality.

In this line, Emmorey (2007) suggests that due to the simultaneity that SLs allow, they tend to use non-concatenative morphological strategies, unlike spoken languages. This simultaneity, together with the greater length of signs, could have an effect on STM capacity, and may induce SLs to disfavor linear affixation. We could think, therefore, that the preference for spatial/simultaneous strategies over concatenative/temporal ones percolates to other levels of linguistic analysis, not only to morphology.

Additionally, Marshall et al. (2011) have suggested that SLs phonological inventories would be higher and more unrestricted than SpLs inventories yielding to what they called "greater degrees of freedom", and affecting differently STM performance across modalities.

4.2.3 Serial order requirement

Another line of research has emphasized the importance of the order requirement in memory tasks, which would favor spoken modality over signed modality. The idea behind the studies defending this thesis is that both modalities encode information in STM in different ways. While speakers would rely mainly on temporal encoding when storing information in STM, signers would rely mainly on spatial encoding (Wilson, 2001).

In this sense, it is worth mentioning here that it is already known that auditory and visual information present time-related differences. On the one hand, auditory and visual information decay at different rates: while echoic (auditory) memory lasts 2-4s (Darwin et al., 1972), iconic (visual) memory lasts 1s at the most (Sperling, 1960). On the other hand, it is a well known fact that the different sensory systems have different mechanisms of transduction, that is, the process by which a stimulus (either visual or auditory) is converted into electrical signals (Kanabus et al., 2002), which result in different times of transduction for each modality. Visual transduction takes 30-40 ms (Woodworth and Schlosberg 1954; Poppel 1988), while auditory transduction takes 2 ms (Ruggero, 1992, 1994).

Thus, this line of research suggests that demanding an ordered serial recall may benefit speakers over signers because speakers have a serial recall advantage (Conway et al., 2009). According to this idea, the so-called serial recall tasks and free recall tasks should show different results between speakers and signers, because the first tasks demand that temporal order is kept while the second tasks do not. Serial recall tasks, the classical way to measure STM span, consist in the presentation of a series of lists of items of increasing length that have to be recalled in the order of presentation. The span corresponds to the longest list remembered in the correct order (normally requiring to remember at least two lists of the target length). What I call serial recall tasks are normally called *span tasks* in the bibliography. Here, I prefer the use of *serial recall* to contrast them to *free recall* tasks, which consist of the presentation of lists of items that

displayed number	7	4	8
temporal display	*second*	*third*	*first*
spatial display	*left*	*middle*	*right*

Table 4.1: Example of presentation of the digits in O’Connor and Hermelin (1973).

have to be recalled with the maximum accuracy possible, irrespective of order.

Older studies (Hanson, 1982) had already suggested that temporal order recall may be facilitated by the use of a speech-based code. In fact, O’Connor and Hermelin (1973) found significant contrasts in STM organization of the information in deaf and hearing children. They presented them with lists of three digits in which temporal and spatial (left to right) presentation were incongruent. For instance, the number ‘in the middle’ of the three numbers in the temporal order never coincided with the number ‘in the middle’ in the spatial presentation (see example in table 4.1). Hearing participants recalled the digits in temporal order of appearance in the presentation list while deaf participants recalled them as they appeared from left to right. This results lead them to conclude that the temporal or spatial organization of stimuli will be determined by the modality of their presentation.

More recently, the performance of speakers and signers has been compared to see whether serial recall tasks (which demand a temporal recall) could be hiding a task-driven effect,[7] since they could favor the participants that do the task in the spoken modality over the ones that do it in signed modality. In this sense, Boutla et al. (2004) showed that signers and speakers performed equally well in a WM task that required maintaining and manipulating online linguistic information without requiring temporal order retention. This task is designed specifically to assess WM in language production, i.e., the capacity to manipulate the material stored in STS in production. In this study, the participants had to listen to a series of words/signs and recall each one in a separate self-generated sentence. For instance, if the participant was presented with the words *voice* and *airplane*, the answer could be *He saw an airplane in the sky*; and *She has a pretty voice* (Boutla et al., 2004). Importantly, the order was not a requirement when answering.

Bavelier et al. (2008) conducted a set of four experiments to assess the role of temporal order in recall tasks. The first one is a forward and backward serial digit recall task (in which maintaining order is a requirement) in English speakers and ASL signers. A significantly shorter span for signers was obtained, both in the forward version (means of 6.40 items for speakers and 4.92 items for signers) and in the backward version (means of 5.70 and 4.42, respectively). These data contrast with some results obtained by Wilson and Emmorey (1997b), who reported a better backward

[7] A task-driven effect is an effect caused by the specific design of the test, rather than by the variables tested in it.

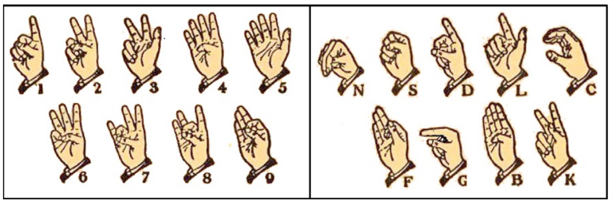

Figure 4.2: High phonological similarity of ASL digits vs low phonological similarity of ASL finger-spelled letters (Bavelier et al., 2008)

recall for signers than for speakers, due to an extremely short STM span in hearing subjects (with a mean of around only 3.5 items). A possible explanation for the differences in the results of the two studies could be that there was an important difference between the subjects of each experiment. The participants in Wilson et al.'s experiment were children and in Bavelier et al.'s were adults. As Bavelier et al. point out, it is possible that developmental differences in the learning of order reversal could be affecting the performance across these groups, by enhancing the speakers' performance on the backward version of the task. Bavelier et al. (2008) interpret their own results as an evidence that when temporal order is required, speakers perform better than signers.

However, ASL digits have a high phonological similarity and these lower span results in the Deaf group could be due to a phonological similarity effect (see figure 4.2).

For this reason, Bavelier et al. (2008) presented a second experiment in which they reduced this similarity contrast between languages. They compared English digits with ASL finger-spelled letters that were carefully selected to be dissimilar. They also wanted to test whether the hearing condition had an impact on the performance in forward an backward serial recall. To do so, they conducted the experiment on a single group of hearing, ASL/English bilinguals (CoDAs -Children of Deaf Adults). The making of the list of participants is interesting in the sense that it allows not for the comparison between deaf participants and speaking participants, but for the comparison of the same tasks in different modalities within the same individuals. This means that if they found a different span between ASL and English in the same individual, the contrast would be attributable to the modality of the presentation of the items. This was in fact what they found, namely a shorter span for the finger-spelled letter recall than for the English digit recall within the same individual.[8]

Wilson and Emmorey (2006) had commented that comparing English digits to ASL letters could benefit the speakers, since higher digit spans have been found in English speakers in comparison to English letter spans. Bavelier et al. (2008) respond to that objection and justify the use of digits in this experiment by saying that the explanation for this higher digit (vs letters) span in speakers is due to a phonological similarity in letters in English (*bee*, *dee*, *gee*, etc). Since they controlled the phonological

[8]However, using CoDAs is not devoid of problems, since it could add an effect of language exposure. That is, the exposure of the participant to a given modality could have an impact on the performance in the other modality.

similarity both in the digit set and the finger-spelled letters, they say the differences cannot be due to this aspect. However, Wilson and Emmorey (2006) attribute these differences between digits and letters also to semantic aspects and not only to phonological similarity.

A third experiment in Bavelier et al. (2008) could further mitigate this doubt on the privileged status of digits and on the phonological similarity of letters in spoken modality. They compared English speakers with Deaf ASL signers in an English letter forward/backward serial recall task[9] and an ASL finger-spelled forward/backward recall task respectively. Both the English and the ASL letters were carefully selected to be dissimilar and thus to prevent the similarity effect in any modality. The results again showed that serial spans were significantly longer in spoken modality than in signed modality. Backward span was significantly shorter than forward span in both groups and this difference was sharper in the speakers group.

To test whether temporal order requirement plays a role in the difference between modalities, a recall task devoid of that requirement is needed. The fourth experiment presented by Bavelier et al. (2008) is precisely designed to test that. They designed two free recall tasks with signs and words to be ran in a group of CoDAs. Interestingly, with regard to the items recalled, no significant differences between modalities were found. Therefore, serial order requirement was playing a role in the better performance in spoken modality in previous experiments. Crucially, a signifi-

[9]The speakers' forward span is taken from Bavelier et al. (2006).

cant difference in relative temporal order was found between modalities. That is to say, in English, participants significantly tended to recall the items following the relative order of their presentation, while in ASL relative order was not followed in the same degree when recalling.[10] This means that the subjects relied more on temporal order to recall English items than to recall ASL items. The use of CoDAs rules out the possibility that the differences in relative temporal order could be due to differences between individual spans or to the deafness condition. However, as pointed out above, the exposure to a modality may have an impact on the performance in the other modality. This point will be retaken in the discussion of the experiments.

In sum, these experiments support the idea that serial recall, a task in which maintaining the temporal order is required, favors a better performance in spoken modality than in signed modality, confirming what other works have suggested (Boutla et al. 2004; Conway et al. 2009; Krakow and Hanson 1985; Hanson 1982).[11]

[10]This score was obtained after repetitions and intrusions had been removed from the answers.

[11]Apart from this line of research, some other works that investigate temporal order recall confronting non-linguistic auditory stimuli to non-linguistic visual stimuli have shown a higher level of correctness in the auditory modality (Kanabus et al., 2002).

4.3 WM span and direction of recall: 2 experiments

4.3.1 Justification of the experiments

At this point, and in order to elaborate the justification of the experiments, let us recall some facts that we already know about the behavior of wh-questions and about the storing in STM in both modalities.

In the description of the linguistic data, we have seen that spoken modality shows the possibility of locating wh-expressions in initial position or *in situ*, while not allowing them to appear in final (non-*in-situ*) position. On the other hand, signed modality allows to locate wh-expressions in final position, while also allowing them to appear *in situ*. However, initial (non-*in-situ*) position of wh-expressions is also possible, but dispreferred (Cecchetto, 2012). Usually, initially placed wh-expressions co-occur with a second wh-expression in final position. As I have already said, this dissertation defends that these differences are not attributable to characteristics of the hierarchic structure, or to different derivational steps, but are rather a matter of linearization and, therefore, post-syntactical.

Regarding WM, on the other hand, we have seen that the spoken modality shows a significantly higher STM span than the signed modality. As we have seen in the overviews of the preceding sections (4.2.1 to 4.2.3), three main causes have been put forward to explain the differences in span between modalities, in relation to: i) the different duration of signs and words, which would entail a difference in rehearsal rate between them; ii) the higher phonological complexity of signs vis-à-vis that of words, which would entail a decrease in the number of signs recalled; and iii) the use of tasks that include the requisite of maintaining temporal order in the recall of the items, which could be favoring speakers over signers.

It is generally accepted that linguistic processing demands memory-based resources. More specifically, WM has been suggested to have a role in sentence processing. The idea in this dissertation goes a bit further, since the claim is that there is a relation between the phenomena observed in the domains of the linearization of linguistic elements and WM processing. The particular way of linearizing wh-expressions in each modality is related to the particular way of storing linguistic information in WM in each modality.

In line with this basic idea, I have designed and carried out two experiments that want to serve as a tool to observe the differences between modalities in the storage of signs and words in STM. The idea behind is that I expect to find not only a quantitative difference in STM span, as other studies have already done, but also a qualitative difference in the recall of items, either reflected in differential primacy/recency effects, or reflected in a difference in performance between modalities according to the type of temporal order required or preferred/adopted in the task (forwards or backwards). The experiments were a span task in forward and backward modalities (recalling of incremental lists of lexical items either in forward or backward order), on the one hand, and a free recall task (recalling of lists of lexical items without temporal order requirements), on the other. They are relevant for a variety of reasons.

First, in no previous studies has a comparison between forward and backward recall of lexical items been carried out, but just between letters and digits. Lexical items were used because, on the one hand, they are the items used in natural language, and, therefore, they are an input closer than digits or letters to spontaneous language. Moreover, this choice discards the problems discussed, namely the allegedly privileged status of digits or the phonological similarity of signed digits and spoken letters.

It has to be noted that the use of words and signs adds a complex semantic dimension that has to be controlled for in the design of the experiments. In section 4.3.2.1 there is a detailed description of the method followed to avoid the possible biases introduced by semantics. The use of lexical items instead of digits or letters also involves an increase of the length of the items which, as explained before, may affect the rehearsal process. For this reason, the presentation rate of the items had to be controlled as well: they were presented at a rate of one item per second.

As we have seen in the preceding section, Bavelier et al. (2008) conducted a task comparing forward and backward recall of spoken digits versus finger-spelled letters, and a free recall task to compare the tendency to maintain temporal order in recall of words versus signs. One of the intuitions underlying this proposal is that there can be differences in the forward and backward recall of items that can be related to the linguistic facts I am trying to explain. Therefore, an experiment with lexical items (and not only digits or letters) is necessary in both directions of recall.

Second, as I will show in the description of the method, it is important to stress that the serial recall experiment has been done over a limited pool of a few items that appeared in different orders, which is different from what Geraci et al. (2008) did. In that study the pool of items was a lot bigger (35 items). Since the main focus in my experiments is to observe the performance in terms of temporal order maintaining, and in order to prevent possible noise effects (recall of some items for reasons out of control), the number of items has been limited to 9. This way, using items that reoccur constantly, the focus of the task is driven to order maintaining.

Third, in the free recall task (recalling items without order requirements) the pool of items was indeed large. 5 lists of 16 items each were elaborated from an overall pool of 80 items. The aim of the task was, on the one hand, to observe if the items towards the beginning or the end of each list were better recalled (thus showing primacy and recency effects) and, on the other, to observe if subjects were spontaneously keeping some sort of temporal order in recall or other strategies. This is why it was important to have a large amount of items to guarantee that the observed effects, if any, were not due to uncontrolled features of the selected items. By increasing the number of lists each participant has to recall, and the number of total items across lists, the possibilities of any single item having an impact on the overall results is minimized, and consistency is ensured. Furthermore, by not re-using items across lists, the focus of the task is driven away from effects derived from the order they might re-occur in.

Fourth, the comparison of tasks with order requirements and tasks without order requirements has not always been carried out within the same group of participants, and it has never been done within the same group of participants using lexical items. In this occasion, by comparing the performance in ordered recall of signs/words of each participant with the performance in free recall of signs/words of the same individual, differences due to differential STM capacities between subjects are ruled out.

4.3.2 Experiment 1. Forward and backward serial recall in LSC and Catalan

4.3.2.1 Methods

Participants Fifty participants (25 deaf, 25 hearing) were recruited for the study. The non-verbal intelligence test Raven's standard progressive matrices was administered to all participants. Two participants in each group were excluded from the analyses because they scored lower than the 10th percentile on this test. The remaining participants were forty-six, twenty three adult Deaf LSC signers (9 men and 14 women) and twenty three adult hearing Catalan speakers (9 men and 14 women) from the province of Barcelona. The mean age was 25.4 for the Deaf signers (SD=8.2) and 20.5 for the Catalan speakers (SD=3.3). In the case of signers, exposure to LSC was not later than 7 years old. All the signers reported LSC as their primary and daily language. In the case of speakers, Catalan was their mother language[12]. Demographic data of both groups are shown in table 4.2.

Group	Gender	Age	Raven test (raw score/percentile)
Deaf	9 men/14 women	M = 25.4	M = 47.2/56.5
Hearing	9 men/14 women	M = 20.4	M = 49.0/65.4

Table 4.2: Demographic data of the participants

All the participants were paid. The criteria for signer participants to be eligible were:

- Fluent signers.

[12]Catalan is a medium-size language which coexists with Spanish in Catalonia, and other parts of Spain and France. This means that, in this territory, all Catalan speakers are bilingual, since they also know Spanish. In this regard, the selected hearing participants reported having Catalan as the language they used at home.

- Exposure to LSC prior to 7 years old.
- Profound deafness.
- Normal non-verbal intelligence measured by the Raven's standard progressive matrices test. The mean raw score for the deaf participants was 47.2 (SD= 4.5) and the mean percentile was 56.5 (SD= 23.0).

In the case of speakers, the criteria for recruiting them were:

- Catalan native speakers.
- Normal non-verbal intelligence. The mean raw score for the hearing participants was 49.0 (SD= 4.6) and the mean percentile was 65.4 (SD= 22.2).[13]
- No hearing loss.

Stimuli Two sets of stimuli were constructed, one with Catalan words and the other with LSC signs, to create a pool of items from which to draw the necessary ones for each experiment: 9 items in the case of this experiment. Each set contained 80 items, carefully selected in terms of frequency, phonological complexity and concreteness. The requirements for the items to be chosen were:

[13]There was no significant difference in Raven raw scores (t(44)=-1.36, p=.18) or percentile scores (t(44)=-1.31, p=.20) between the deaf and hearing participants.

- Common, nominal words/signs with no emotional connotations.

- No categorical ambiguity.

- Whenever possible, the equivalent word/sign was used.

- Frequency value between 10 and 13. As we do not have a frequency register for LSC, we assume the same frequency for both labels, since they exist in the same territory. The frequency was extracted from the online Frequency Dictionary of the *Institut d'Estudis Catalans*, the Language Academy of Catalan Language. This dictionary was made using the non-literary part of the *Corpus Textual Informatitzat de la Llengua Catalana*, which accounts for 60% of the total and adds up to roughly 30 million words. Frequency is given in two ways: first, total number of occurrences of the lemma, and second, a G-value, which is a logarithmic normalization of the first value in a scale from 1 to 16. This G-value is the scale used to select the items. In appendix 6 the list of items is attached with this G value and also with the total number of occurrences.

- When it was not possible to have the same item for both modalities, because either the word or the sign did not match the criteria, a sign that accomplished the requirements was selected and another word in Catalan with that same frequency was selected.

- Concreteness value between the range of 3 and 7. The concreteness value was extracted from the University of South Florida word association, rhyme, and word fragment norms.

- Non-salient words/signs: words that are salient for some reason although this is not reflected in their frequency were avoided, such as loans, swear words, affective diminutives, and emotionally connoted words.

- Non-compounds.

- In the case of Catalan, disyllabic words were chosen.

- Handling-like signs were excluded. Transparency in other signs, which yields generally to a metonymic item, was disregarded.

As for the phonological properties of the signs, we tried to control their phonological weight. We avoided path-movement signs in which the handshape changes during the path. Also, signs that involved a path-movement plus a local movement were avoided. Path-movement signs are opposed to local-movement signs in the sense that the former involve a path from a point A to a point B. The latter are signs in which there is movement but no path is involved, like for instance a wiggling of the fingers. Path-movement signs which additionally have either a change of the handshape or a local movement during the path have been described as phonologically heavier (Brentari, 1998). In addition, the signs did not share more than one formational parameter. With regard to the phonological properties of the Catalan words, no syllable was shared between them.

From the pool of the two sets of 80 items, 9 signs were selected to prepare the lists for the serial recall task in LSC and 9 words to prepare the lists in Catalan. The selected items were intended to be the translation between languages. All items in these subsets had a concreteness value between 4.4 and 6.4. The G frequency value was between 11 and 13 according to the Frequency Dictionary by IEC. The selected items are shown in table 4.3.

Item	English translation	G value	Concreteness value
Mestre	Teacher	13	6.38
Pedra	Stone	13	6.32
Mare	Mother	13	5.47
Color	Color	13	4.45
Amic	Friend	13	4.40
Ocell	Bird	12	5.77
Soldat	Soldier	11	5.68
Paper	Paper	13	5.96
Cafè	Coffee	11	6.43

Table 4.3: Stimuli in experiment 1

Design and procedure For ease of argumentation, the experiments are presented span task in the first place and free recall task in the second place. However, the experiments were actually run in the opposite order, to prevent priming effects in the free recall task caused by the subset of 9 items used in the serial recall task, which were common to both experiments.

Participants were tested individually in a quiet room at the Pompeu Fabra University. The stimuli were presented on a laptop, using an interface specifically developed for the experiments, with a minimalistic black background and devoid of linguistic stimuli other than the items in the tests themselves (see a screenshot in Appendix 6). Signers watched the stimuli on a video and speakers listened to the stimuli through a set of headphones. Deaf participants were guided by a Deaf native signer interviewer who led all the experiment in Catalan Sign Language. Hearing participants were guided by a hearing interviewer who spoke in Catalan. All the participants were video recorded.

The presentation rate of the items in the test was matched between modalities: items were presented at a rate of one item per second in both cases. In the case of signed modality, the recordings were edited in a way they looked natural but also in a way they respected the rate we wanted. The beginning of the sign was fixed in the frame where the hand began to move from the rest position and the end was fixed when the hand was back in the rest position. The space between the items was filled with a clip of the signer standing holding her hands in a resting position (hands clasped in front of herself at waist height) (4.3). This way, the video looked very natural, since the signer recorded the signs beginning and ending with that position: holding hands, signing, holding hands. The insertion of this clip, instead of a blank screen or the scene without the signer, was suggested by our Deaf informants. According to them, this is a more pleasant displaying of the list, since the intermittence between an empty space and the presence of the signer was reported as bothering and unnatural. This interspersed clip with the signer in resting position was considered the closest visual analogue to silence in the auditory modality. The insertion of these clips in between allowed us to exactly make up the lists in a rate of one sign per second. For instance, when the sign lasted 0.7 sec, the inserted clip lasted 0.3 sec. This means that no sign lasted more than one second. With regard to sign transitions, notice that they were included for the lists to look more natural. However, the duration of the signs was calculated without those transitions. That is to say, the duration of a sign was calculated from the handshape formation until the handshape was undone.

At the beginning of the task each participant watched a signed video or listened to an audio with the instructions and the interviewer solved the possible doubts that arose.

We presented a serial recall task in forward and backward direction. In serial recall tasks, maintaining the order of presentation is required to

Figure 4.3: A frame of a sign and a frame of the interspersed rest position

answer correctly. The 9 items were randomly distributed in a series of lists with increasing number of items. In the forward recall the participant must repeat the lists in the order they are presented. In the backward recall they had to repeat the lists in reverse order of the one they are presented. The lists increased one item at a time from two item lists to seven item lists. Each level had three instances. The serial recall score obtained is the maximum level that the participant reached. A level was considered completed when at least two of the three instances were repeated correctly.

4.3.2.2 Results

Serial recall spans were analyzed with a 2x2 Anova with Group (speakers vs signers) and Direction (forward vs backward). The analysis yielded a significant effect of Group ($F(1,44)=20.90$, $p < .001$) and a significant effect of Direction ($F(1,44)=30.42$, $p<.001$). Importantly, there was also

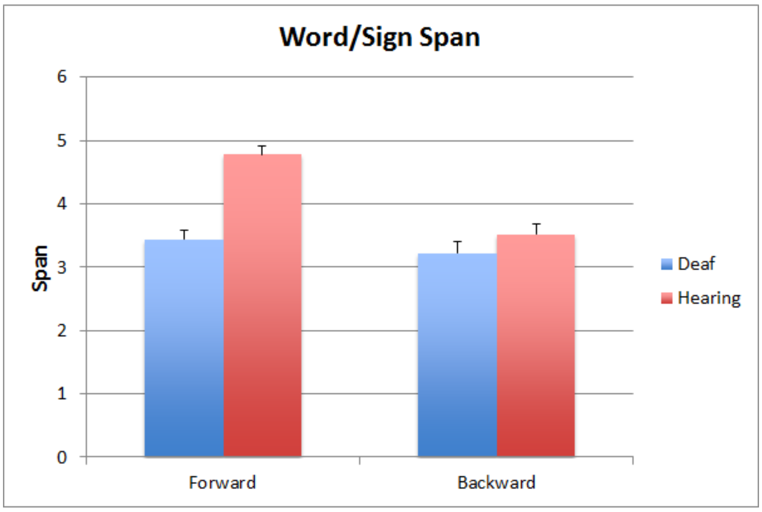

Figure 4.4: Recall by position within lists in deaf and hearing participants

a significant Group x Direction interaction (F(1,44)=15.16, $p < .001$). Speakers had a significantly larger span than signers in forward recall ($p < .001$), but not in backward recall (p=.23). Furthermore, whereas speakers had significantly larger forward spans than backward spans ($p < .001$), forward and backward spans did not differ significantly for the signers (p=.17).

Since the only significantly different interaction of Group x Direction is the outperforming forward recall by speakers, the results should be interpreted as showing an advantage for speakers in forward modality rather than a disadvantage for signers. The graphs for the results are shown in figure 4.4.

4.3.2.3 Discussion

In the span task, two main results were obtained. As predicted, the task revealed significant effects of group and direction. Speakers obtained a significantly higher span in forward recall than signers. This is in line with some previous works that found this span to be higher for the spoken modality not only in hearing speakers versus deaf signers Geraci et al. (2008) but also within hearing bilinguals (CODAs) when doing the task in spoken and signed modality (Boutla et al. 2004, Bavelier et al. 2008). Furthermore, these results are consistent with those studies regardless of if they used digits/letters or words/signs.

A possible explanation to the longer span speakers have obtained when compared to signers is that it is an effect of auditory modality versus visual modality, rather than of the linguistic nature of the information presented in the test. In fact, it is well known that echoic memory (auditory primary store) lasts between 2 and 4 seconds (Darwin et al., 1972), while iconic memory (visual primary store) lasts 1 second at the longest (Sperling, 1960). This difference in the decay rate between modalities could explain the fact that speakers and signers perform similarly to each other in non-linguistic visual tests. Since it is complicated to design homologous comparable, effective STM tasks in auditory modality with non-linguistic material, it is difficult to rule out completely the linguistic effect.

An alternative explanation, not excluding the one just presented, is that there are differences between modalities in the capacity to store serially ordered information. In fact, the auditory system is more efficient than the visual system in retaining the order of presentation of nonlinguistic sounds (Kanabus et al., 2002). Classic span tasks require the participant to store items in a predetermined order. If auditory modality is better suited when it comes to retaining serially ordered information, the requirement of maintaining temporal order could be going against the signing participants.

As a matter of fact temporal order seemed to make a difference since direction had a significant effect in auditory modality. Forward recall in speakers was significantly higher than their corresponding backward recall while in signers forward and backward recall did not differ significantly. This extends previous results that showed the same patterns with letters and digits (Boutla et al., 2004; Bavelier et al., 2008).

These results seem to point to an advantage of the auditory modality in the forward recall, and not to a reduced STM in the visual modality since the difference between forward and backward recall is significant in speakers and non significant in signers. In any case, to observe if there is an effect caused by the requirement of the task of maintaining temporal order, the second experiment I will present here, a free recall task, did not force an ordered response.

Within the linguistic domain, an explanation of the differences in span between modalities that has been adduced in previous works is based on the differing duration of signs versus words. According to this idea, signs, being longer to articulate, would negatively affect the rehearsal process. Indeed, this could have an impact on the results. In comparisons of spoken languages with other spoken languages, it has been observed that languages like Chinese, whose words for digits are shorter and fast to produce, show longer STM spans than languages with longer words for digits, like Welsh (Elliott 1992; Ellis and Hennelly 1980). Nevertheless, item length based explanations do not account for the fact that there is not a significant difference in forward versus backward recall in visual modality. Why signers do not show differences when recalling forwards and backwards, as speakers do, remains unexplained.[14] Furthermore, studies like Geraci et al. (2008) also obtained a lower span in signed modality, even though they controlled the articulation rate between modalities. In my own study, the items where not modified to match durations, but presentation rate was equal for both modalities (1 second per item). This was the model adopted by Bavelier et al. (2008) too.

Another possible cause that has been put forward is the allegedly increased phonological heaviness of signs when compared to words, which would make them harder to recall. Specifically it has been suggested that signs have a sublexical structure which makes them specially hard

[14]Bear in mind that the default hypothesis is that backward recall is more demanding than forward recall, since the latter only requires to repeat a list, while the former requires an additional operation: inverting it before.

to recall (Hanson, 1982). This particular heaviness would be due to their greater simultaneous nature, since SLs express meaning through several articulators at once, namely manual and non manual features. Furthermore, it has been noted that, unlike spoken words, they must have all the four parameters expressed (handshape, movement, location and orientation). Also, it has been aduced that signs are dynamic, since path movements must be kept from their initial until their final location (Geraci et al., 2008). In this line, some theoretical models for measuring phonological heaviness in signs have been developed (Brentari 1998; Napoli et al. 2014). However, the comparison of the impact of phonological weight on WM between modalities has not yield clear results yet.

4.3.3 Experiment 2. Free recall in LSC and Catalan

4.3.3.1 Methods

Participants The same participants who took part in experiment one participated in experiment two.

Stimuli Each of the sets of 80 items in the pool (signs and words) was distributed in five lists of 16 different items. The items within each list were standardized according to the criteria of frequency, phonological complexity and concreteness: the lists were designed to balance the frequency level of the items across lists, maximize phonological distinctive-ness within lists and balance concreteness level. The distribution in lists is presented in Appendix 6.

Design and procedure As noted in section 4.3.2.1, the experiments were run in the opposite order from the one they are presented here. The setting was the same as in experiment one. At the beginning of the test each participant watched a signed video or listened to an audio with the instructions and the interviewer solved the possible doubts that arose. They were presented 80 different items distributed in 5 lists of 16 items each. The participant was asked to recall as many items as she could no matter the order at the end of each list. Before starting the experiment, the participant was shown a practice list for her to warm up and understand the procedure, following the same design as the test lists in terms of the duration of signs/words, rate of presentation, etc. The practice list was made up of 16 items from a different category, namely adjectives, and it was not considered in the analysis. At the end of each list of signs in the experiment, a green dot on the center of the screen indicated that the participant could begin to answer. As for the speakers version, the item lists were audiorecorded and were also presented at a rate of one per second. After each list of words ended, a *bip* sound indicated that they could begin to answer.

Although the order of the signs within each list was always the same, the presentation of the five lists was semi-randomized. Three orders of presentation of the lists were created. These three orders were equally distributed across the two groups.

With regard to the grouping of the items in the 5 lists, some semantic and phonological aspects were taken into consideration to prevent priming. Semantically related items were distributed in different lists. Although semantic notions are sometimes difficult to pin down, since they are not always exhaustive and sometimes can overlap, no particular priming effects derived by any possible semantic relation were observed. Phonologically, the signs did not share more than one formational parameter feature within lists. When one of the features was shared, like for example the index handshape, the two items having it did not appear adjacent in the list. Within the Catalan lists, no syllables were repeated between words.

4.3.3.2 Results

The mean for the sign versus word span in the free recall task is shown in figure 4.5. As can be seen, the speakers had a greater span than the signers. The speakers obtained a mean of 5.4 (SD=1.4) and the signers a mean of 4.4 (SD=1.5).

The classical effects of primacy and recency were observed in both modalities (figure 4.6). The analysis was done through an ANOVA 2x4 with modality (speakers versus signers) and situation of the items within the lists (split in 4 segments: items 1 to 4, 5 to 8, 9 to 12 and 13 to

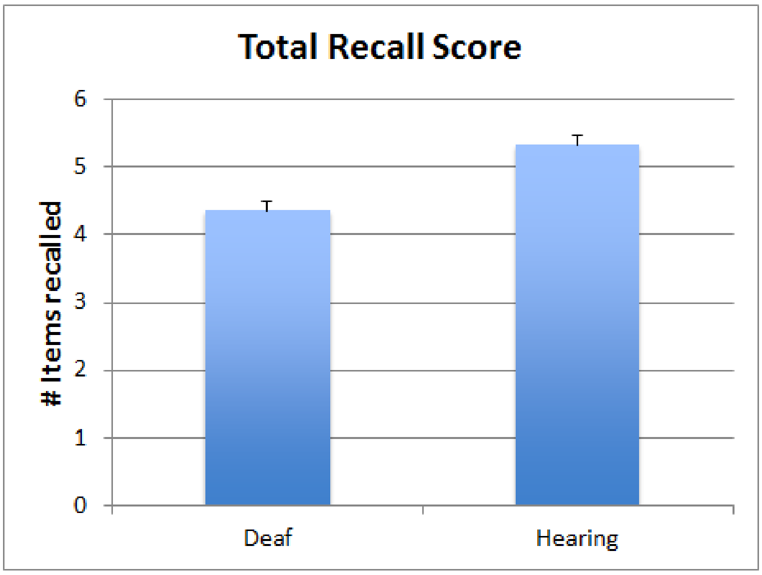

Figure 4.5: Free recall score in deaf and hearing participants

16). This analysis showed a significant effect (F(1,44)=13.69, p<.001) of group and an effect of position (F(3,132)=122.75, p<.001) but no significant interaction (F <1, p=.54). Speakers had higher overall accuracy than signers. Each of the 4 segments is significantly different from the rest (all ps<.01, Bonferroni-corrected) except the first and third set (p=.76). That is, all possible 2 combinations of sets are significantly different from each other, except when one compares the first and third set. Figure 4.7 shows the recall curves per position for each modality and a graphic for the four segments per modality.

Even though the task did not require maintaining the order of the items, two analyses were carried out to see if the two groups were nat-

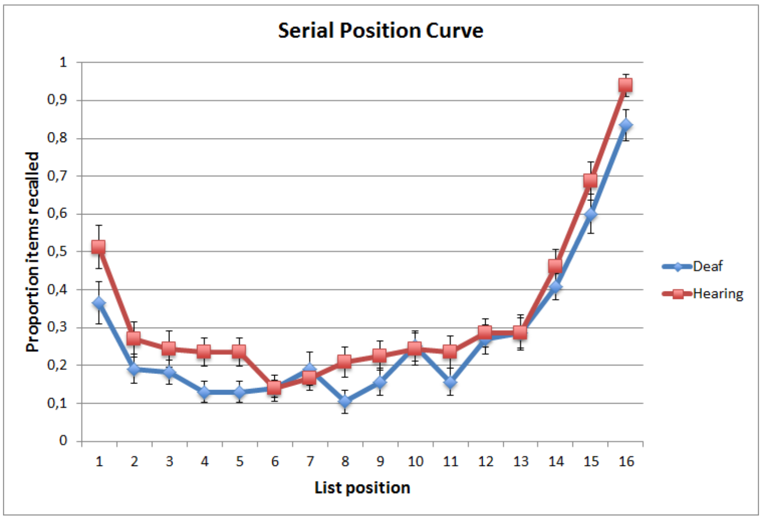

Figure 4.6: Serial position curve in deaf and hearing participants

urally keeping order in different ways. First, an analysis of relative temporal order adopting the method that Bavelier et al. (2008) used (fig. 4.8). This method takes into account the number of adjacent pairs that are in the same order as in the presentation list, divided by the total number of possible pairs in the subject's response. Since this scoring method is affected by overall performance, it corrects possible differences in item scores when comparing groups. This analysis yields significantly higher relative temporal score for speakers (M=.52, SD=.16) than signers (M=.41, SD=.14, $t(44)=-2.43$, $p<.05$). Second, an analysis of adjacent/absolute forward and backward temporal order was used (fig 4.9). By adjacent/absolute ordering of items, we understand the recall of an

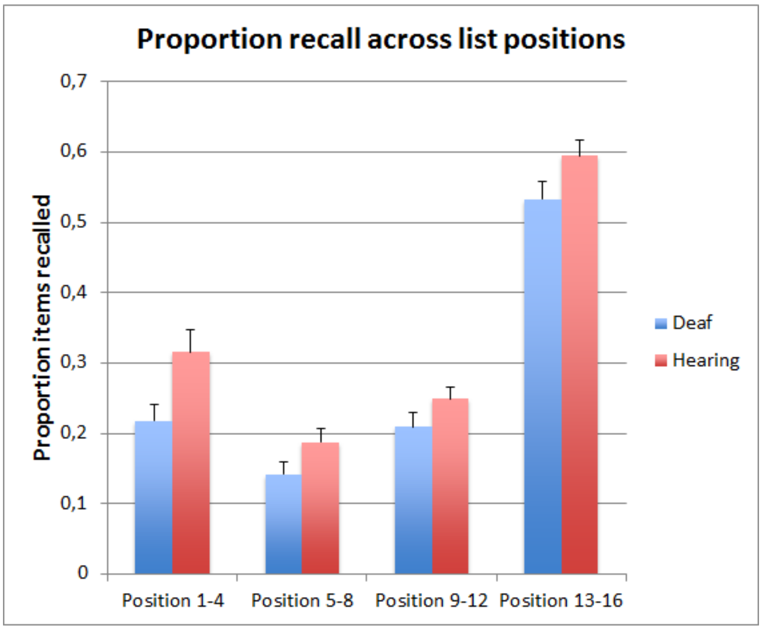

Figure 4.7: Recall by position within lists in deaf and hearing participants (error bars represent 1 standard error from the mean).

item that is immediately preceding (backward recall) or following (forward recall) the previously recalled item according to their order in the presentation list. Under this analysis, speakers maintained adjacent pairs in forward order 22% of the time (SD=11%) and backward order only 12% of the time (SD=9%), whereas signers maintained adjacent pairs in forward order 12% (SD=9%) of the time and in backward order 17% (SD=14%) of the time. Adjacent/absolute order preference was analyzed with a 2x2 ANOVA with Group (speakers vs signers) and Direction (forwards vs backwards). The main effects of Group ($F < 1$, p=.42) and Direction ($F(1,44)=1.77$, p=.19) were not significant, but crucially the Group by Direction interaction was significant ($F(1,44)=8.10$, $p<.01$). Forward temporal order scores were significantly higher for the speakers than for the signers ($p<.01$), whereas backward temporal order scores did not significantly differ between the two groups (p=.13). Furthermore, whereas forward and backward temporal order scores did not differ significantly for the signers (p=.17), forward temporal order scores were significantly higher than backward temporal order scores for the speakers ($p<.05$).

So, as the results show, speakers tended to recall the items in forward temporal order. Signers, on the other hand, did not show a clear tendency for recalling in one direction or the other.

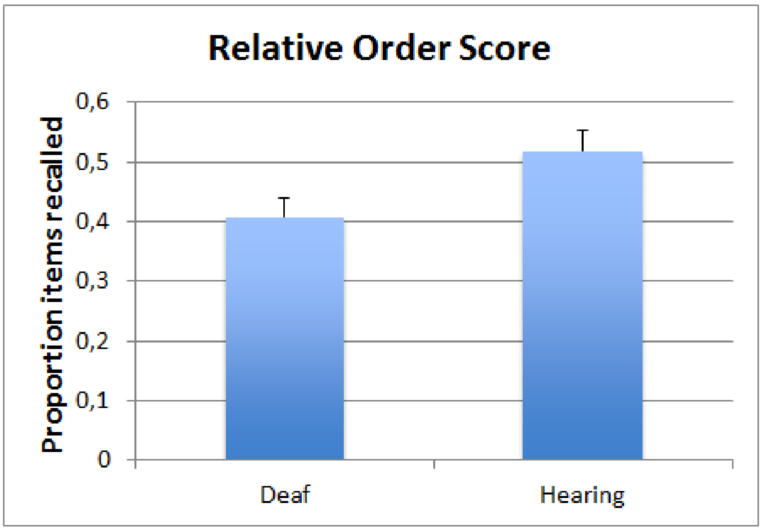

Figure 4.8: Relative order score in deaf and hearing participants.

4.3.3.3 Discussion

In the free recall task, a significantly higher span for the speakers was obtained. This means that the requirement of maintaining temporal order was not specially harmful for signers, as has been suggested in other studies. In fact, these results contrast with Bavelier et al. (2008) who did not obtain significant span differences between groups when temporal order was not required. One possible explanation of this discrepancy could be due to the fact that participants in Bavelier et al. (2008) were hearing bilinguals. Maybe the exposure to a spoken language could affect the results in the signed task yielding no differences between both conditions. It has been shown that the more the subjects rely on a speech-based code,

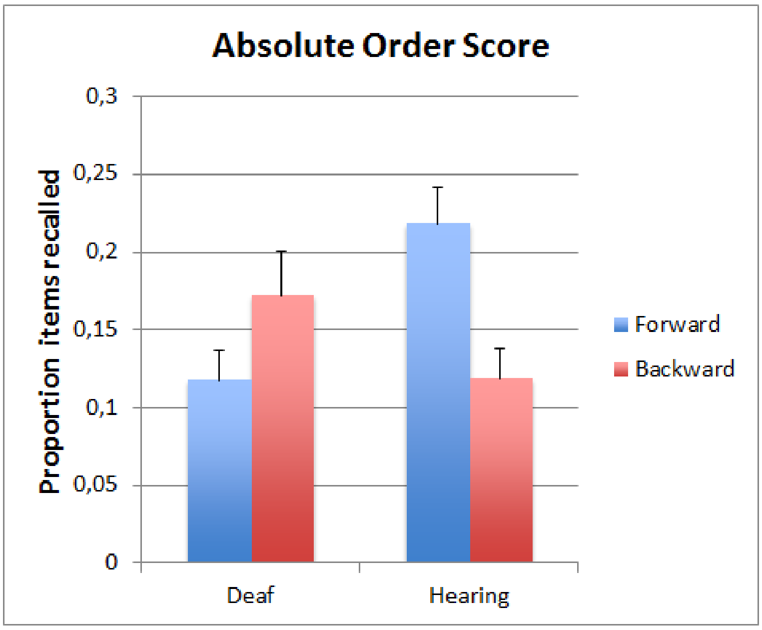

Figure 4.9: Adjacent/Absolute order score in deaf and hearing participants.

the better they maintain temporal order (Hanson, 1982).

In the results, there is also an effect of item position across groups. This can be observed in the classical primacy and recency effects that were obtained. These effects did not differ significantly between modalities as has been reported from other studies (Krakow and Hanson 1985; Bavelier et al. 2008).

Interestingly, even though keeping temporal order when recalling items was not a requirement of the task, speakers spontaneously tended to keep forward order in more cases than signers. This behavior is observed in a significant amount of cases, and is observed particularly well if we analyze the absolute/adjacent ordering of items in the responses. That is to say, speakers tended to recall items presented adjacent to one another (in forward order), while signers did not. Signers, on the other hand, did not show a statistically significant preference for keeping any temporal order in this task. This is in line with old studies that showed that hearing individuals preferred to recall information in the order it was presented and deaf individuals relied in other strategies (spatial notions) to recall (O'Connor and Hermelin 1973; Rönnberg and Nilsson 1987).

In short, apart from the significant quantitative difference in the number of items recalled, speakers having a higher span than signers, there is an interesting qualitative difference in the way items are recalled, speakers strongly preferring to recall them in forward order, in the temporal sequence they were presented. It seems that, even if they are not asked explicitly to do so, speakers cannot ignore this tendency of resorting to temporal forward recall, which suggests that we are facing an over-specialization of the temporal recall of hearing individuals, rather than a defective recall span of signing individuals.

4.3.4 General discussion

In the first place, the novelty of the experiments I have conducted lies mainly in two factors. On the one hand, this is the first study that compares both free recall and serial (forwards and backwards) tasks in the same group of speakers. This serves to give additional robustness to the results, by ruling out differences in performance attributable to differences in the groups of participants. On the other hand, this is also the first study to use lexical items in both tasks, a decision that aims at closing the gap between the tasks used in WM observation and linguistic processing, since lexical signs are more natural items than digits or letters, which have shown some additional effects (privileged status or similarity effect).

Talking in quantitative terms, both experiments have shown a significantly longer span in speakers than in signers. Regardless of whether the task required to keep the temporal order of the items presented or not, speakers were quantitatively better than signers. This result contrasts with the one obtained by Bavelier et al. (2008) in which speakers and signers did not differ significantly when temporal order was not required in recall. A possible explanation to this discrepancy is that the participants in Bavelier et al. (2008)’s study were hearing bilinguals, and could have transcoded the signed items to speech-based forms.

Although the non-verbal intelligence scores are within normal levels and similar between groups, and although the education level is equivalent between the groups, it cannot be excluded that the different recall between groups could be due to some non controlled factors. Although the fact that backward recall did not show any difference between groups seems to go against that, the importance of matching all factors should not be disregarded, since it can hide relevant contrasts between groups (Andin et al., 2013).

Several possible causes for the differences in span between modalities have been suggested in the literature, mainly greater sign length and greater phonological complexity of signs. The requirement of keeping temporal order I have discussed so far has not had a major impact on the results of the studies presented here, since speakers outperformed signers regardless of the requirement of maintaining temporal order.

However, as has already been mentioned, the difference could be due to a modality specific effect. It has been shown that auditory modality and visual modality differ in decay rates. This means that the span differences could be attributed to non-linguistic factors in the form of primary storage capacity in different modalities. In this respect, the results of the CoDA participants in the free recall task in Bavelier et al. (2008), which do not show differences in modality within the same individual, seem to go against this idea. However, this account does not rule out modality causes within the linguistic domain. Both factors could coexist.

On the other hand, in qualitative terms, it can be said that we are observing an over-specialization in forward recall in speakers versus signers. This would account for the significantly better performance of speakers in forward recall in the span task, but also for their apparent impossibility of ignoring temporal order in the free recall task, even when it was not a part of the requirements of the task. In that sense, signers are more flexible than speakers, since they do not show a preference for a specific direction when recalling.

The two experiments obtained very coherent results. That is, first, in both experiments speakers preferred forward than backward order while signers did not prefer any direction. Second, speakers preferred forward order in more cases than signers but the two groups did not differ with regard to backward order performance. Speakers are always doing a serial recall task strategy, even when they are not asked to. That is why he results can be regarded as signers being more flexible, since they do not prefer any particular direction. These differences between groups are specially visible when looking at absolute order and not to relative order, which could be the reason why previous studies did not find differences in order recall.

In the next chapter I will show how these modality differences in

WM processing and order preferences may impact the processing of wh-sentences and their syntactic properties in spoken and signed languages.

Chapter 5

THE ROLE OF MODALITY IN WH-QUESTIONS

In chapter 4, I have presented some quantitative and qualitative differences between auditory and visual modality with regard to WM. The next logic question is whether these differences also have an impact on sentence processing in each modality. The aim of this chapter is to show that they do.

The chapter is organized as follows: in section 5.1 I present some studies that point to the involvement of WM in the processing of wh-questions; in section 5.2 I present some perspectives on the role of sentence processing in shaping language; in section 5.3 I offer a proposal to link the results on WM presented in chapter 4 to the behavior of wh-questions in LSC presented in chapter 3; in section 5.4 I present a proposal to explain the preference for final wh-location in LSC; section 5.5 is devoted to the conclusions.

5.1 Working memory is involved in the processing of wh-questions

In chapter 4 I have reviewed some works that show that WM is involved in sentence processing. More specifically, wh-questions have motivated a number of studies which claim that there is a WM involvement in the processing of this kind of sentences in SpLs. An extensively studied contrast is the preference for subject wh-dependencies (186a) versus object wh-dependencies (186b).[1]

(186) a. Who did they claim [__ had criticized him for voting that way]?
b. Who did they claim [he had criticized __ for voting that way]?

An explanation given to this contrast is the greater linear filler-gap distance in object wh-dependencies than in subject wh-dependencies. In fact, linear distance between the filler and the gap affects the parser negatively (Cooke et al, 2001, Fiebach et al, 2001). That is, the longer the parser has to hold the filler until the gap is found, the more WM is strained.

[1]Examples are taken from Kluender (2004).

This contrast is also observed between a subject-extracted relative clause (187a) and an object-extracted relative clause (187b). The object extraction in (187b) is more costly than the subject extraction in (187a).

(187) a. [$_S$ The reporter [$_{S'}$ who [$_S$ attacked the senator]] admitted the error].

b. [$_S$ The reporter [$_{S'}$ who [$_S$ the senator attacked]] admitted the error].

This greater cost has a reflection in some brain responses and behavioral differences. Object-extractions provoke a higher activation in language areas in the brain: third frontal gyrus, BA 44 and BA 45, as well as in the left Wernicke region (Just et al., 1996). Additionally, studies on sentence comprehension in aphasics showed that they had difficulties answering questions about object extracted relative clauses but not about subject-extracted relative clauses (Caramazza and Zurif 1976; Caplan and Futter 1986; Grodzinsky 1989; Hickok 1993).

However, linear distance is not the only factor that affects the parser negatively. Some other factors have been reported to yield processing costs. The number of intervening clause boundaries between the filler and the gap, for instance, is known to load WM. The classic 6-word example by Wanner (1980) showed that a relatively short sentence can be hard to process if it has many clause boundaries.

(188) [Vampires [werewolves [rats kiss] love] sleep]

Actually, (188) shows that the number and depth of nesting clauses affects the parser to the point of making some sentences unprocessable (189a-189b)[2] (Chomsky 1965; Chomsky and Miller 1963; Miller and Isard 1964).

(189) a. [$_S$ The intern [$_{S'}$ who [$_S$ the nurse supervised]] had bothered the administrator [$_{S'}$ who [$_S$ lost the medical records]]].

b. [$_S$ The administrator [$_{S'}$ who [$_S$ the intern [$_{S'}$ who [$_S$ the nurse supervised]] had bothered]] lost the medical reports].

Although (189a) and (189b) have the same words and meaning, (189b) is a lot more demanding than (189a), to the point of hindering processing. In (189a) the relative clause 'the nurse supervised' is nested in the subject-verb dependency of the matrix clause. In (189b) the relative clause 'who the nurse supervised' is nested in the first embedded clause 'the intern had bothered' requiring an extremely high cost to process and making it effectively unprocessable for most people (Gibson, 1998).

It has also been suggested that the referential processing of NPs and verbs has an impact on the parser. According to this idea, the new referents introduced in the discourse, unlike anaphoric elements, are more difficult to access and involve a greater processing load (Gibson, 1998, 2000).

[2]Examples are taken from Gibson (1998).

Furthermore, it has been suggested that the D-linkedness (referentiality) of the DPs intervening between the filler and the gap affects the parser negatively (Kluender, 2004). Some studies have proposed this as an explanation to account for the classic Spanish case of the ungrammaticality of subject-verb non-inversion in wh-questions (190a-190b). According to them, the D-linked nature of preverbal subjects in Spanish makes (190b) specially hard to process (Goodall, 2004, 2007).

(190) a. Juan compró una botella de vino.
Juan bought a bottle of wine.

b. * ¿Qué Juan compró?
What Juan bought?

Further studies have suggested that what loads the parser is, specifically, the referential processing at the boundary of the clause from which that element has been extracted (Kluender, 2004). So, it would be not only the referentiality of the intervening elements between filler and gap that would affect processing, but also their positioning at the edge of clauses. It is generally agreed that once a clause is processed, its specific structural configuration fades quickly and is replaced by its more general semantic representation (Kluender, 2004). The idea is that the load of referential processing at the boundary of the clause makes the replacement of the extracted element within the clause harder.

(191) a. The woman [the man [the host knew __] brought __] left

early.

b. The woman [someone [I knew __] brought __] left early.

In (191a) the parsing is strained by the high demands in referential processing caused by the two definite embedded subjects, the man and the host, which both occur at clause boundaries. On the other hand, in (191b), the cost is considerably reduced by the use of an indefinite, *someone*, and an indexical pronoun, *I*, which reduce the necessity of accessing relevant discourse referents. Another way to mitigate this load is to eliminate them by resourcing to an infinitival relative, as already observed in Ross (1967) with respect to wh-islands (192). Notice that in the *a* versions of each instance, without overt subject and with a non-finite clause, the dependency into the island is easier to form than in the cases in *b*. Bear in mind that, as has been suggested, finite verb forms are more referential than non-finite verb forms, since finiteness relates the time of events in the discourse and the time of the speech event itself (Kluender, 1992).

(192) He told me about a book which I can't figure out...

a. whether to buy or not b. whether I should buy or not

a. how to read b. how I should read

a. where to obtain b. where I should obtain

a. what to do about b. what I should do about

Additionally, it has been claimed that the parser is sensitive to canonical word order. According to this idea, the permutation of the canonical order, whatever it is, affects the parser by hindering effortless comprehension (Kluender, 2004). Apart from its general application, this explanation has also been adduced to account for the contrast between wh-subjects and wh-objects mentioned in (186a) and (186b), on a more specific note. It is very likely that this sensitivity to canonical order permutation is due to a frequency effect (Arnon and Snider 2010, Tremblay and Tucker 2011). In any case, some studies report that brain responses point to the fact that the parser tries to restore displaced objects to their canonical place, which is necessarily going to involve a greater working memory cost (Kluender, 2004).

In sum, WM is involved in the processing of wh-questions and it is negatively affected by some factors: the linear distance between the filler and the gap, the number of clause boundaries between the two, the number and depth of nesting clauses, the referents intervening between the two, the D-linked nature of those referents, the amount of referential processing at syntactic boundaries, and the permutation of canonical word order. This last factor may be produced by an effect of frequency. It has been claimed that different strategies could be selected by the parser depending on the demands of each language. That is to say, from the shared set of strategies in parsing, speakers of different languages would select different options in order to fit to the demands of different kind of structures.

The next section is devoted to reviewing some ideas dealing with the impact of memory demands on language change.

5.2 Memory demands shape language variation

Across different theories, it is assumed that the structure of the human brain and the structure of language are intimately tied. The discrepancies between theories emerge when defining the nature of the relationship between the two. Specific views of this link between brain and language yield very definite positions on the very nature of human language, on what it is and on how it evolved.

Some views see human language as the result of the specialization of the human brain. Within these perspectives, some approaches hold an adaptationist explanation by which brain mechanisms specific to language evolved over long periods of natural selection (Pinker and Bloom, 1990). On the other hand, there are some other views that hold a non-adaptationist explanation, that is, a scenario in which the characteristics of the human brain that make human language possible are not the result of evolutionary adaptation but rather the result of two or three abrupt mutational events (Lanyon, 2006). Both adaptationist and non-adaptationist views are what could be called approaches 'from inside to outside', since human language is seen initially and foremost as a consequence of some specific changes in the human brain.

However, in the last few decades, some other views have arisen in a trend that considers that language is specially influenced by external forces, and that its properties are emergent features that arise from its use. In this regard, while the former approaches assume some abstract internal properties prior to language use, the latter views underestimate (or even deny) those abstract formal properties in favor of the external use of language-like abilities, which, to a great extent, shapes language as we know it. The proposal in Christiansen and Chater (2008) is interesting in this sense. According to it, human language has evolved into the way it is to fit in the brain we have. That is, language has evolved through cultural adaptation to be easy to learn, easy to produce and easy to comprehend by our brain. Notice that both this account and the 'inside to outside' accounts view the cognitive machinery of the human brain as a constrainer of human language. The crucial difference is that in the former, those abstract innate features shape human language, regardless of what users do, whereas the latter emphasizes the use of language as a factor that plays a key role in how language changes and evolves. The direction of its reasoning spins 180 degrees and it poses the opposite question: "Our question is not, 'Why is the brain so well suited to learning language?' Instead, we ask 'Why is language so well suited to being learned by the brain?' " (Christiansen and Chater, 2008, 490).

In any case, there is agreement on the fact that human languages are constrained by the limits of the cognitive machinery in the brain. There is also evidence that some linguistic structures are more demanding than others, like filler-gap dependencies involved in wh-questions or relative clauses, and that parsing strategies may change depending on the type of language demands. In this regard, as we have seen, some classical syntactic phenomena traditionally explained through formal theoretical characterizations have also been explained under some approaches through arguments based on processing.

5.2.1 Complexity and grammatical variation

Hawkins (1999) studies filler-gap dependencies in wh-questions and relative clauses, and proposes an explanation of their behavior based on processing complexity. The general idea is that the processing costs of filler-gap dependencies have an impact on variation patterns across languages. These costs are, on the one hand, the maintaining of the activation of the filler in working memory and, on the other hand, the identification of the gap. Grammars resort to different linguistic strategies to make filler-gap dependencies less costly. More specifically, the strategies that languages can use to mitigate the complexity of filler-gap processing relate to three patterns: narrowing of the search space by reducing the syntactic and semantic domain in which fillers and gaps occur; making gap identification easier mainly by locating the filler linearly prior to the gap; or conventionalizing structural alternatives altogether, such as the use of resumptive pronouns.

These strategies conventionalize in grammatical rules and can account for some ungrammaticalities which have been traditionally explained via formal rules which did not bring processing into account. According to Hawkins (1999), at least in the particular case of filler-gap dependencies (and, therefore, probably in others) what drives the construction of a particular set of grammatical rules is processing power and processing easiness. Furthermore, the conventionalization of these preferences in language processing leads to some universals, “to implicational hierarchies in the cutoff points for grammatical conventions, and to variation in structures for which independently motivated preferences are in competition” (Hawkins, 1999, 279).

The idea that processing and performance are on the basis of grammatical constraints is further developed in Hawkins (2003). In that work, the author develops the hypothesis that principles of efficiency and complexity shape grammatical preferences: the Performance-Grammar Correspondence Hypothesis.

> PERFORMANCE-GRAMMAR CORRESPONDENCE HYPOTHESIS: Grammars have conventionalized syntactic structures in proportion to their degree of preference in performance, as evidenced by frequency of use and ease of processing.

(Hawkins, 2003, 122)

According to his hypothesis, easier to process sequences or structures will be both more frequent across languages and preferred within languages where they coexist with equivalent, more difficult ones.

In the particular case of wh-questions, the overwhelming preference for languages that move wh-expressions to front them is a reflection of the principle he enunciates as MAXIMIZE ON-LINE PROCESSING. That principle states that at the moment of processing each element, the parser prefers to assign the maximum possible syntactic and semantic properties to it. Regarding wh-questions, and provided that the interpretation of the gap is highly dependent on the properties of the filler, the principle can only be satisfactorily met if the filler precedes the gap.

Notice, nevertheless, that the principles that flesh out the hypothesis in Hawkins (2003) can be in tension among them in some occasions. What this means is that the model is not deterministic and leaves open a space for linguistic variation, as a result of the different resolutions of these tensions. Still in the domain of filler-gap dependencies, this can be seen in the different behavior of relative clauses within head-final languages, which can either be in prenominal (Japanese, Basque) or postnominal (Georgian, Persian) positions.[3]

Another proposal to explain the fact that processing constraints have

[3]The second conflicting principle in this case is the EIC (Early Immediate Constituents), which favors linear orders with adjacents heads.

an impact on language typology is MacDonald (2013), who claims that some aspects of memory demands on language production are central in how certain forms distribute across languages. In this sense, this approach contrasts with many other typological proposals which have based their predictions and explanations on the memory demands of comprehenders. According to the author, trying to make things easier for themselves, producers follow three main biases: Easy First, Plan Reuse, and Reduce Interference. Easy First bias makes words and phrases which are easier to retrieve[4] more likely to be used first in an utterance plan. The idea is that, positioning easier elements first, the execution of the utterance can begin early, leaving more time available for more difficult elements. The second bias is Plan Reuse, also called syntactic priming or structural persistence. This bias makes recently used utterance plans more likely to be reused. The third factor described by MacDonald is Reduce Interference. This factor reflects already observed effects of interference between similar items in working memory retrieval, by a tendency to not using them together in the same utterance when possible, or at least to separating them as much as possible.

The three biases described by MacDonald do not always work in the same direction, but can be in tension in some situations. The resolution of the cases in which tensions arise conforms a space for linguistic variation

[4]By easier to retrieve, MacDonald refers to words and phrases that are more frequent, shorter, less syntactically complex, more conceptually salient, and given in the discourse.

that different grammars fill in different ways. These biases, being driven by utterance planning constraints, operate at an individual level. Nevertheless, as Scott-Phillips and Kirby (2010) point out, when the individual production choices are guided by common biases or principles, dramatic statistical population-level regularities arise.

In fact, frequency of use has been reported to have an impact in the processing and the shaping of language. High frequency expressions tend to be grammaticalized, which produce further change (Bybee 2006, Bybee and McClelland 2005; McClelland and Bybee 2007). Since unmarked options, the most frequent ones, tend to be easier to articulate and process, the influence of frequency in language change follows straightforwardly.

5.2.2 Seriality and language processing

However, the capacities of the brain are not the only constraints that shape the structure and more importantly the processing of language. The features of the motor and perceptual hardware that are involved in language production (and also comprehension), like the vocal tract or the articulatory properties of the hands, affect the nature of language and the strategies of the processor too. That is, the properties of the way the linguistic signal is externalized influence how language is processed and, in turn, how it is structured.

The seriality of vocal and signed output is a good example of these constraints by the sensorimotor system. With our limited capacity to temporarily store unprocessed material, the sequential nature of language output forces an incremental processing system. That is, the processor assigns structure to the sequence as it is being perceived, and it tries to assign the maximum amount of information possible at each moment, to each element. We could say that the parser uses "greedy", non-procrastinating strategies: due to the limited WM capacity and the necessity to maximize on-line processing in order to free the buffer from unnecessary loads, strategies that would imply the reanalysis of already processed elements are costly (Hawkins 2003;Ackema and Neeleman 2002).

As has been already said, once the parser has analyzed the structure of a clause, that specific structure decays and the semantic representation of that clause is stored to free the processor for other units to be processed (Kluender 2004;Ackema and Neeleman 2002). This procedure yields the so called garden-path effects (193) by which the ongoing analysis of a sentence contradicts the analysis that has already been assigned to previous clauses during parsing.

(193) The horse raced past the barn fell

In (193), a classic garden-path example by Bever (1970), the hearer/reader analyzes *raced* as a past tensed verb. When the main verb *fell* is reached, the parser gets a contradiction because *raced* had been analyzed as the main verb of the sentence and not as an embedded participial within a relative. In these cases, a reanalysis is required.

In the end, processing language means to extract structural patterns from a linear string and garden path effects are instances of an incongruency with respect to an already extracted pattern. As a matter of fact, a vast amount of studies focus on what has been labelled ‘sequential/statistical learning’ to draw insights on the mechanisms underlying language, like the studies on the location of phrase boundaries (Saffran 2001, 2002), on speech segmentation (Saffran et al. 1996a,b), or on the identification of long-distance relationships between elements (Onnis et al., 2003), to cite just a few. These studies link sequential learning to grammatical ability and in fact have been also corroborated by neuroimaging studies. For instance, it has been shown that people who have been trained on an artificial language have the same event-related potential (ERP) brainwave patterns to ungrammatical sentences both in artificial and natural languages (Friederici et al., 2002). Also in event-related functional magnetic resonance imaging (fMRI) studies, it has been shown that the same area is involved in an artificial grammar task and in natural language processing, namely Broca’s area (Petersson et al., 2004). Also from behavioral studies of language-impaired people, it has been reported that different language pathologies which involve language processing problems, such as aphasia (Hoen et al., 2003) or specific language impairment (SLIs) (Tomblin et al., 2007), co-occur with associated sequential learning problems. In any case, it has been suggested that there is a strong connection between temporal sequencing abilities and the processing of sentences in spoken modality.

5.2.3 Different word orders, different parsing strategies?

In section 5.1, we saw that the parser seems to be sensitive to canonical word order. It is therefore natural to wonder whether there is a universal parser or whether the parser differs from one language to another depending on the requirements of their grammars.

As a matter of fact, this is one of the main topics in sentence processing literature. With regard to it, there are three main types of theories: i) theories that assume a universal parser, ii) theories that assume that the parser is 'customized' by the specific grammars and by the priority of certain operations, which they will promote certain strategies over others, iii) theories that assume a more extreme customization of the parser, starting with a *tabula rasa* and learning the algorithms during the exposure to language and modeling strategical preferences to proceed. Some more radical theories even assume that the parser is differently customized from one speaker to another depending on the specific experiences each individual has had (Cuetos and Mitchell, 2013).

Several studies have challenged the universal theories, providing data that show that the parser behaves differently interlinguistically. For instance, in ambiguous sentences in which the possible analysis involves the attachment of a PP either to a more embedded clause or to a higher one like the one in (194), different strategies have been reported for different languages.

(194) Someone shot the servant of the actress who was on the balcony.

While some languages tend to attach the PP to the highest possible node, like Spanish, other languages tend to attach it to the lowest possible node, like English (Cuetos et al. 2013). According to these perspectives, the parser is provided with a universal toolbox but it learns to proceed optimally (by promoting certain strategies over others) from the information it extracts based on certain systematic occurrences, such as canonical word order or the degree of frequency of some structures.

Regarding word order and the possible effects it may have on parsing strategies, a major difference among the languages of the world is the position of the head and its complements. Head-final languages seem to challenge the assumptions in section 5.2.2 about maximizing on-line processing, since they require the parser to leave some items (complements) under-specified and active on the workspace as to some of their syntactic or semantic properties until a proper head is found (for instance, in the case of thematic role assignment). Once the head is found, consequently, the active, pending complement has to be revisited to fulfill the analysis, which is supposedly a costly operation.

According to the Performance-Grammar Correspondence Hypothesis (PGCH) in Hawkins (2003), the additional processing cost associated to placing the head after its complement should be reflected on a cross-linguistic preference for having initial heads. And yet, there are roughly the same amount of head-final languages and head-initial languages among the languages of the world.[5] Either the PGCH is wrong, or the processing of final heads is not significantly more costly than that of initial heads.

Ackema and Neeleman (2004) offer an approach to processing that is adequate to frame the discussion on this issue. Essentially, they propose that the parser scans the input as it receives the elements of the sentence, in temporal order from beginning to end; every time it closes off a unit of already parsed structure, it removes it with the elements within it from WM; finally, they claim that such closed units cannot be re-open once removed from WM. Theirs is not the only proposal in these terms: Kluender (2004) also assumes that already parsed chunks are removed from the workspace to free the working load and are, therefore, inaccessible to later parsing operations.

The key, as Cecchetto (2013) points out, is in determining when a given element stops being accessible for parsing. The answer to this question might be easier for forward dependencies than for backwards: when the parser finds a moved element (a filler) or a head, it keeps the unit it

[5] At the moment of writing this, a query in the World Atlas of Linguistic Structures (WALS) shows 580 languages with OV order and 608 language with VO order.

is in open until a satisfactory gap or complement is found and the dependency is resolved, at which point the unit can be closed. No backwards revisiting of already processed elements is needed, and no risk of inadvertently closing a unit containing a gap for which a convenient filler has not been found yet.

Head-complement relations are always local. Therefore, both elements are included in the same processing unit before it is closed and moved off WM, regardless of which one precedes the other. What could be potentially difficult to fit in the processing mechanism being used as the basis of this account are filler-gap dependencies resulting from the forward movement of the filler which, then, follows the gap it leaves. As a result, the parser, proceeding in forward temporal order, will have to backwards locate the gap when it finds the filler.

The proposal in Cecchetto (2013) is clear in this extent. Logically, backwards location of the gap is only possible if filler and gap belong to the same parsing unit, which would therefore not yet be closed and shipped out of WM. In other words: forward movements (or, as traditional formal models call them, rightward movements) cannot go beyond the local domain of the parser. This idea has been present in the field for a long time, and was first formalized in Ross (1967)'s Right Roof Constraint (RRC):

> RIGHT ROOF CONSTRAINT: An element cannot move rightward out of the clause in which it originates.

The actual formulation of the RRC in Cecchetto (2013) is actually stronger, since he refers not to a clausal limit but to a phrasal one: elements cannot move rightward out of the phrase in which they originate. In either case the result is the same: while backward (leftward) movements are unrestricted as to the boundaries they may cross in processing terms, other locality requirements notwithstanding, forward (rightward) movements are extremely constrained and cannot go beyond the local domain of the parser, either understood as the phrase or the clause.

As Cecchetto (2013) points out, in harmonic head final languages like Japanese, Turkish or Hindi, some instances of final dislocation of some elements seem to give raise to structures that would contradict the RRC, at least in its stronger formulation. Dislocation of the object in Hindi is possible, for instance, resulting in a linear order in which the moved objects seem to have crossed at least the VP boundary, as in (195a). Following the data about linear order and scope in Bhatt and Dayal (2007), Cecchetto gives an account of this kind of structures in which the moved element is not the object, but the whole VP, out of which the verb has been previously extracted (195c), so no long rightward movement takes place and the RRC is respected.

(195) a. Subject-V-AUX-Object

b. John watched has Mary

c. [$_{\text{TP}}$ John t_j watched$_i$ has] [$_{\text{VP}}$ Mary t_i]$_j$

The major consequence of this approach is that backward dependencies cannot be long distance dependencies, but must always be short. According to the data in section 3.1.2.2, which will be further discussed in section 5.3, this could not be true for sign languages or, at least, for LSC.

In sum, human sensorimotor systems and cognitive machinery constrain human languages. The sequential nature of language output is an instance of said sensorimotor constraints, as it forces an incremental parsing system, which proceeds assigning structural analysis as soon as possible, while the proference is being uttered. As for cognitive constraints, some structures are more demanding than others and it has been suggested that the parser may use different strategies depending on that. It has also been claimed that these differences in parsing may be observed from language to language, even from speaker to speaker, since performance is arguably at the basis of some explanations to facts related to variation. In this sense, for instance, the big constraints on backward dependencies in spoken languages can be accounted for in terms of processing, if we think of the strong bias to forward recall in the modality.

Next section is devoted to how these aspects can explain the facts observed in the characterization of wh-questions in LSC and in the results of the WM experiments.

5.3 Differences in WM processing between modalities yield differences in the behavior of wh-questions

Up to this point, I have shown how the sensorimotor system may constrain language and how the parser can use different default strategies in different languages to adapt to the input it receives according to the grammatical properties of each language. Given the results obtained in the WM experiments and presented in chapter 4, let us see how they can be related to the behavior of wh-questions in both modalities.

The free recall task showed a greater span of the speakers alongside a greater (spontaneous) maintaining of serial order (see section 4.3.3.2). The serial recall experiment showed a greater span in forward order in the auditory modality than in the visual modality (see section 4.3.2.2). In line with previous works, these results suggest that auditory modality seems to be specially suited for the sequential forward recall. In contrast, visual modality does not exhibit this advantage in forward recall and, therefore, does not have a clear preference regarding the direction of recall.

In any case, signed modality does not seem to resort to sequential order as clearly as auditory modality. However, could we say that the pattern in the recall of lists of words we observed in chapter 4 is replicated in the processing of sentences in SL? Although current evidence is not yet undeniable, there are some studies that argue for the bearings of serial recall tasks on language production (Amato and MacDonald 2010; hirshorn2015). In any case, the choice of tasks with word lists responds to the necessity of analyzing the differences in basic processes of WM between modalities (qualitative and quantitative). In the search of this basic differences that may affect syntax processing, it is necessary that the latter is not involved. Once these differences are found and interpreted, experiments will add the sentence component to test whether these claims and interpretations are on the right track. In addition, the use of words/signs instead of letters/digits moves the experiment closer to natural language.

It has been suggested that the sequential nature is an inherent property of sound, regardless of whether the stimuli are linguistic or not, and that exposition to sounds may help bootstrapping the development of cognitive abilities related to the representation of temporal or sequential patterns. In that sense, deafness, which is a deprivation of such exposition, could entail a difficulty for the development of these abilities (Conway et al., 2009).

In that regard, Supalla et al. (2014), in a study involving child and adult deaf signers and adult hearing signers, shows some very interesting results. A sentence repetition task was carried out in which sentences gradually increased in complexity and length, in ASL. Data were gathered from the three groups which were expected to differ in fluency. From the analysis of their errors in the task, it became evident that the most fluent signers relied less in the sequential order of the signs and tended to preserve semantic details at the expense of their incurring in errors involving alterations in the morphosyntactic domain. They tended to produce cascading errors because of the necessity of fitting their responses in a grammatical utterance. The intermediate signers tended to use a more linear strategy, preserving lexical status and word ordering while omitting local inflections, and occasionally resorting to visuo-motoric imitation to overcome lexical and morphological limits, which led to the illusion of comprehensible signing. The least fluent signers recalled the same amount of well-formed signs regardless of the increasing complexity of the input and tended to give ungrammatical utterances as answers more frequently. That is, while fluent signers tended to assign structure as much as they could, less fluent signers followed a linear strategy. Supalla et al. (2014) conclude that "in order to achieve further proficiency, a signer would need to switch from 'episodic' to 'linear' and finally to 'non-linear' type of scaffolding". This way, Supalla et al. (2014) suggest that being a "good" (fluent) signer means to rely less in sequential order and more in grammatical scaffolding.

The question is, then, what does it mean to be a "good" speaker? Although both modalities are constrained and driven by the requirements of grammar, it could be the case that in auditory modality, just as we saw in the experiment with word lists, the advantage in forward temporal recall cannot be ignored. If that was true, just as it happened in the word lists recall tasks, in the processing of sentences in auditory modality temporal storage would be more prominent than in signed modality.

If we accept, in line with what we have seen in section 5.2.3, that the parser can adapt to the varying necessities of the characteristics of different spoken languages, it is logical to think that it will adapt also to the characteristics specific to each modality, which, following the models that place performance as one of the sources of linguistic variation, will have consequences on the construction of the grammars in each modality. Even more so since the processing of visual and auditory information is different, both quantitatively and qualitatively, as we have already seen in the discussion of the experiments in section 4.3.4. While auditory modality is inherently sequential, visual modality is not: it is not specially adapted to keeping temporal order. By resorting to sequential strategies, somehow, low fluent signers in Supalla et al. (2014) may have been using a strategy of the “wrong” modality and behaving like speakers.

The preference in maintaining forward order specific to auditory modality imposes some restrictions on the parser that cannot be easily ignored when processing. The parser is highly specialized in operating in this direction and exploits this bias greedily, thus rendering other options, like operating backwards, strongly limited. A reflection of this in language, perhaps one of the most evident, is that while forward dependencies in auditory modality are quite unbounded as to types and distance (and other locality conditions), backward dependencies are more restricted than them and they can never be long.

Visual modality, on the other hand, does not show a specific tendency to maintaining forward or backward sequential order. The absence of a strong bias, in this sense, allows for a greater degree of flexibility. The difference in operating forward or backward in this modality is narrower, which would leave both options available to roughly the same extent.

Furthermore, in addition to the temporal dimension, visual modality can use a spatial dimension which is totally unavailable in auditory modality. Sign languages exploit space productively and at many levels: for expressing referential specificity (Barberà Altimira, 2012), for encoding verbal agreement and assigning theta-roles, for describing spatial relation meanings through classifiers (either literal or metaphoric), and for expressing direct speech through role shift, to cite just a few. This additional dimension opens up alternative mechanisms to mark syntactic dependencies and other structural relations untied from the notion of precedence.

Finally, and because of the intervention of multiple articulators at the same time, visual modality can make an intense use of simultaneity. This property, often called multidimensionality, allows to simultaneously incorporate more features to signs. This possibility has been suggested to make SLs not to depend on concatenative morphology so much as SpLs do (Emmorey, 2007). In this regard, the NMMs are a specific tool of SLs to encode information at various linguistic levels. As a matter of fact, as presented in section 2.4, NMMs have been suggested to be used as a strategy to mark syntactic dependencies which is specific to signed modality.

The specific properties and additional dimensions of visual modality render the temporal aspect less determining and, probably, less restricted regarding the linearization of dependencies and combinations of elements within the sentence. Although this proposal is based specifically on the absence of a bias towards forward recall in visual modality, which is interpreted as the cornerstone that allows less restricted rightward movements of the SLs, these other features and strategies must also be considered. They must necessarily affect the lack of dependence of SLs on particular linear orders, even if it is in an indirect way and acting as facilitators. In other words, without those elements, absence of forward bias might not be enough to allow SLs to exibit this kind of patterns.

In wh-questions in particular, while spoken languages exhibit only fronted and *in situ* patterns, sign languages allow placing wh-expressions in fronted, *in situ* and final position. As discussed in chapter 1, hierarchy is not violated in the case of signed final wh-expressions. It is not hierarchy that prevents wh-expressions to appear in final position in spoken languages, but the externalization of spoken languages driven by their parser.

Sign languages exhibit an additional possibility of linearization that we might have had mistakenly taken to be forbidden by hierarchical considerations. Actually, the impossibility of finding final wh-expressions in

SpLs could be explained by the strong bias of auditory memory to forward keeping the order of sequences and, therefore, be due purely to a matter of performance.[6] In this sense, notice that although movement in LF cannot be directional, since only notions of dominance are encoded at that level, the processing of *in-situ* wh-expressions, for instance, must in any case be made after the parser reaches the *in-situ* wh-expression, which needs then be retained in WM until a proper landing site is found in an operator position in the periphery of the sentence (Alphonce and Davis, 1997). This mechanism is strongly reminiscent of "rightward" movement.

If visual languages do not rely so much in ordered forward recall in sentence processing as auditory languages do, some other operations must be used in a more prominent way. As the analyses of errors in Supalla et al. (2014) suggest, a fluent signer is the one that relies more on grammatical scaffolding than just on serial order. The idea is that signers assign syntactic structure as soon as they can when processing a sentence.

[6]One of the consequences of an approach based on performance, according to the idea expressed by the Performance-Grammar Correspondence Hypothesis, is that it does not completely rule out the existence of marginal cases. The correspondence is statistical in nature, not deterministic: the more costly in terms of performance, the more unlikely a given feature is to exist. What this means for wh-sentences in particular is that we could still find some spoken language which allowed long-distance rightward movement and/or placing non-*in-situ* wh-expressions in sentence final position. In that extent, Dryer mentions two spoken languages that place wh-expressions in positions other than the beginning of the sentence or *in situ* (Dryer, 2013).

This importance of assigning structure as soon as possible is visible in LSC in an interesting contrast already mentioned in examples (161-162), here repeated as (196).

(196) a. WHO SAY COOKIE STEAL

Who said that (someone) stole the cookies?

b. SAY COOKIE STEAL WHO

Who did (someone) say that stole the cookies?

In (196a) WHO is interpreted as the agent-subject of the main verb SAY, that is, a short distance movement. In (196b) WHO is interpreted as an argument (the agent-subject) of the embedded verb (STEAL), that is, a long distance movement (the short distance interpretation is highly dispreferred). This contrast reflects two well known parsing strategies originally formulated by Frazier and Fodor (Frazier, 1979; Frazier and Fodor, 1978), namely Minimal Attachment and Late Closure. Minimal Attachment principle says that the parser tends to first interpret the simplest syntactic structure of a sentence given the material already uttered:

> MINIMAL ATTACHMENT: Attach incoming material into the phrase marker being constructed, using the fewest possible nodes consistent with the well-formedness rules of the language under consideration.

This principle yields sometimes garden paths effects, since the final analysis may not coincide with an analysis already assigned to a partial segment of the string (197b).[7]

(197) a. The teacher told the children the ghost story that she knew would frighten them.

b. The teacher told the children the ghost story had frightened that it wasn't true

Decision times are shorter in sentences like (197a), in which the structure coincides with the analysis driven by minimal attachment principle than sentences like (197b). In (197b) the hearer/reader is garden-pathed by this principle because she tends to assign the simplest analysis given the uttered material, that is, interpreting *the ghost story* as the object of the main verb and not as a relative clause.

Hawkins (2003) also offers a principle of economy to minimize the structural complexity of the result of the parser and, in consequence, to minimize the costs of parsing linguistic input. His principle, Minimize Domains, is not a procedimental rule to be applied during parsing but a requirement on the efficiency and complexity of the syntactic markers measured in terms of size.

> MINIMIZE DOMAINS: The human processor prefers to minimize the connected sequences of linguistic forms and their conventionally associated syntactic and semantic properties

[7] Examples are taken from Frazier and Clifton (1996).

> in which relations of combination and/or dependency are processed [...] (Hawkins, 2003, 123)

To set the frame for the application of this principle, he describes, in terms of processing, the relations of combination (two elements are in a relation of combination iff they occur within the same projection) and dependency (two elements A and B are in a relation of dependency iff the processing and specification of some under-specified or zero-specified property of B requires access to A).

This principle is maximally accomplished when the number of items the parser deals with at the same time is reduced to the minimum necessary for building correctly the syntactic tree. This has consequences both in the linear order in which the items are presented and in the complexity of the syntactic relations they establish among them. In this sense particularly, it can be seen as an extension of Minimal Attachment that seeks to promote the utterances that favor the adjacency of terminals and, most specially, of heads. Following Hawkins (2003)'s argumentation, this could explain, among other things, different phenomena like the tendency to harmonicity in language, Greenberg's cross-category ordering correlations or the end-weight principle.

In a broader sense, Minimize Domains can be used to account for some adjacency effects. This is so because the elements that enter in a combinatorial or dependency relation will somehow "push" to be adjacent at a string (phonological) level, to favor parsing. It is obvious that other forces are in tension when flattening the syntactic structure of the tree but, nevertheless, the Adjacency Hypothesis is worth being considered at the level of parsing.

> ADJACENCY HYPOTHESIS: Given a phrase {H,{X,Y}} [...] the more combinatorial and dependency relations whose processing domains can be minimized when X is adjacent to H, and the greater the minimization difference between adjacent X and adjacent Y in each domain, the more H and X will be adajcent. (Hawkins, 2003, 130)

The Adjacency Hypothesis is, this turn, a requirement on the ordering of elements on the linguistic string, and also a requirement on the complexity of processing the relations derived from a particular order. Essentially, it promotes that related elements are adjacent. In this sense, and talking specifically about filler-gap dependencies like wh-constructions, Hawkins assumes that the general ordering of asymmetrically c-commanded elements depends on how the sister nodes in the construction are ordered in particular. The overall result, nevertheless, must always be guided by minimizing the parsing domains.

Another economy principle put forward by Frazier (1979) is Late Closure, a principle that says that the processor tends to bind an item to the clause currently being processed:

> LATE CLOSURE: When possible, attach material into the clause

or phrase currently being processed.

This can be observed in examples like (198) where the users tend to attach the PP in the library to the latter verb, *reading*, more often than to the former, *put*.[8]

(198) Jessie put the book Kathie was reading in the library.

In the LSC contrast in (196), repeated below in (199), minimal attachment is observed in (199a). The parser's analysis of WHO as an argument of the main verb SAY blocks the possibility of analyzing it as an argument of the embedded one, STEAL. Late closure is observed in (199b), since the parser prefers to relate WHO to the phrase marker that is being processed, to the embedded verb, and makes the long-distance dependency much more preferable than the short-distance one.

(199) a. WHO SAY COOKIE STEAL

Who said that (someone) stole the cookies?

b. SAY COOKIE STEAL WHO

Who did (someone) say that stole the cookies?

These processing principles, which are universally available for any language, are not applied in the same manner by all languages (Mitchell

[8] This principle, which was taken to be universal by Frazier (1987), has been claimed to behave differently across languages (Mitchell and Cuetos, 1991). In examples like (198), while English speakers seem to prefer lower attachments, it has been reported that Spanish speakers tend to prefer higher attachments.

and Cuetos 1991; Carreiras and Clifton 1999; De Vincenzi and Job 1993). This permeability of the parser to chose strategies according to the frequency of patterns in the linguistic input it receives can set the difference between what is acceptable and what is not. That is to say, this sensitivity of the parser to the frequency of configurational patterns in a language can make the processing of a given sequence result in an unacceptable structural analysis in that language, beyond garden-path ambiguities. That is, of course, the expected behavior considering the PGCH.

This way, regarding wh-questions in LSC, these processing strategies have crystallized into grammatical principles. With regard to the previous contrast, because maintaining temporal order is not so prominent in LSC, Minimal Attachment and Late Closure are more exploited and make the wh-dative reading in (199a) the only one possible in LSC and the wh-long extraction reading in (199b) the highly preferred one.

As a byproduct of the combination of a lack of forward recall preference and the application of the principles we are discussing, the canonical linearization of wh-elements in LSC appears to satisfy the Adjacency Hypothesis to a greater degree. That is so because LSC allows the wh-expression in complex sentences to appear linearly closer to the verb phrase where it was originated: by fronting it if it is a complement of the main verb and has undergone short movement (199a), or by putting it in sentence final position if it is a complement of the embedded verb and has undergone long movement (199b).

Let us see some other LSC asymmetries already described in chapter 3 that corroborate this pattern. In (168-169), now repeated in (200-201), there are two multiple complex sentences with the two wh-expressions occurring in initial and final position. Interestingly, the initial one is always interpreted as a short-distance dependency, that is, an extraction from the main clause. In (200), what is being asked is where was Mary when she said something, whereas in (201), what is being asked is how she said that, in what manner. The final wh-expressions are interpreted as long-distance dependencies, that is, as extractions from the embedded clause that have scope over the whole sentence. In (200), what is being asked is how John stole something, whereas in (201) it is from where John stole something.

(200) $\overline{\text{WHERE MARY SAY JOHN STEAL HOW}}^{\text{wh}}$

Where was Mary when she said that John stole how?

(201) $\overline{\text{HOW MARY SAY JOHN STEAL WHERE}}^{\text{wh}}$

How did Mary say that John stole where?

In complex sentences like these, Minimal Attachment makes an initial wh-expression to be attached to the main verb, thus yielding a short-distance extraction reading. On the other hand, Late Closure makes the final wh-expression to link to the trace in the phrase marker that is currently being processed, the embedded clause, yielding a long-extraction reading and, again minimizing the parsing domain by following the Adjacency Hypothesis.

Let us also remind the examples in (165-166) repeated here as (202-203), which try to replicate the scenario in (200-201) with WHERE and HOW, but now with argumental-like wh-expressions, WHO and WHAT. That is, a multiple wh-question involving a complex sentence with the two wh-expressions in initial and final position. In (202), again, the initial WHO is interpreted as an extraction from the main clause, a dative. On the other hand, WHAT is interpreted as an object extracted from the embedded clause, that is, a long-distance extraction. That is the expected pattern according to what we have seen.

(202) $\overline{\text{WHO MARY SAY STEAL WHAT}}^{\text{wh}}$

What did Mary say that was stolen to whom *(did she say it)*?

However, one could argue that there is a semantic effect, specially in the case of WHAT, since WHAT can only be interpreted as an object and the only available object gap is in the embedded clause. To test that, we reverse the wh-expressions and put WHAT in initial position and WHO in final position (203). Interestingly, the sentence is interpreted as a non-multiple wh-question in which only the final wh-expression is considered, of course, as a long extraction. The initial wh-expression is just ignored and this question is answered only with the name of the possible thief. Probably, this sentence is not rejected because WHAT is an unmarked wh-element.

(203) $\overline{\text{WHAT MARY SAY STEAL WHO}}^{\text{wh}}$

Who did Mary say that stole *(something)*?

Although the pattern is better seen with multiple wh-questions, it is also observable in complex sentences with a single wh-expression. Again, placing of the wh-expression in sentence-final position and adjacent to the embedded verb is the canonical way of formulating the sentence with a long-extraction reading. Fronting the wh-expression, on the other hand, makes that interpretation difficult, although not totally impossible. When the wh-expression appears fronted, the more natural interpretation also follows the patterns discussed above, and is understood as a complement of the main verb that has undergone short movement.

(204) a. JOHN SAY t_i COOKIE STEAL WHO$_i$

b. ?? WHO$_i$ JOHN SAY t_i COOKIE STEAL
Intended reading: Who did John say that stole the cookie?

Sentences like (204a) can seem ambiguous between a long wh-extraction and a declarative sentence with an embedded indirect wh-question. However, as discussed in section 3.1.2.1, the NMMs associated to indirect questions are articulated softer and quicker than the ones associated to wh-sentences, so no ambiguity arises.

In sum, the final position is an available location for wh-expressions in signed modality probably due to the lack of the strong forward recall bias that auditory modality has. In this sense, visual languages would not rely so much in sequential order in processing sentences as auditory languages do. Visual languages would assign structure as soon as possible in sentence processing following the principles of Minimal attachment and Late Closure and satisfying the requirements of the Adjacency Hypothesis. I propose that, in LSC, this is visible in complex wh-questions, which exhibit a different use of the margins of the utterance. Specifically, initial wh-expressions are interpreted as short-dependencies and final wh-expressions are interpreted as long-dependencies.

5.4 Some explanations independent of modality. Focus as an attractor to the end

Whereas the availability of wh-final location in visual modality, and its unavailability in auditory modality, can be explained by taking into account the qualitative differences in WM that are tied to language processing, the specific preference for this location in a particular sign language is not so straightforwardly derived. Notice that said differences give rise to a set of possibilities from which each language must draft its own grammatical subset. Departing from the set of possibilities available in visual modality for wh-location (initial, *in situ* and final), in this section I suggest an intralinguistic explanation for the wh-final preference in LSC.

As described in chapter 3, in LSC simple wh-questions canonically exhibit final wh-expressions. The sentences in example (205) are in increasing order of acceptability. Example (205c) is the most preferred and example (205b) is preferred over (205a), which is accepted but dispreferred.

(205) a. WHAT JOHN STEAL
b. JOHN WHAT STEAL
c. JOHN STEAL WHAT

The example (205a) is dispreferred because JOAN, the subject, is following the wh-expression, which is the focus of the sentence. In LSC, a language which allows null subjects, an overt preverbal subject has additional discourse meaning, more topic-like, that must precede focus information. As Wilbur (1991) suggests for ASL, LSC tends to locate focus/new information in final position and topic/given information in initial position. This can be observed in (206).[9]

(206) BALL CHEESE MAKE PRODUCE IX NETHERLANDS

Edam cheese is produced in the Netherlands.

The topic-comment structure has been reported as prevalent for various sign languages (see Rosenstein 2001). Although one could discuss the topic-like status of preverbal overt subjects in LSC and the way LSC

[9]Taken from Quer (2005).

treats topic-like information, what is clear is that focus information tends to follow non-focus information.

Focus may be marked by syntax, lexical focus markers or prosody (Wilbur, 2012). As Büring (2008) notes, in any case, focus must be maximally prominent. In this sense, the edges of the senses are privileged positions. As claimed for ASL (Wilbur 2012; Wilbur and Patschke 1999), LSC also uses word order and NMMs to convey which element or elements are the focus of the sentence. However, in LSC there are also some manual signs that can be used to give prominence or emphasis to nominals, like the INDEX, MATEIX, or a bimanual B handshape sign used for humans (Barberà, 2012).[10] The occurrence of these signs may allow foci to occur in non final position, although this seems the default position for them. Among SLs, NMMs also behave differently depending on the given versus new nature of information. For instance, body lean is usually used to mark focus (Pfau and Quer, 2010), squinted eyes has been claimed to convey shared information between signers and brow raise has been traditionally associated to topics. However, as for LSC, it is not clear yet which is the specific behavior of NMMs in information packaging and when they are obligatory and when they are not. Nevertheless, in example (205a), the topic-like overt subject is intervening between two elements which should be both part of the comment.

[10]This sign is articulated with the palm of the hands facing each other and a downward movement (Barberà Altimira, 2012).

According to all these considerations, which result in a particular way of linearizing discourse information, in LSC overt preverbal subjects should precede focus information and not follow it, which is not the case of (205a).

On the other hand, in example (205b), no element splits the comment, which makes the example more acceptable. However, (205b) is dispreferred over (205c) because, as shown in (206), focus/new information tends to be canonically located in final position in LSC and it is not the case, since the wh-expression is *in situ*. Nevertheless, although it is not the most preferred option, it is accepted as grammatical if the NMMs reach the end of the sentence.

The example (205c) is the best preferred because the wh-expression is located where focus/new information is normally expected to be, namely final position. This way of focusing information by locating it at the end of the utterance is observed in LSC self-questions (aka rhetorical questions) (207). This focus strategy has been described also for ASL (Wilbur, 2012).

(207) MONTSE BUY WHAT, CHINESE NOODLES

This construction is equivalent to it-clefts (208a) or to shift stressed sentences (208b) in English which are two strategies to focus elements.

(208) a. It is Chinese noodles that Montse bought.

b. Montse bought **Chinese noodles**.

Wh-NMMs have been shown to behave in connection to whether some lexical material [+wh] has reached Spec,FocP or not. Specifically, they spread until the end of the utterance whenever a non-final wh-expression occurs.

(209) a. $\overline{\text{WHAT JOAN STEAL}}^{\text{wh}}$

b. * $\overline{\text{WHAT}}^{\text{wh}}$ JOAN STEAL

(210) a. JOAN $\overline{\text{WHAT STEAL}}^{\text{wh}}$

b. * JOAN $\overline{\text{WHAT}}^{\text{wh}}$ STEAL

When lexical material [+wh] fills that final position, NMMs may spread optionally over the previous material. In this case, some differences arise regarding discourse information, as (119-120) now repeated in (211-212) show: (211) could be uttered out of the blue, in a situation without any shared information whereas (212) would be uttered when the possibility of giving puppies away was already shared.

(211) $\overline{\text{PUPPY WANT WHO}}^{\text{wh}}$

Who wants a puppy?

(212) PUPPY WANT $\overline{\text{WHO}}^{\text{wh}}$

Who wants a/the puppy?

Given the fact that wh-expressions are a proper subset of all the possible focus elements in any language, it means that wh-expressions are inherently focused elements. Any element that falls under the domain of a wh-NMM will therefore be interpreted as focus/new information. So in (211) there is no previously known/shared information, and that is why it can be uttered out of the blue.

In contrast, in (212), the wh-NMMs delimit two major prosodic constituents. The last one, comprising only the wh-expression, will be interpreted as focus/new information. The first part of the utterance, which has no NMM associated to it, will consequently be interpreted, by contrast, as known/given information. The presence of shared information prevents the possibility of uttering (212) out of the blue, in a context where the possibility of giving puppies away is not present in the context.

This tendency to fill Spec,FocP with lexical material [+Foc] is seen in wh-doublings, in which one of the two coreferential wh-expressions must occupy the final position.

(213) a. WHAT JOAN STEAL WHAT

b. JOAN WHAT STEAL WHAT

c. * WHAT JOAN WHAT STEAL

Furthermore, as shown in chapter 3, indirect wh-questions do not exhibit a preference for the final location of wh-expressions as direct wh-questions do. Also, NMMs in indirect wh-questions do not need to spread and can be superseded by non-wh-NMMs. This, again, points to a tendency to locate focus information at the end of the main sentence, since focus is a root phenomenon. Notice that this has been also corroborated by the data from ASL indirect wh-questions by Petronio and Lillo-Martin (1997).

(214) a. MARY SAY $\overline{\text{WHAT}}^{\text{wh}}$ JOAN BUY

b. MARY SAY JOAN $\overline{\text{WHAT}}^{\text{wh}}$ BUY

c. MARY SAY JOAN BUY $\overline{\text{WHAT}}^{\text{wh}}$

Notice that final wh-expressions are in a peripheral position and not *in situ* (215), since adverbials may occur between them and the IP.

(215) JOAN STEAL YESTERDAY WHAT

In sum, the tendency to locate wh-expressions in final position in LSC is due to their focus nature. Spec,FocP, which is preferentially linearized in final position, attracts wh-expressions to check their [+Foc] features. Canonically, this is visible in questions with final wh-expressions although it is also accepted to locate wh-expressions *in situ* or initially if wh-NMMs reach this final position. Wh-doublings and indirect wh-questions corroborate this idea. The former require at least one wh-expression in final position. The latter show that wh-expressions in indirect wh-questions do not show this preference for final location and do not show the same NMMs behavior.

5.5 Conclusions

We have seen that SpLs and SLs show two different sets of possibilities regarding the location of wh-expressions. While Spoken Languages allow only wh-fronting and wh-*in-situ*, Sign Languages also leave open the possibility of placing wh-expressions in final position. I have suggested that these two scenarios are the reflection of some quantitative and qualitative differences in WM between auditory modality and visual modality. The first has shown a bias to forward recall which it cannot ignore, whereas the second seems to be more flexible, and seems not to rely so much in sequential order: it does not show specific preferences regarding recall direction. I suggest that the flexibility observed in word lists in visual modality has a reflection on the permissiveness to linearize wh-expressions in the three possible places that hierarchy allows (setting apart partial movement). On the other hand, the rigidity of auditory modality (a consequence of a significant advantage in the maintaining of forward order) would cause SpLs to allow only fronted and *in situ* wh-expressions. This tendency to maintain forward sequential order in auditory modality would make forward dependencies less restricted and backward dependencies more constrained in SpLs: in this modality, forward dependencies can be either long or short but backward dependencies must be short.

It has been reported that the parser selects different strategies accross languages based on experience. I have claimed that this sensitivity is also observable across modalities. Since, unlike in SpLs, neither forward nor backward order is specially prominent in SLs, other principles (which the parser selects differently from language to language) might gain importance in contrast, such as Minimal Attachment and Late Closure. The importance of these principles for SLs would make SLs to linearize in a specific way that is observable in some asymmetries between the margins of the utterance when involving complex wh-questions. Specifically, these principles would be in the root of the tendency to interpret initial wh-expressions in complex wh-questions as short-distance extractions (minimal attachment) and final ones as long-distance extractions (late closure).

These considerations could explain why Sign Languages exhibit a pattern in wh-questions that Spoken Languages never do. However, they are not enough to give an adequate explanation to the preference of LSC, in particular, for placing wh-expressions in final position. My suggestion is that LSC places its wh-expressions preferably in final position (over the other two possible locations) due to intra-linguistic causes, namely to give them focus prominence. In LSC, a pro-drop language, overt preverbal subjects could have an additional discourse meaning. Following Huang (1984) for Chinese, it has been proposed that ASL, which allows null arguments without verb agreement, is a discourse-oriented language (Lillo-Martin, 1991). If LSC follows a discourse-oriented pattern, overt preverbal subjects would be less accessible in the discourse than null subjects, and this would make (213b) preferable over (213a) in order to preserve the topic-comment structure.

Moreover, as claimed for ASL Wilbur (1991), in LSC, 'topic/given information is sentence initial' and 'focus/new information is final'. This final location of focus is also observed in LSC and it may account for the doublings described in chapter 3, which involve wh-expressions, index, modals, verbs and negative signs. In fact, it has already been suggested that doublings are a way to give prominence (Sandler and Lillo-Martin, 2006).

Chapter 6

CONCLUSIONS

This dissertation has offered the first characterization of wh-questions in LSC after Alba (2010). As reported for other SLs, LSC locates wh-expressions in final position as the default option to express a wh-question. This is true both in the case of wh-heads and in the case of wh-phrases. The occurrence of these elements following temporal adverbs gives support to the idea that they are not in fact *in situ* but in a higher position on the syntactic tree, namely Spec,FocP. Although other positions are also available in this language for wh-expressions, the final located FocP in wh-sentences "requires" the presence of [+Foc] wh-material in all cases. Whenever the wh-expression is pronounced in a non-final position, spreading of the wh-NMMs to the end of the proference is compulsory.

An explanation for a differential phenomenon between modalities has also been offered: SLs allow locating wh-expressions in final, non-*in-situ* location whereas SpLs never exhibit this pattern. As discussed in chapter 1, from the point of view of formal linguistics the literature on the topic has assumed some errors with regard to hierarchy and linearization and, more importantly, has not dealt with the question of why signed modality exhibits a pattern that is impossible in spoken modality. I have pointed out the error (from non-Kaynean perspectives) of acknowledging notions tied to right and left on hierarchical structures printed on 2D surfaces, because, actually, syntactic trees are tridimensional structures which do not encode information in terms of left or right. What syntactic trees do encode is the notion of constituency and the dominance relations between constituent nodes. In terms of precedence (grossly, left and right), the structure of syntactic trees just prevents higher constituents from splitting lower constituents.

This sharp difference between modalities, which has received little attention to date, has been addressed through the dissertation. According to the analyses and the discussions offered here, hierarchy is respected in both modalities, and the difference is due to post-syntactical phenomena tied to differential processing features. Specifically, the proposal offered here focuses on WM. I have conducted two experiments to carry out a comparative study of WM between both modalities. The results, which I discuss in detail in chapter 4, show that the differences in WM storing between modalities do not only differ quantitatively, but also qualitatively.

On the one hand, as previous works had already shown, speakers have a greater WM span than signers. But, differently from some of those works (Bavelier et al., 2008), the results of my experiment show that the difference in span is also kept when the requirement of keeping the temporal order items are presented in is left out of the task. Possibly, the selection of the participants in the tests can account for this differential result. In Bavelier et al.'s study, the participants were CODAs, while in my study there was a group of Deaf signers and a group of hearing speakers. Maybe the exposition to a language in the spoken modality can facilitate transcoding the signs in the visual part of the test in the case of CODAs, which may have masked the differences between speakers and signers I report here. In this sense, Geraci et al. (2008) report that some of their hearing participants in a visual recall test using emblems used a transcoding strategy, which enhanced their results compared to the results of those who did not. The selection of two different groups, one for each modality, with the due measures to balance both of them out, was a decision to minimize the possible effects of this kind of strategies.

On the other hand, one of the most interesting results I report in my study is that speakers keep forward temporal order when recalling even when this is not a part of the requirement of the task, while signers do not show a preference regarding order in the same situation. This spontaneous keeping of forward order on the part of speakers has been interpreted as an over-specialization of auditory modality that cannot be ignored by them, since the rest of values relative to the interactions between direction of recall and modality are essentially equivalent. Backward recall does not differ significantly between modalities, is always less than forward recall and, crucially, does not differ significantly from forward recall in visual modality. In this sense, visual modality seems to show a flexible pattern when looking at direction of recall, while auditory modality shows a bias to keeping forward order.

I have reviewed works that give evidence supporting the involvement of WM in sentence processing. If that is true, a difference in WM can have an actual impact on how language is processed. What I propose here is that, in effect, the differences I report in the storage of WM between modalities have a relation with the differences observed in the linguistic patterns of wh-questions in each modality, given the fact that the restrictions of the sensorimotor system have an impact on linguistic variation across languages.

APPENDIX A: LISTS OF ITEMS USED IN THE TWO EXPERIMENTS

LSC Sign	G-Value	Occurrences
factory	12	2748
actor	11	1188
garlic	10	735
sea	13	6517
total	12	2390
park	10	735
glass	11	1978
exam	11	1983
stone	13	5260
mother	13	7113
enterprise	13	5521
train	10	877
image	13	5525
country house	11	1971
light	13	6552
police	10	991

Table 6.1: Item list number one: signs

LSC Sign	G-Value	Occurrences
room	11	1135
limit	12	3611
pain	12	2642
toilet	10	988
bridge	11	1409
chairman	12	3978
mirror	10	583
cent	10	709
color	13	7268
window	10	1021
flower	13	4552
ship	11	1584
bed	11	1884
thief	10	744
accent	11	1462
family	13	7852

Table 6.2: Item list number two: signs

LSC Sign	G-Value	Occurrences
heat	11	1990
movie	11	1102
grass	12	2148
paper	13	6260
crisis	12	2948
moon	11	1456
material	13	4742
prince	11	1578
apple	10	550
friend	13	5790
theater	13	5466
age	13	6469
milk	11	1704
bird	12	2450
hospital	12	2197
teacher	13	7199

Table 6.3: Item list number three: signs

LSC Sign	G-Value	Occurrences
cement	10	514
shoe	10	577
gold	12	3099
onion	10	800
brother	13	4183
dog	11	1300
money	12	3444
cinema	11	1578
mountain	13	5260
newspaper	11	2045
lawyer	10	1020
soldier	11	1750
morning	12	3046
tree	13	5440
university	12	3092
bell	11	1498

Table 6.4: Item list number four: signs

LSC Sign	G-Value	Occurrences
sailboat	10	555
level	13	6944
song	12	2979
olive	10	622
television	11	1107
map	10	996
rose	10	703
director	12	2978
week	12	2862
city hall	13	5268
battery	10	583
economy	12	3396
coffee	11	1322
tale	10	691
meeting	12	2484
neighbour	11	1916

Table 6.5: Item list number five: signs

Catalan word	G-Value	Occurrences	English translation
arbre	13	5440	tree
càrrec	13	4670	position
taula	13	4553	table
olor	10	859	smell
concert	11	1352	concert
roda	10	1011	wheel
lletra	13	1511	letter
terreny	13	5761	terrain
barca	10	811	boat
dibuix	12	2354	drawing
ferro	12	3070	iron
plaça	13	4991	square
vidre	11	1987	glass
actor	11	1188	actor
torre	11	1971	country house
pluja	12	2215	rain

Table 6.6: Item list number one: words

Catalan word	G-Value	Occurrences	English translation
aire	13	6262	air
color	13	7268	color
metge	12	3694	doctor
vaixell	11	1584	ship
tasca	13	4481	task
client	10	714	client
vespre	11	1214	evening
tema	13	5497	topic
lladre	10	744	thief
cuina	10	988	kitchen
accent	11	1462	accent
cama	11	1300	leg
herba	12	2148	grass
mirall	10	583	mirror
cèntim	10	709	cent
amic	13	5790	friend

Table 6.7: Item list number two: words

Catalan word	G-Value	Occurrences	English translation
príncep	11	1578	prince
forat	11	1388	hole
calor	11	1990	heat
lluna	11	1456	moon
paper	13	6260	paper
crisi	12	2948	crisis
fusta	12	3531	wood
cotxe	11	1033	car
ocell	12	2450	bird
ciment	10	514	cement
poma	10	550	apple
sala	12	2416	room
quadre	12	3860	painting
peça	13	4642	piece
mare	13	7113	mother
turó	10	910	hill

Table 6.8: Item list number three: words

Catalan word	G-Value	Occurrences	English translation
pastor	11	1768	shepherd
somni	11	1186	dream
cartell	10	595	poster
núvol	11	1183	cloud
soldat	11	1750	soldier
fulla	13	5268	leaf
ceba	10	800	onion
despatx	10	668	office
pedra	13	5260	stone
matí	12	3046	morning
festa	13	6145	party
sostre	10	791	ceiling
frase	12	2872	sentence
illa	12	3204	island
feina	12	3705	job
conte	10	691	tale

Table 6.9: Item list number four: words

Catalan word	G-Value	Occurrences	English translation
dolor	12	2642	pain
suro	11	1246	cork
discurs	11	1876	speech
veler	10	555	sailboat
genoll	10	565	knee
mestre	13	7199	teacher
cafè	11	1322	coffee
presó	11	1047	prison
germà	13	4183	brother
branca	12	2740	branch
mapa	10	996	map
diners	12	3444	money
passeig	11	1239	walk
carta	12	3233	letter
zona	13	4991	zona
múscul	10	752	muscle

Table 6.10: Item list number five: words

APPENDIX B: SCREENSHOTS OF THE INTERFACE USED IN THE EXPERIMENT

Figure 6.1: Screenshot of the interface used for the Deaf participants

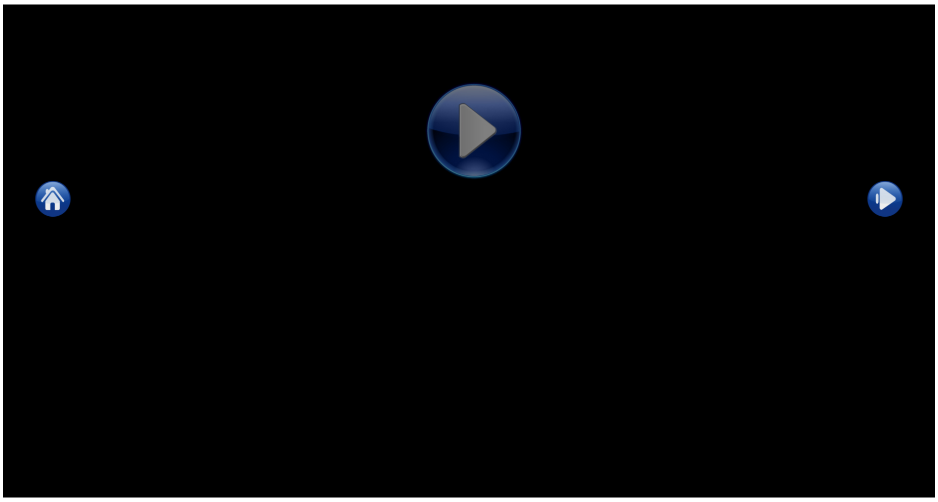

Figure 6.2: Screenshot of the interface used for the hearing participants

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