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First and Second Language Acquisition of Recursive Operations: Two Studies

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**FIRST AND SECOND LANGUAGE ACQUISITION OF RECURSIVE
OPERATIONS:
TWO STUDIES**

A Dissertation Presented

by

Jon S. Nelson

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2016

Department of Languages, Literatures and Cultures
Spanish and Portuguese Program

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**FIRST AND SECOND LANGUAGE ACQUISITION OF RECURSIVE
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Jon S. Nelson

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DEDICATION

I dedicate this to my wife, Victoria. Many times I wavered, but she always brought me back on course, convinced that I had what it took to see this through to the end.

ACKNOWLEDGMENTS

So many people have helped me along the way with this dissertation that I could easily write a chapter trying to thank each of them individually. I will strive to be brief, nonetheless. I would sincerely like to thank the co-directors of my dissertation, Professors Luiz Amaral and Tom Roeper, whose knowledge, helpfulness and guidance in my research were instrumental in seeing this through. I would also like to thank the other members of my committee, Professors Patricia Gubitosi and Jeremy Hartman, for their generosity with their time and energy throughout.

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to thank the dozens of participants who took part, without whom none of this would have been possible.

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ABSTRACT

FIRST AND SECOND LANGUAGE ACQUISITION OF RECURSIVE OPERATIONS: TWO STUDIES

September 2016

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Linguistic theory has increasingly revolved around the notion of recursion. Most recently, many have advocated a view wherein it forms the essence of the Language Acquisition Device (LAD) purportedly contained in the human mind, while others have argued that it remains a separate and not necessarily related component of language processing. L1 Acquisition theory has suggested that appropriate recursive input is required to activate the LAD's recursive faculties; nonetheless, L1 recursive structures may resist instruction and cause initial confusion among children. The effect that any of this may have on L2 has only begun to be studied.

This dissertation attempts to fill this gap in knowledge by describing two experiments which concentrate on the interpretation of adjacent prepositional phrases (PPs). The first experiment exploits the similarity of PPs in Spanish and English by using identical prompts in both languages and with both L1 and L2 speakers, while the second experiment studies the growth of their recursivity in L1 acquisition in English. Both experiments also study the effect that unique pairs of prepositions have on this as well as the effect created by extending the chain of adjacent PPs beyond only two.

The results provide a valuable insight into the interpretation of these structures. Recursive responses suggest an L2 path to acquisition which may result in L1 levels of performance. Yet Spanish and English each display their own behavior patterns, revealing dissimilarities that suggest Spanish possesses a more productive right-recursive rule than does English. Growth in L1 child English is also clearly observed in some scenarios but not in all. The important role individual prepositions clearly play is observed in both experiments, with unique pairs having unique levels of recursion. Increasing complexity of the NP based on number of PPs also entrenches recursion in interpretation. Nonetheless, certain participants resist recursion in multiple scenarios, a fact which may support an argument for targeted recursive input.

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CHAPTER 1

OVERVIEW

1.1 Introduction

This dissertation concentrates on syntactic recursion and coordination and how they are understood by L1 and L2 speakers. While recursion's significance in linguistic theory is hotly debated, its role in first language acquisition (FLA) is being thoroughly investigated. Nonetheless, several gaps in the knowledge remain, and the existence of few L2 studies limits the conclusions that can be drawn in Second Language Acquisition (SLA) theory. These studies will ask questions about how recursion grows in both FLA and SLA and whether cross-linguistic similarity in Spanish and English plays a role in interpretation. Furthermore, they investigate how aspects such as PP heads and more complex PP chains affect recursion.

1.2 Background

Recursion has taken an ever-increasing role in linguistic theory and studies in language processing and acquisition. The core concept germinated in linguistics in the Post-war era in the work of Bar-Hillel (1953a) as a way to simplify grammatical descriptions, as recursive operations permit a finite set of rules to generate an infinite number of sentences. This notion was embraced by Chomsky, who proposed (1965) that it was a core element of language competence as guided by Universal Grammar (UG), without which the grammar of any natural language would be impossibly complex and unwieldy. This has since grown in importance to the point where Hauser, Chomsky and Fitch

(2002) suggested it was the core competence in UG, and by extension the characteristic which distinguished human communication from all others.

All do not share this point of view, however, and the idea that UG = recursion has met considerable resistance on various fronts. Much of the dissent results from an argument based in natural language processing—why must grammars account for infinite sentences that could never be spoken, let alone comprehended. Performance data showed that the ability to process multi-level recursion was, in fact, quite limited. Others have attempted to demonstrate that it could not be a linguistic universal simply because they have found a language (Pirahã) which does not use recursive operations. Yet others (Arsenijević & Hinzen, 2010) do not refute recursion's importance but claim that it resides outside UG and emerges as a natural property of UG's interface in production.

When producing a complex phrase, the common alternative to a recursive operation is a coordinate one, and studies began to emerge (Matthei, 1982) that suggested that default recursive structures are found to be ambiguous by children, who may perform conjunctive operations instead. This led to theoretical developments in language acquisition (Roeper & Snyder, 2003) that suggested that fully productive L1 recursion is arrived at through thorough exposure via adequate input of the appropriate operations. In fact, coordinate operations may morph into recursive ones as children age (Roeper, 2011). This morphing is put down to the activation of a specific algorithm or a feature marked on particular nodes. Yet it is unclear whether this path is fully adopted by all speakers; some individuals may not get the memo and lag behind in recursive interpretation as a result.

Various FLA studies have shown the challenges speakers face when confronted with embedded structures. Very little extant work, however, addresses these properties in SLA studies, although Limbach and Adone tackled a section of it dealing with German speakers' readings of English possessives. That was a case of cross-linguistic differences, though, as English and German differ in productive recursion; little is known of the effect of cross-linguistic similarity and its effect on interpretation.

Prepositional phrase (PP) recursion is a productive field of study with several important players already. Some have shown the difference in processing difficulty between coordination and recursion (Maia, França, Gesualdi, Lage, & Oliveira, 2013) while others have emphasized the challenge presented by multiple levels of embedding (Christiansen & MacDonald, 2009). Nothing is known, however, of the effect that prepositions have on the recursivity of the phrases which they head.

1.3 Purpose of Studies and Research Questions

Two quantitative studies were designed which would test speakers' preferences to perform *recursive* operations or *coordinate* operations (other operations are observed as well) in Spanish and English.

The purpose of the two experiments is to help deepen the understanding of recursive acquisition in various ways. One experiment asks if L1 and differing levels of L2 interpretation of recursion are different: does a 'path' become apparent? Another experiment looks for a similar path in child L1 acquisition?

Other factors which might affect recursivity are explored here as well. How do the PP heads change perceptions of their phrasal recursivity? For instance, are adjacent

identically-headed PPs (e.g. *in the bag in the box*) more recursive than differently-headed ones (e.g. *in the box next to the books*)? Also, how do increasing numbers of adjacent PPs affect these perceptions, in light of what earlier research into this field has shown?

Unlike genitive or substance PPs, Spanish and English are assumed to perform recursive operations similarly in locative PPs due to their similarities not only in syntactic structure but levels of ambiguity and possible interpretations as well. Thus, one might expect similar levels of recursive interpretation as well.

1.4 Hypotheses

A number of hypotheses attempt to predict the behavior of recursion and coordination as affected by several variables.

The broadest one, though perhaps the most central, is that, overall, recursion will be the default interpretation over coordination, preferred by all levels of speakers. While uncontroversial, it is important to state plainly.

Were a path to recursion to exist, then this entails distinctions among groups. One is that L1 speakers will enjoy a recursive advantage over L2 speakers; advanced L2 will likewise benefit in comparison with intermediate speakers. As in L2, so it should be in L1: an acquisition path to recursion should be observable over the ages 5-8 and adult.

In addition to differences by level of speaker, others are forecast based on manipulating the PPs themselves. Early trials led to the observation¹ that identically-headed PPs seemed to trigger a more inherently recursive response than differently-headed ones; this intuition was built into the design of the experiment in order to verify it.

¹ Thank you to Magda Oiry for having this intuition.

PP heads themselves will affect interpretation, although the exact nature of that effect is unpredictable.

Furthermore, an increase in the number of adjacent PPs involved in a complex NP is predicted to result in increased recursion; despite the obstacle of increased processing load, its status as the default should only strengthen.

1.5 Experimental Design and Methodology

Effectively, the acquisition challenge the subjects needed to resolve was the following: presented with a complex NP containing at least two adjacent restrictive PPs whose default operation was recursive, what would they do? Would they proceed with the recursive operation, or would they fall back on coordination, or even resort to something else?

The two experiments used quite different methodologies and are described separately.

The adult L2 experiment was carried out with five groups of subjects (n=114) who were divided up based on both L1 and L2. The experiment was conducted in Spanish with three of the groups: L1 and both advanced and intermediate L2 groups (L1 English). The English version used an L1 group and an advanced L2 group (L1 Spanish).

The experiment comprised a series of multiple-choice questions whose corresponding prompts were heard on headphones with the choices presented on a computer screen.

Subjects were presented with a very brief scenario and heard a complex NP which contained two or three adjacent PPs whose default operation was recursion. The subjects could choose from either a recursive option or a conjunctive one, or use an alternate

strategy to resolve the challenge. Making a choice carried them to the next question; a macro recorded all answers.

The child L1 experiment also used five groups of participants (n=50) but was carried out only in English. There were four groups of children distinguished by age—five, six, seven and eight years old—and a control group of adult L1 speakers.

The second experiment targeted identical structures but was adapted to the new subject group (young children) by using an application on a tablet computer that allowed the subjects to creatively construct the locational relationships contained in the prompts. The application also recorded all the data from this, which could afterwards be coded in regards to recursion and conjunction.

The analysis which emerges from a thorough study of the data these experiments provide should inform the current discussion regarding recursion in L1 and L2 acquisition. A better grasp of the link between L1 and L2 will possibly be of use to pedagogical researchers who need to know how adults acquire an L2. This could be of value in the development of relevant materials to help augment the recursive input in the hopes of speeding and improving acquisition. The information about child L1 will allow, in a similar fashion, pedagogical development of ‘augmented input’ if the value of recursion is determined to be essential to natural language development.

1.6 Results

The data demonstrate significant differences between L1 and L2, between advanced and intermediate L2, as well as an identifiable path across the 5 ages in L1. Spanish is found to be ‘more recursive’ than English in regards to PP operations; L1 Spanish speakers

apparently carry this parameter into L2 English use. Furthermore, the data show recursive differences among PP heads, which additionally reveal the potential importance of a distinct step on the path to recursion: stacking (Langendoen, McDaniel, & Langsam, Preposition phrase attachment in noun phrases, 1989), or Direct Structured Recursion (Roeper & Oseki, to appear), which shares some features with Indirect Recursion (compositional semantics, hierarchical structure) though not others (PP self-embedding). Increasing the complexity of NPs by increasing the number of embedded PPs leads to increasing levels of recursive interpretation.

Nonetheless, preference for recursion is not universal among participants in the study—individuals in all age and language groups remained firmly conjunctive in many of their answers.

1.7 Summary

The data have provided rich material for discussion. Definite effects are observed relating to age of children in L1, L2 status in regards to L1, and heads and numbers of PPs used. The growth of stacking/Direct Structured Recursion in unique environments suggests some new paths to be made in the discourse on recursion. While many of the findings help to fill in gaps, many more remain.

Regardless of the theoretical approach used to describe these results, the data make clear recursion's dominance in interpretation by the vast majority of speakers in the scenarios studied; nonetheless, certain subjects resist its use. An argument could be made that a stronger awareness of recursion may be beneficial to individuals lacking recursive

awareness and that with appropriate, targeted input, they would have an opportunity to increase their recursive interpretation up to baseline levels.

This dissertation is organized into eight chapters. The first gives an overview of the project. Chapter 2 discusses the history of recursion in linguistic theory, processing and language acquisition. Chapter 3 outlines a formal grammar that will be used to analyze the data. Chapter 4 explains the research questions, hypotheses and methodology for the L2 experiment. Chapter 5 presents the L2 results and discusses their implications. Chapters 6 & 7 repeat chapters 4 & 5 respectively for the L1 experiment. Chapter 8 compares the two sets of results, draws some final conclusions and recommends several paths for future work.

CHAPTER 2

RECURSION'S ROLE IN THEORY, ACQUISITION AND SLA

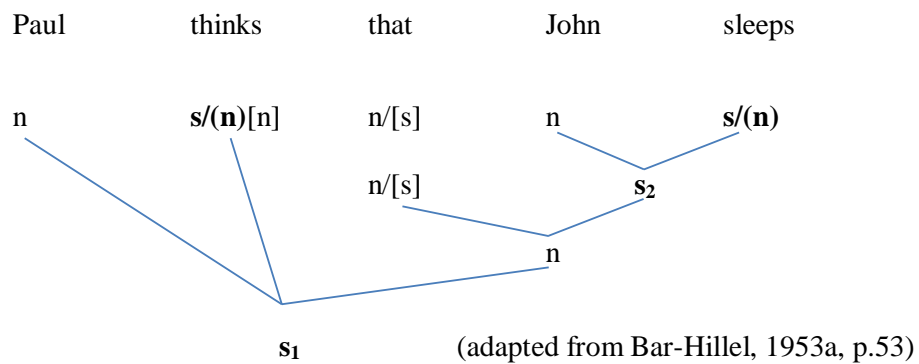
2.1 Introduction

This chapter provides an overview of the work that has gone into recursion's role in linguistics and language acquisition. It reviews its growth in traditional transformational grammar and UG-based theory. It also addresses several dissenting views as well as alternate, processing-based explanations for phenomena before reviewing the extant work in both first and second language acquisition studies.

2.2 Theoretical background

Before the post-war period, recursion as a component of theoretical development had largely been confined to the formal sciences such as math. Its use in the empirical sciences such as linguistics had been held back by the resistance to defining items in terms of themselves, which would create a circular, and thus illegitimate, chain. Bar-Hillel (1953b) addresses this point, however, by giving an example of a definition of a sentence in French, wherein, he claims, "it is inevitable to use in the definiens the term 'sentence' itself, if the definition is to be adequate" (p. 163). This is because, in addition to needing nominal phrases and transitive and intransitive verbal phrases at least, the definition must also allow for "a sequence of a sentence, the word 'et', and a sentence". What is more, nominal phrases must be partly defined using the term 'sentence' as well ('que' and a sentence would form an NP). If the terms 'sentence' and 'nominal' contain each other in their definitions, this "does not form a set of viciously circular definitions but...are rather a pair of *simultaneous recursive definitions*" (p. 164).

Bar-Hillel (1953a) demonstrated the value of recursion in linguistics in his efforts to improve syntactic notation. Through a demonstration of a reduction of sentential constituents, he proves that it is, in fact, obligatory in many situations to define constituent in terms of themselves.



1. Preliminary recursive sentences (Bar-Hillel)

In the tree in 1, ‘s/ (n)’ denotes strings that “with an n to their left form a string belonging to the category of sentences” (p. 48). S₂ embeds in S₁; there is no defined limitation on this operation, allowing theoretically infinite repetition. He had demonstrated how what was essentially a mathematical device may be able to simplify greatly notational structure in syntactic theory.

There had been resistance to this idea because of what Bar-Hillel referred to as the “fear of circularity.” “If (say) the term ‘morpheme’ is used in the definition of the phoneme, and vice versa, then certainly this procedure looks viciously circular, and the logical soundness of the science that uses such definitions is gravely jeopardized.” (Bar-Hillel, 1954, p. 234); naturally, this applies to the sentence embedding shown above as well. Yet

he claims that, as these ‘recursive definitions’ were already proven useful in mathematical logic, there was no need to fear infinite repetition, since the cycle of sentence-nominal-sentence-nominal “did not vitiate the process since we arrived at a stage where no further recursion was necessary and a matching with certain lists, for instance that of proper names, settled the question” (1953b, p. 164). Naturally, the concern for not falling over the lip into infinity strikes one as curious, given that the power granted by recursion as theory developed came to be considered precisely what allows languages to possess infinite numbers of sentences! Citing their usefulness in mathematical logic and previous work by Kenneth Pike (1952), Bar-Hillel states that there was nothing impeding the use of these ‘recursive definitions’ in order to better formalize grammatical representations as well.

Afterwards, it is precisely this quality of recursion which Chomsky (1957) emphasizes so strongly due to its ability to simplify grammars. “If a grammar does not have recursive devices...it will be prohibitively complex. If it does have recursive devices of some sort, it will produce infinitely many sentences” (Chomsky, 1957: 24). He, too, acknowledges specifically the logical concerns proscribing circularity expressed by Bar-Hillel, and how Bar-Hillel thought they may be addressed through recursive definitions. Finally, Chomsky notes that although “logic is indispensable for formalizing theories, of linguistics or anything else” and although “work in logic has incidentally led to important insights into the use of language” it does not logically follow that “the study of the formal (or semantic) properties of natural languages should model itself on the study of the formal (or semantic) properties of logic and artificial languages” (Chomsky, 1975, p. 84). Consequently, recursion was free to empower formal syntactic theory.

The usefulness of recursive devices to move linguistic theory away from complexity and towards simplicity is not done merely in the interests of minimizing confusion. “[I]n the case of philosophical systems...the motives for the demand for economy are in many ways the same as those behind the demand that there be a system at all. ...the same is true of grammatical systems” (Chomsky, 1975, pp. 114, note 2).

Chomsky (1975) also adopts a form of Bar-Hillel’s phrase structure rules to show how a form of indirect recursion is integral to their nature. Bar-Hillel had proposed this (1953b) in discussing recursion in its broader application in the empirical sciences. Bar-Hillel illustrates the simplest of recursive structures by noting how sentences can be formed by two other sentences joined by ‘and’ (or ‘et’ in French, his example). Chomsky (1975) restates this same idea, pointing out that “a phrase of a given type can be included within a phrase of the same type, so that a finite number of conversions will generate an infinite number of strings of words” (Chomsky, 1975, p.116). Without such devices, the grammar would be ‘intolerably complex’, at least from a descriptive point of view. This, in essence, restates the core of syntactic recursion, where a syntactic object (in this case a sentence) is (or rather, can be) (indirectly) defined in terms of itself, thereby opening the doors to an infinite number of combinations, as there is no explicit limit on how often the rule can repeat.

Nonetheless, whereas recursion was valuable for simplifying and improving efficiency in linguistic theory, Tomalin (2007) points out that ‘no strong claims were made concerning [recursion’s] biological status,’ (p.1785) until the sixties and the rise of Universal Grammar (UG) and the innateness hypothesis. That the ability to acquire languages was, in fact, innate, was expressed through the development of the idea of a language

acquisition device (LAD), which was proposed as an alternative to “the empiricist notion that language is essentially an adventitious construct, taught by ‘conditioning’ (as would be maintained...by Skinner...)...or by drill and explicit explanation...or built up by elementary ‘data-processing’ procedures (as modern linguistics typically maintains), but, in any event, relatively independent in its structure of any innate mental faculties” (Chomsky, 1965, p. 51). Instead, as laid out in *Aspects*, the LAD was an actual mental organ responsible for the successful development of a grammar in a child, activated by the input of its environment.

With the tools made available by UG, discrete languages no longer operate in complete isolation from each other; instead, the unifying constraints imposed by UG determine the output of all possible grammars. Chomsky (1965) suggests that the grammar would not only consist of what he classified as *substantive* universals such as that a particular syntactic object such as a noun may be found in any language, but also of ‘universal properties of a more abstract sort.’ These abstract properties are *formal* universals, such as recursion. Thus, from the point of view of generative grammar, far from being learned through conditioning or data-processing, the capacity for recursion is instead an organic part of the LAD., Effectively, the seeds planted by Bar-Hillel and formalized by Chomsky in what was according to Tomalin (2011) “an informal, error-strewn, high-level summary of existing research, which was suitably dumbed-down for an undergraduate audience,” grew to create a debate regarding recursion’s exact parameters, extent and importance in linguistic theory which has taken root and continues to thrive today.

With recursion now linked with the biological faculty of language, let us fast forward to its role in the Minimalist Program (MP). This emphasizes the distinction between

competence and performance; it is the competence that “permits infinite use of finite means” (Chomsky, 1995, p. 14), these ‘finite means’ being whatever steady state grammar any individual speaker has achieved. The reiteration of Principles and Parameters is germane to the recursion argument: UG contains the property of ‘discrete infinity’, a hypothesis which dictates that “languages are based on simple principles that interact to form often intricate structures, and the language faculty is nonredundant” (1995, p. 168). In essence, the broader notion of recursion is one of those simple principles; the specific form it may take in any one language forms a discrete parameter.

The role of recursion evolved and grew until ultimately Hauser, Chomsky and Fitch (2002) claimed that it was, in fact, “the only uniquely human component of the faculty of language” (p.1569), which they described as the faculty of language in the narrow sense (FLN). FLN is a key component of the faculty of language in the broad sense (FLB). Other components in FLB may include the sensory-motor and conceptual-intentional systems, although they themselves recognize that this is debatable; the essence of FLB is that some form of LAD in the brain is what gives humans alone the ability to “master any human language without explicit instruction” (p. 1571).

FLN, though a part of FLB, is an abstract linguistic system whose exact structure is up for debate. Hauser et al recognize differing points of view in how the components of the FLB interface, but that “[a]ll approaches agree that a core property of FLN is recursion...FLN takes a finite set of elements and yields a potentially infinite array of discrete expressions. This capacity of FLN yields discrete infinity” (p. 1571).

This claim found support, for instance from Corballis (2007) who agree that recursion was 'possibly the principal characteristic,' and 'may be the primary feature that distinguishes human language,' from everything else.

2.3 Alternative views

The theory of UG as 'recursion-only' also met with criticism. Some doubted its preeminence within UG, others its location within UG itself, while others preferred to describe it as a processing phenomenon. Perhaps most famously, others doubted its status as linguistic universal by purporting to present languages which contain no recursive operations.

2.3.1 Recursion falls outside of UG

While Everett's claims that his Pirahã data fundamentally weaken many linguistic universals might not stand up to careful scrutiny, recursion's supposed preeminent role in UG (Hauser et al, 2002) has been questioned from a variety of quarters that raise valid theoretical questions. Firstly, staying largely within a formalist framework does not necessitate building UG around recursion, however. Arsenijević & Hinzen (2010) deny that recursion is an element of UG, let alone the one unique characteristic of Hauser et al's FLN. This is not to say that they reject recursion's infinite power to embed structures; rather, it is "truly a property of the interface between the narrow faculty of language and the discourse in which language use takes place," (2010, p. 168). The position asserts that there is no "empirical evidence of recursivity of the structure-building mechanism of grammar," without the interfaces; instead, the mechanism and the interfaces combine to achieve recursion. In the schema of Hauser et al, this would locate recursion within the FLB instead of the FLN.

The view that recursion is not a basic component of UG finds other adherents. Mithun (2010) claims that the fact that typical recursive structures vary both cross-linguistically and over time within discrete languages undermines the central tenet of the FLN. Instead, evidence from Yup'ik and other languages suggest that “recursion is not the basic, hard-wired feature proposed” but is “in a sense epiphenomenal, the product of a host of cognitive abilities.” This reflects the notion that “the logical possibility of infinitely long sentences is neither the goal of speakers nor the essence of language. It is an artifact of a view of language as a mathematical system,” (Mithun, 2010) and something which reflects an awareness of Bar-Hillel’s early attempts at recursive definitions. In fact, Bar-Hillel (1953b) himself specifically claimed how his recursive definitions were not intended to be circular (the key to permitting infinity). Progressing in a definition, for example, from sentence to nominal to sentence to nominal (as one might in an embedded clause) does not crash because one arrives “at a stage where no further recursion [is] necessary” (Bar-Hillel, 1953b, p. 164).

Others have questioned the integral value of infinity in assessing recursion’s role in UG. “Determining the size of a natural language is not as easy as simply declaring that there is no longest expression in any language” and thereby assuming infinity thanks to recursion (Langendoen, 2010). Pullum and Scholz (2010) refer to what they call the ‘Standard Argument’ as the rationale behind infinitude dogma. This consists of the fact that simply adding “I know that” to any expression creates an unbounded set of embedded structures, or by adding another “very” to a chain unending iterative recursion is achieved.

Thereafter follows the No Maximal Length claim (as there is always something longer using techniques such as those above), which leads inexorably to the Infinitude Claim,

that the set of grammatical expressions in language L is an infinite set. They refute this from several points of view. One is the potential for using purely constraint-based grammars such as HPSG which they consider to be neutral with regard to infinitude. In fact, they claim that “there is no generative component at all” (Pullum and Scholz, 2010, p.123), which is at odds to say the least with the architecture laid out by Sag, Wasow & Bender (2003) in their updated description of HPSG.

Pinker and Jackendoff (2005) found that ‘recursion-only’ crashes when confronted with aspects as varied as speech production, phonology, and morphology, among others.

Tomalin (2007) suggests that the differences in opinion may be rooted in an ill-defined notion of ‘recursion’, and in fact proposes abandoning the term altogether in favor of something else (he prefers ‘inductive definition’).

2.3.2 Processing

Aside from the theoretical issues raised above related to competence, there have been others focusing on the actual performance limitations on processing. Part of the difficulty in arriving at satisfactory results may derive from the differences in analyzing ‘competence’ versus ‘performance’. As Minimalism bases its assumptions on the competence of an ideal speaker/listener, there is a tendency to dismiss the importance the divergence between competence and performance within the program as well. Others, however, have started with performance and worked the other way, coming up with radically different analyses. Usually labeled ‘usage-based’ or ‘connectionist’ theories, their processing-based approach has led to considerably more substantive attacks on analyzing recursion as a UG problem.

Looking to find an explanation outside of formal generative grammar for the acquisition of recursion, connectionism approaches the problem from a completely different tack. Minimalism partly tries to account for an infinite number of sentences due to the recursive devices inherent in the program, seeing the problem as one of explaining the ideal speaker's *competence*. Since any sentence can be lengthened by simply adding 'She thought that...' there can be no theoretical limit. From the point of view of connectionism, this is effectively putting the cart before the horse. Christiansen and Chater (1999) instead try to explain recursion by examining *performance*, "without assuming the existence of a mentally represented competence grammar allowing unbounded recursion." One of the difficulties for a competence-based grammar which accounts for recursion is that if it licenses one level of recursion, then it should allow two, three and more levels of recursion. This allows sentences which could 'never be uttered or understood.' This is abundantly clear when illustrated by center-embedded object relative clauses, a type of nested-dependency (deVries, Christiansen & Petersson (2011) discuss similar examples in German, as well as crossed-dependencies in Dutch; Schlesinger (1975) also emphasizes the difficulty of processing center-embedding):

1. The cat killed the rat.
2. The cat the man kicked killed the rat.
3. ?The cat the man the woman kissed kicked killed the rat.
4. ??The cat the man the woman the child hugged kissed kicked killed the rat.

For this to be considered conclusive evidence that this type of recursion is not integral to a speaker's competence, however, this can only be done "when 'competence' is

interpreted as pertaining to knowledge which is in principle retrievable in full” (Schlesinger, 1975). This type of difficulty does not arise with subject relative clauses, “since a single pointer can be held in memory to show where to pick up the original procedure,” according to Corballis (2007). Consider the example:

5. The cat that bit the man that kissed the woman that hugged the child killed the rat.

Here memory must retain only one pointer (the cat) throughout, as all the others are resolved immediately.

Church and Patil (1982) noted this ambiguity of interpretation as well and attempted to resolve it through combinatorial mathematics’ Catalan numbers, which emphasize the exponential increase in ambiguity which accompanies increasing numbers of embedded phrases. “The block in the box on the table,” in their example already presents considerable ambiguity; by adding “in the kitchen,” the available attachment points are upped considerably.

Despite the difficulty of interpreting sentences such as 3 and 4, according to Christiansen & Chater (1999), “Chomsky used the existence of center-embedded constructions to argue that natural language must be at least context-free.” Their difficulty, however, is usually put down to performance limitations/extrinsic factors which hide the true unbounded competence of the speaker. Christiansen & Chater instead propose that the real reason impeding interpretation of complex embedding lies in ‘intrinsic constraints’ which are found in Elman’s (1990) Simple Recurrent Network (SRN). In this model, both *Input* and *Context* interact as they feed into the *Hidden Unit*, a type of processor. This has a ‘*Copy Back*’ function which feeds back into *Context* again; this itself is a type of recursive function with no specified limit on how many times copy back may occur. The

Hidden Unit also interfaces with *Output*, what the speaker produces. There is yet another level of recursive activity in that the Output passes through what's called a *Stochastic Selection Process* (SSN) wherein information is 'chosen' and fed back into the Input level. Christiansen & Chater demonstrated the process using an artificial grammar, and found that "an SRN can be trained to process recursive structures with similar performance limitations regarding depth of recursion as found in human language processing," (Christiansen & Chater, 1999), thus demonstrating the model's practical application.

Processing is also central to Truscott and Sharwood-Smith's (2004) proposal for syntactic acquisition. Their 'Acquisition by Processing theory' (APT) "seeks to explain linguistic development as much as possible in terms of on-line processing, without reference to mechanisms existing specifically for the purpose of acquisition," (Truscott & Sharwood-Smith, 2004). Essentially competency-based (unlike the SRN above), it focuses on a modular view of mind and language which is constrained by UG yet does not have a role for an age-constrained language acquisition device (LAD). As such, it applies to both L1 and L2 equally, and "differences may be explained by the presence of a second set of linguistic items co-existing with and competing with the first ... plus the much richer metalinguistic (extra-modular) knowledge that typically accompanies SLA," (Truscott & Sharwood-Smith, 2004).

Roeper (2004) compares APT to his own theory (1999) of L2 Multiple Grammars, which effectively shares the premise that language conflict boosts computational demands. Unlike APT, however, Multiple Grammars facilitates identifying when and where recursion may be activated in a language (through the presence of the LAD). Citing an

example from German, which permits recursive modals, Roeper points out how questions of dominance arise as Merge operates that are crucial to the appropriate selection of recursive grammatical structures and which would be difficult to answer without access to language-specific grammars.

Furthermore, other difficulties arise if we try to eliminate recursion from UG. Compound nouns in English provide an example. In these, only the last noun describes the object; the preceding ones continually specify what type it is. Yet this option is only open to bare nouns; neither determiner + noun nor adjective + noun combinations allow recursion to take place:

6. The Spanish group video culture project.
7. *The Spanish the group the video the culture the project.
8. *The fluent Spanish small group hi-def video popular culture fun project.

(Roeper, 2007)

The meaning here is not really the problem, and when given right-branching structures, acceptable recursion ensues:

9. The fun project on popular culture in hi-def video by small groups of fluent Spaniards.

Thus, it must be a language-specific grammar, not a processing module, which impedes this.

A usage-based theory of language acquisition (Tomasello, *Constructing a Language: a Usage-Based Theory of Language Acquisition*, 2003) has also been used to account for recursion (see also Christiansen & MacDonald (2009)). This has more in common with

connectionism, and in fact could be considered somewhat of an evolution/extension of Christiansen & Chater's earlier (1999) account. Pure formalist, generative approaches to language acquisition of syntactical abstractions (such as recursion) are unsatisfying, Tomasello argues, "because they have not yet solved the problem of cross-linguistic variability and developmental change" (see also Mithun, 2010, above). It follows that a usage-based approach concentrates more on performance rather than competence, since Tomasello argues that the only true measure of acquisition of 'abstract linguistic representations' can be found in the appearance of acquired structure *s* in new contexts, either in spontaneous speech or controlled experiments.

The core of the approach is that children build up these abstractions gradually, including recursion, which arises as an "acquired skill" constrained by "interactions between linguistic experience and intrinsic constraints on learning and processing," (Christiansen & MacDonald, 2009). Elman's Simple Recurrent Network is carried over effectively unchanged from Christiansen & Chater's connectionist approach (1999), which "does not have a built-in ability for recursion, but instead it develops ... processing of different recursive constructions through exposure to repeated instances of such constructions in the input," (Christiansen & MacDonald, A usage-based approach to recursion in sentence processing, 2009). The interactions described explain the problem of 'excess recursive capacity' arising in the generative UG-based approach.

In experiments with college students, not children, involving word prediction and a type of continuous grammaticality judgment, the model successfully predicted acceptability across a variety of recursive structures (right-branching, center-embedding, etc.), leading to the conclusion that, "the ability to use specific constructions recursively is acquired in

an item-based manner... [and suggests] that recursion is unlikely to be a key factor in language evolution,” (Christiansen & MacDonald, 2009).

Nonetheless, Chomsky dismisses these approaches to language acquisition as “dramatic failures when they address questions about the nature of language” (Chomsky, 2013, p. 34).

2.3.3 Recursion is not a universal phenomenon

In what came to be perhaps the most widely-known rebuttal to recursion’s preeminence in linguistic theory was Everett (2005). Commenting on the article, Berlin (2005) believes that “his paper [is] one of the most controversial to be published in anthropological linguistics in many years” (p.635). This is due to what can only be described as an assault on commonly held linguistic universals. As regards linguistic universals, Chomsky stated, “[t]he strongest possible proof of the inadequacy of a linguistic theory is to show that it literally cannot apply to some natural language” (Chomsky, 1957, p. 34). This naturally attracts pursuit of the investigation of aspects of language claimed to be linguistic universals. Daniel Everett’s work with Pirahã, the sole remnant of the Mura language family, purports to shatter the very notion of various linguistic universals, among them recursion. While Everett’s (2005) claims concerning recursion may be what have thrown his work into the spotlight, and what make it especially pertinent to the present discussion, isolating this review of his claims to those centering on recursion would be inadequate. This is due to the far-reaching claims made for Pirahã beyond recursion, in various different areas, which together Everett claims force a complete revision of the accepted “design features of human language” (p. 622). Given that these claims are based on one language in which Everett is effectively the sole

scholar, it is worthwhile to review the data presented. Inherent in his proposal is that since he found so many breakthrough differences with Pirahã that their sheer bulk shattered various linguistic edifices. Though the interest here focuses on recursion, it is worthwhile to discern whether Everett's analysis holds up not only for recursion but as the unified assault that it is presented as. Thus, touching on each of the claims as part of a unified review of Everett 2005 would be a more effective manner to critique its relevance and import to the discussion of linguistic universals in general and recursion's place in them more specifically.

Everett's thesis is a twist on neo-Whorfianism, the proposal that language shapes thought and culture. While the strongest form of the (Sapir-) Whorf hypothesis is largely discredited by modern linguistics (Pinker, 1994), it does still find a minority of adherents (for example, Boroditsky (2011)). What Everett proposes reverses the direction of causality of the hypothesis, namely that culture, in fact, has the capacity to shape language; specifically, that "Pirahã culture severely constrains Pirahã grammar in several ways, producing an array of otherwise inexplicable 'gaps' in Pirahã morphosyntax." The consequences for Chomsky's UG, states Everett, are "severe—some of the components of so-called core grammar are subject to cultural constraints, something that is predicted not to occur by the universal-grammar model" (p. 622).

Everett finds so many absolutes in Pirahã that would seem to run counter to what are considered linguistic universals that the claims merit close attention. It as if a language had erupted from the soil without myriad properties considered core to human languages, as if we found a plant or animal that had not evolved according to natural selection.

According to Everett, Pirahã:

- is the only language without number, numerals, or a concept of counting.
- lacks quantifiers such as “all,” “each,” “every,” “most,” and “some.”
- is the only language without color terms.
- has the simplest pronoun inventory (which may have been borrowed to begin with).
- is the only language without embedding (i.e., recursion).
- has no power of abstraction.
- has no perfective aspect.

All of these are brought about by the constraints that culture can place on language, according to Everett. If all of these characteristics except for recursion were found to be valid breakthrough discoveries for natural human languages, Everett would have a much more solid footing from which to defend his stance regarding recursion. However, as various difficulties can be found with most of the claims in Everett (2005), it would be beneficial to give several of them a brief overview to better assess and evaluate the overall strength of the argument. As for numbers, Franz Boas² had already made the point that many languages did not exceed two or three, but that “as soon as these same people acquire standards of value that have to be counted, they adopt with perfect ease higher numerals from other languages and develop a more or less perfect system of counting,” (Boas, 1911, p. 55). Wierzbicka (2005) thoroughly rebuts the claims concerning quantifiers by noting that the avoidance of polysemy in Everett’s discussion discards “a basic tool in semantic analysis, and rejecting it altogether leads to ludicrous results...” (2005, p. 641). The claims concerning Pirahã’s lack of “color quantification” had been

² Curiously, Everett prefaces his article with a quote from the very same source (Boas, 1911) which provides much of the evidence that this is not new.

raised and subsequently razed by Harold Conklin (1955) half a century earlier, whose warning that “the study of isolated and assumed translations in other languages can lead only to confusion” (1955, p.190) seems especially relevant. And refutation of the supposed lack of abstraction can again be found in work decades’ old. While discussing the supposed lack of a general term for ‘washing’ in Cherokee, Archibald Hill (1952) pointed out how “[m]ost modern linguists who have experience of preliterate languages would reject the idea of the...over-particularity of primitive speech” and bemoaned the fact that “there are many who still hold such views; namely that primitive tongues...*fail to generalize*, and are almost exclusively concrete” (1952, p.172, italics mine).

2.3.3.1 Embedding and recursion in Pirahã

While Everett speculates that “the absence of clear evidence for embedding” is perhaps Pirahã’s most curious aspect, he does not claim, nor provide evidence, that Pirahã *cannot* allow embedding.

Everett first compares Pirahã to standard English embedded structures using ‘say’ or ‘think,’ such as ‘I think that we should leave’ or ‘I said he was tall.’ Pirahã conflates these two verbs into one morpheme, *gái*; furthermore, this morpheme is always nominalized (with *-sai*) and never inflected. What he calls the complement clause is “interpreted as the content of what was said but not obviously involving embedding” (p.629). He continues that other types of (English-equivalent) complements nominalize “one of the clauses”:

10. ti	gía	-sai	kó’óí	hi	kaháp	-íí
I	say	-nomin.	name	he	leave	-intention
I said that Kó’óí intends to leave.				=	My saying Kó’íí intend-leaves.	

11. hi	ob	-áa'ái	kahai	kai	-sai
he	see	-attractive	arrow	make	-nominative

He knows how to make arrows well. = He sees attractively arrow-making.

(Everett, 2005, p. 629)

One thing that stands out on comparing these two examples is how the nominalization switches from the matrix clause (10) to the ‘complement clause’ (11). No explanation is offered as to why this is permitted, or if some variation is allowed—either way, it would seem pertinent information. Everett claims that ‘say’ (*gái*) is always nominalized in Pirahã, thereby obtaining (10). With (11), however, the complement verb is nominalized and conjoined with the clause headed by the morpheme for ‘know’—effectively creating a reversal from (10). Everett claims that this “analysis seems to fit the general grammar of Pirahã better” because the nominalized form should precede the verb if it is to be the object (not the case in (11)). Yet this description would seem to apply to (10), as well, putting nominalized “say” (*gái-sai*) as the direct object of the “embedded” verb, instead of as glossed; it is unclear if Everett’s direct object description could apply.

In any case, lack of syntactic subordination alone should not suggest evidence of a new type of human language. Givón (1979) points out how there are some surviving languages “—all in preindustrial, illiterate societies with relatively small, homogeneous social units—where one could demonstrate that subordination does not really exist” (p. 298). The phylogenetic growth of human language involves ‘loose coordination’ giving way to ‘tight subordination’ (p. 305). McWhorter (2001) lists 19 languages which do not display “syntactic asymmetries between matrix and subordinate clauses” (p. 163), and may thus also not display embedding of the type discussed by Everett.

Instead of trying to tease out embedding from his corpus of Pirahã speech, Everett might have solicited some more direct examples to see if they are simply possible. One can ask a series of questions such as the following:

12. What do you think about x?

13. What do you think he thinks about x?

14. What do you think he thinks she thinks about x?

‘Think’ is the same morpheme as ‘say’ in Pirahã, and so is always nominalized. Thus if this were possible it would create a series of embedded nominals.

Chomsky himself, in discussing Pirahã, dismisses its relevance to work on UG: “[n]o one has proposed that languages must have subordinate clauses, number words, etc. Many structures of our language (and presumably that of the Pirahã) are rarely if ever used in ordinary speech because of extrinsic constraints” (Chomsky, 2006), effectively dismissing the relevance of performance data to fine-tuning linguistic theory.

2.3.3.2 Pirahã Summary

Everett (2005) claims in his closing response section that his central point is that living languages show us that languages evolve (a point that is not necessarily under attack in the linguistic community) and that “hypotheses such as universal grammar are inadequate to account for the Pirahã facts because they assume that language evolution has ceased to be shaped by the social life of the species,” (p. 642); however, that seems a fundamental misrepresentation of what universal grammar (UG) purports to do. If indeed UG involves “a restrictive and rich hypothesis concerning the universal properties that determine the form of language...” (Chomsky, 1965:35) then in fact the properties shared

by all languages which can then be set aside in the study of their discrete grammars. It makes no attempt to minimize the contribution of ‘social life’ or culture to the development and evolution of language. However, the distinction created in Hauser et al (2002) between the FLB and FLN may bear some relevance to Everett’s point. The properties Everett discusses very well may fall into the other components of the LAD/FLB while not encroaching on the FLN.

An explanation for the nature of Pirahã grammar may possibly be found in the suggestion of Levinson (2005), who raises the possibility of Pirahã potentially being a creolized version of a proto-Mura language, due to both its unknown origin and regional history. In *The world’s simplest grammars are creole grammars* (2001), McWhorter posits that older natural languages tend to be over-specified in regards to what UG demands. For every language that overtly marks perfectivity (to use one of the argument points of Everett), for example, “there are several others that neither have the same marking nor any equivalent mechanism” (p. 161).

Perhaps the most telling aspect of Everett 2005 is his overt lack of emotional and professional distance from his subjects. After having spent thirty-some-odd years with them, it is understandable that a certain bond will have developed; however, it is not apparent that this need be on display in order to convey the scientific points desired. Thus, when one reads that the “Pirahã are some of the brightest, pleasantest, most fun-loving people that [he] know[s]” who enjoy playing jokes on him, though “always good-naturedly” (p. 621). and that “the beautiful language and culture, fundamentally different from anything the Western world has produced, have much to teach us about linguistic theory, about culture, about human nature, about living for each day and letting the future

take care of itself, about personal fortitude, toughness, love, and many other values too numerous to mention here” (p. 634), one cannot help but agree with Levinson’s (2005), observation that Everett “surely has some obligation to have presented a more balanced picture throughout” (p. 638).

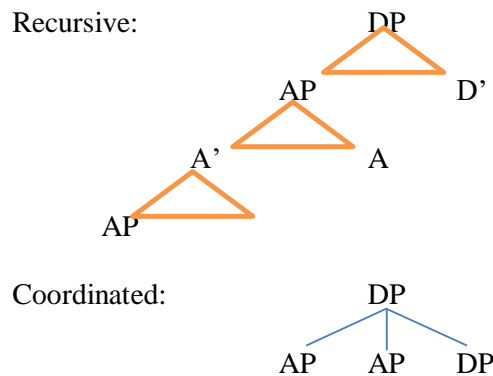
Nonetheless, regardless of any issues with Everett’s study, others have concurred with his conclusions. Sakel and Stapert (2010) claim that the studied Pirahã structures “have shown no evidence of being syntactically recursive” (p.13), and that even more syntactically complex languages (such as English) often prefer non-recursive structures, although they have recursion as an alternative. Furthermore, they assert that, being an oral language only, Pirahã has “no apparent functional need for recursion” (2010, p.13), partly due to its esoteric use within the community and limited use outside. They take their position to an extreme, however, by citing the suggestion of Wray & Grace (2007) that, in fact, “rule-based grammar is a cultural add-on” (echoing Everett’s suggestion) whose complexity evolves in tandem with the need to use it—quite a distance, theoretically speaking, from the core of UG theory as typically understood.

Tomasello (2005), a staunch advocate of the recursion-via-processing school (see processing, above), argues as much against UG as for “the particularities of the case Everett presents” (2005:640). Therefore, his objection lies in the fact that, in “universal grammar analyses, the most common practice is to invoke universal grammar without specifying precisely what is intended, as if we all knew what it was.” Consequently, UG “was a good try...but...we have learned a lot about many different languages, and they do not fit one universal cookie cutter.”

Of course, there is much of value to be noted in Everett (2005), and much which the cautious investigator will find worthy of attention. As a highly endangered language (some 150 speakers at the time of Everett's study), its extinction sadly seems all but assured in the near future—documentation and research on it would seem absolutely essential, from a purely scientific standpoint. Furthermore, to better settle the issues raised here, a comprehensive ethnography of speech and psychology, as Pawley (2005) stresses, is sorely needed. Surrallés (2005) as well emphasizes how these are lacking, along with “descriptions of other scholars working among the Pirahã...to convince us that his theses are not the result of a personal bias in his data gathering, given that he offers only his own data as evidence” (p. 640).

2.4 Acquisition

Before the claims of Hauser et al (2002) regarding recursion's centrality to human language empirical studies of recursion's role in language acquisition were scant. Matthei (1982) studied children's interpretations of recursively embedded adjective phrases and found that these did not follow those of adults. Asked to choose “the second green ball” children preferred the second ball, which was the first green one, in a series of five; adults chose the second green one regardless of its overall position in the series. Children effectively interpreted “second (and green) ball,” where green becomes a non-restrictive modifier which merely lends additional information in a conjunctive function. The underlying difference in these interpretations could be represented as follows:



2. Recursive vs coordinated adjectives

Langendoen, McDaniel & Langsam (1989) conducted a pair of pilot studies specifically targeting locative PPs. Through directed drawing tasks, they were able to determine preferences in teenaged speakers for recursive attachment, where each PP attached to the DP immediately preceding it and not the head DP, versus other types. They found that the teenagers drew recursive (they use “alternating”) relationships 54% of the time (64% of coded responses) while 18% (22% coded) used coordination, attaching both PPs to the head DP.

The follow-up study also brought to light some interesting aspects by increasing the number of PPs used to four from two. Not only did the tendency towards recursive interpretations strengthen in succeeding PPs, but also the tendency to use a consistent interpretation throughout the entire phrase. Thus, if someone started with recursion they were more likely to continue with that choice throughout, but if someone started with coordination, they were also more likely to continue down that path throughout. Those who shifted their interpretations mid-stream were far more likely to shift to recursion than to any other type of interpretation.

Gentile (2000) tested whether similar interpretational challenges befell children acquiring recursion in the English genitive 's structure: *Paul's father's bike*. She emphasizes that different recursive structures are available in different grammars for possessives: English 's is leftward-building, Spanish prepositional phrases (used for marking possession) are rightward-building; German allows the latter but also the former with proper names. Thus a child is presented with a learnability issue, because she “would not be able to determine what type of syntax her language has by simply hearing an example of the leftward-building construction like English's *Ana's school*, because that structure might be limited...[she] would need to have a third option in possessive structure...” (Gentile, 2000). These constraints would minimally allow rightward-branching possessives (obtained in all); leftward-branching may be permitted, as in English, and lexically determined exceptions, as in German.

Gentile found that children, in fact, gave recursive interpretations of conjoined possessive structures the majority of the time. Furthermore, she found that the youngest subjects (3-4 years old) had fewer recursive responses than the oldest ones (5 years old); this difference was attributed to a potentially lower attention span for the younger subjects. She further observes that apparently leftward-building possessive recursion appears to take shape in grammars while leftward-building adjectival recursion is still causing confusion; consequently, it would be logical to conclude that “all types of recursion are not acquired at the same time” (p.29).

These facts lead Gentile to propose that “[e]xposure to recursion is required for a fully productive, recursive rule to appear” (2000).

Examining first the question of acquisition from the perspective of UG, if recursion is an inherent (or *the* inherent (Hauser et al, 2002)) component of UG, then it must be evidenced in child language acquisition. Looking at the fundamental, universal aspect of recursion, the child has a breakthrough when, shortly after beginning to produce two-word utterances, she then grows these to multi-word sentences (Roeper, 2007). This demonstration of Merge is universal, but other instances of recursion are language-specific and must be learned by each speaker. English, as noted, demonstrates recursion in left-branching genitives with the Anglo-Saxon “‘s”; Spanish (and other languages) disallows this type, but permits right-branching genitives in the form of prepositional phrases. Recursive English forms resist instruction and cause initial confusion in young speakers (Roeper, 2007) as well as in fluent adult second language learners. If all get Merge without resistance, then these language-specific forms must have a different explanation, whether through some type of maturational constraints, an acquisition triggered by input, or something else. In this form, recursion may reflect the Principles and Parameters approach.

From a formalist, generative standpoint, the language-specific types of recursion can be classified into several types, Direct and Indirect being two of the principal forms. Direct recursion, where a syntactic object can be defined in terms of itself, has been put forth as the Acquisition Default:

15. A child first analyzes adjacent identical structures as Direct Recursion with a Conjunctive reading. (Roeper, 2011)

This connects directly to the coordination formulated by O’Grady (1997) for describing child language acquisition of embedded clauses, who states that “elements of the same

category type can be combined to form a coordinate structure of that type” (p.125).

O’Grady states that the LAD “masters the syntax of multiclausal sentences over a period of several years” (1997:127).

Roeper’s experiments with recursive possessives found similar interpretations to those of Gentile, though with a smaller percentage of conjunctive readings. The proposal in 15, however, does not preclude the logical problem of language acquisition, which asks how a child is able to acquire a structure present in the input and apply it to novel structures wherein she has never heard it before.

Working with experiments using an artificial grammar, Poletiek (2011) claims that staged-input was essential in facilitating the acquisition of recursive structures. Although this was tested on adult university students, Poletiek suggests the acquisition path for children is similar, since, “linguistic utterances children are exposed to are simpler, shorter, and contain more frequent constructions than adult language. Only later on is the system to be induced by the natural learner hierarchical and recursive — not linear.”

Trueswell, Sekerina, Hill & Logrip (1999) examined the acquisition of argument vs adjunct PPs in ambiguous situations and found that children encountered greater difficulties than adults in appropriately processing information. They suggest that access to a Referential Principle, which guides interpretation decisions when ambiguity must be resolved, is impeded in five-year-old children, making them “unable to employ it in certain processing conditions” (p125).

Kidd & Bavin (2007) measured PP-final attachment ambiguity as well, through the lenses of semantics and referential cues, finding that while adults use the definiteness of NP

objects to help in resolving ambiguities, children were not able to use this information in a similar fashion. Consequently, PP attachment interpretation was less consistently recursive in children than in adults. They claim that their data are consistent with a constraint-based model of parsing “since strong constraints that have high cue reliability will be more strongly relied upon than weaker constraints” (p.46). This model argues that children “forge parsing preferences by accumulating probabilistic cues to interpretation that vary in strength” (p. 46).

Both right-branching and left-branching ambiguity questions have also been tackled from the processing perspective. Christiansen and MacDonald (2009) used grammaticality judgment tasks first with multiple PPs, where they found that complex DPs containing one or two PPs showed little variation in their acceptability; the addition of the third PP significantly worsened their perceived grammaticality.

Following up on Gentile’s work with possessives, Christiansen & MacDonald also studied multiple-embedding with the English genitive ‘s. Their study showed again that acceptability sank while level of embedding increased, and again the significant jump came with the third-level of embedding. Perhaps more interestingly, though, was the observation that the possessives experiment triggered twice as many ungrammatical ratings as the PP experiment; this would seem to build on Gentile’s observation that different types of recursion are acquired at different times or rates by suggesting that different types of recursion receive different rates of acceptability, regardless of the fact that they are technically equally grammatical.

Neither of their tests, however, provided any insight into how the subjects interpreted the sentences, so there is no way to know whether a phrase rated as grammatical was understood to behave recursively or conjunctively. As such, they provide limited insight into whether the challenge to processing comes from a recursive interpretation or a lack thereof.

Christiansen & MacDonald ran the same test with two different types of center-embedded VPs. While the rejection rate here was much higher than with the previous experiments, the common denominator was the third VP, which was rejected far more often than two VPs were. Together these would seem to suggest that a certain threshold is reached with the third level of embedding regardless of the type of structure involved; this is likely due to the extremely low frequency with which three-level embedding appears. Although C and M conclude that this helps to substantiate the usage-based perspective on recursion discussed above, in fact these data do not necessarily contradict UG-based perspectives.

Terunama and Nakato-Miyashita (2013) found a parallel effect in the level of embedding studying recursive possessives in Japanese. Nearly all children aged 3-6 grasped one-level possessives in an adult-like manner, yet when they had nearly adult use of second-level recursive possessives, they still struggled to produce third-level recursion and beyond. Once they could produce third-level, however, fourth-level appeared at the same time, leading them to propose three stages in this particular acquisition path:

16. Stage 1: One-level possessives

17. Stage 2: Two-level possessives

18. Stage 3: >2 possessives

Although these results overlap with those of Christiansen and MacDonald, the conclusion here adapted current transformational schema. Terunama and Nakato-Miyashita suggest a substitution account wherein DPs substitute for NPs (allowing recursive possessives) in stages and not all at once thanks to a licensing mechanism.

Pérez-Leroux, Castilla, Bejar & Massam (2012) followed up on some of these questions in children's acquisition as well, studying both level of embedding and differentiating between English left-branching possessives and right-branching PPs. Regarding the possessives, they observed that "producing coordinated nominals is easy...but...recursive complex nominals are difficult" (p. 459) and attributed this potentially to coordination's "simpler semantics" when compared to recursion, in keeping with Minimal Attachment. Furthermore, the existence of different stages of acquisition were observed in that, whereas some children could only manage single-level NP embedding but others, "mostly older" succeeded in producing second-level structures. Yet they also observed different recursive abilities between NPs in possessive phrases and PPs, which were much more available to produce, leading them to conclude that "genitive recursion is harder than PP recursion" (Pérez-Leroux, Castilla, Bejar, & Massam, 2012, p. 7).

Maia, França, Gesualdi, Lage & Oliveira (2013) tackle the contrast between the ease of coordination and the relative difficulty of recursion directly in a study of the processing of adpositional phrases in both Karaja (postpositional) and Brazilian Portuguese (prepositional) by L1 speakers of both and L1 speakers of Karaja in Portuguese. They observed that "recursive PP constructions were more difficult to process than coordination PP and NP constructions" with all three groups of speakers. Furthermore, third-level embedding of PPs was found to be significantly more challenging than

second-level, concurring with data cited above suggesting a fundamentally different challenge beyond two levels of recursion. The ‘licensing mechanism’ of Terunama and Nakato-Miyashita here becomes ‘the recursive algorithm,’ which, once “engaged” facilitates subsequent embedding.

Franchetto, Santos & Mehinaku (2013) provide further evidence of substantive differences in recursive operations between nominals/possessives and PPs in Kuikuro, an Amazonian language spoken by 600 people. The apparent difference, however, seems to be in the other direction. They suggest that preliminary data suggest that while nominal/possessive (and left-branching) recursion is productive and unbounded, PP recursion is not found and, in fact, may not exist. Their conclusions were tentative, though, and had yet to be confirmed by further analysis.

As with other aspects of language which differ between languages, recursion’s presence in the input to a child is presumed essential to recursion’s growth (Gentile, 2000, above). Roeper & Snyder (2003) formalize and expand this notion yet more thoroughly in their proposal that “[e]xplicit evidence of recursion, in the form of self-embedded structures, plays a central role in language acquisition” and offer several arguments in support. One is their proposal of the Abstract Clitic Hypothesis (ACH), which offers an explanation for a recursive phenomenon, root-compounding in English, which is disallowed in some languages.

Novel root-compounding appears in a child’s speech at the same point as V-NP-particle constructions (*lift the box up*), which systematically appear in root-compounding languages. The ACH (following Keyser and Roeper 1992) proposes that the modifying

root in a compound (such as *coffee* in *coffee cup*) is generated in a right-branching structure from the root *cup*, and located in the Abstract Clitic Position (ACP), but which after derivation has moved to a left-branching node. The trace left behind can be deleted, and the ACP process can thereafter be repeated.

The potential for the ACP is demonstrated in Swedish as well, while the grammar of French, a language without “novel, endocentric root compounds” has no ACP. This cross-linguistic variation suggests that languages can be divided into those that “permit the ACP as a complement to a lexical category” and those that do not.

Limbach and Adone (2011) found differences in rates of interpretation of conjunctive and recursive structures among child and adult native speakers (NS) and non-native (NNS) German-speaking adults in Germany. Recursive English possessives (John’s brother’s car) are ungrammatical in German. Adult NSs had the highest rates of recursion and the lowest rates of conjunction; young NS and NNS had similar and lower rates of recursion, although differing significantly in their rates of conjunction. Limbach & Adone suggest that NNS difficulties may be due to processing or structural differences between L1 and L2.

Roeper (2011) proposes that all adult grammars may in fact be “unfinished” forms of acquisition striving towards a goal that is by its very nature unattainable. This inability to achieve the ‘perfect’ grammar results in displacement with the result that the syntax/semantics interface is inexact. According to this model, input alone cannot create appropriate, language-specific recursive operations; the LAD instead strives for this “perfection” in the grammar that remains ever elusive.

Roeper also suggests an innovative way to address the evolution of the acquisition path to recursion. The first step is to merge high at the root, which would favor conjunction over recursion initially. The next step is the creation of an “operator”. This operator is likely to engage the same theoretical framework as Terunama and Nakato-Miyashita’s ‘licensing mechanism’ and Maia’s recursive algorithm. With this operator in hand, so to speak, one can “assign local scope,” which, in this case, allows the head of a PP to attach to the immediately preceding NP (the most local NP).

More recent work (Roeper & Oseki, to appear) has suggested a modification to the proposal of an acquisition path stretching from Direct to Indirect recursion (Roeper, 2011). Building on Chomsky’s (2013) Feature-sharing, their idea contains effectively an intermediate step on this path: Direct Structured Recursion. As this relates more closely to the grammar laid out in the next chapter, a fuller exposition of this proposal will be handled there.

Roeper & Oseki (2013) also propose “finer-grained levels of recursion” with the potential to influence Labelling theory.

19. Variation of recursion
 - a. Lexically-specific recursion
 - b. Semantically-specific recursion
 - c. Categorically-specific recursion
 - d. Syntactically-specific recursion

(Roeper & Oseki, to appear, p. 4)

They continue that “each specific formal representation of recursion should be induced in a ‘bottom-up’ way from the lexical level to the syntactic level. In other words, children generalize recursion from concrete lexical items (e.g. *in*), through their meaning (e.g. Locative) and category (e.g. PP) and possibly to an abstract syntactic schema (e.g. XP).”

Specifying the nature of recursion in this fashion may prove to be extremely useful, as it helps provide initial guidance for explaining discreet variation in recursion across items.

2.5 Recursion and SLA

While many aspects of linguistic theory have been incorporated into the field of Second Language Acquisition (SLA), viewing recursion through the lens of SLA will require the extrapolation and combination of the main tenets involved in both due to there being little extant work explicitly linking the two. Thus, the interplay of UG access, the Critical Period Hypothesis (CPH), L1 transfer, and the logical problem of (second) language acquisition must be analyzed.

The essence of the CPH claims that there is a limited developmental stage for humans during which it is possible to acquire one's native tongue; beyond this, the potential for full language acquisition declines. The argument in favor of the existence of a CP in L1 derives from the mercifully rare cases wherein a child (such as Genie) is deprived of input of any sort and as a result is unable to demonstrate nativelike performance in any language. The exact nature and specific age of the CP is debated, however; in fact it has been suggested that "there may be multiple CPs for linguistic competence, perhaps with different timings, or the some components (modules) of linguistic competence may be subject to CPs whereas others are not" (Eubank & Gregg, 1999, p. 74). Recursive abilities may very well be a specific competence restrained by a CP, as Eubank and Gregg also noted how Genie "never was able to produce an embedded sentence" (1999). Furthermore, the specific boundaries of the period are hotly debated, as evidence can often be contradictory (Schachter, *Maturation and the Issue of Universal Grammar in Second Language Acquisition*, 1996).

As far as whether critical periods and their presumed extinction affect acquisition in L2, the question can be looked at from different perspectives. Unlike Genie, normal L2 speakers received L1 input during the CP and thus “they do not respond to L2 input as Genie...did to L1 input” (Eubank & Gregg, 1999), obviating the question. This point of view neglects to account for linguistic differences, however, as discussed above in Roeper and Snyder (2003). On the other hand, adult speakers almost universally fail to become native-like speakers of a target language, so “one could argue that there must be a CP that affects L2 competence” (Eubank and Gregg 1999). Indeed, Hyltenstam and Abrahamsson (2003), among others (Long, 1990), have posited that what they refer to as ‘maturational constraints’ are the default hypothesis in SLA, while also recognizing the role other factors (social, psychological) have as well. The implications for acquisition of recursive structures, therefore, would be that nativelike attainment of recursion may never happen in L2; this would seem to be especially true with recursive L2 structures not present in L1.

Related to the CPH, the question of UG access in SLA comprises a range of possibilities. At one end of the spectrum, there is considered to be no access after L1, with a CP closing off that form of acquisition. Clahsen and Muysken (1986) instead argue that adults use general problem-solving abilities to formulate rules. As these rules do not follow standard constraints laid out by UG, it would follow that UG is not being accessed in order to formulate them. Bley-Vroman (1989) formalizes the strongest position of the no-access scenario with the Fundamental Difference Hypothesis (FDH); more recently, Montrul (2009) has found evidence which she claims offers support for the FDH. The development of recursion in an L2 adult will be constrained by three inherent differences

from L1. Firstly, the internal cognitive state of adults is different from that of children, and as such recursion would be perceived differently, regardless of any external event. Also, the specific language faculty has changed due to the growth of L1; potential recursive operations have been established. Finally, the FDH proposes that the LAD has closed off in adults—the development of new recursive structures cannot rely on any language-specific developmental organism. Instead, the L2 speaker

will expect that the foreign language will have a syntax, a semantics, a lexicon which recognizes parts of speech, a morphology which provides systematic ways of modifying the shapes of words, a phonology which provides a finite set of phonemes, and syllables, feet, phonological phrases, etc.

(Bley-Vroman, 1989)

Additionally, L2 speakers will have an (subconscious) awareness of L1 recursive constraints, which can thereby be used as an inherent part in the formulation of L2 recursion, along with general problem-solving abilities. Thus, if recursion were the essential human element to UG, recursion in the L2 speaker would arise through non-language specific strategies. Nonetheless, even Bley-Vroman (1989) recognizes that “language is not merely difficult to learn with only general cognitive strategies, it is virtually impossible.”

At the other end of the spectrum, all principles and parameters that may be inherent in UG remain as available in L2 as in L1. In this view, the relevance of the CPH to L2 acquisition is negligible as long as UG has been activated by normal L1 input; instead, one would “expect to find evidence that indicates that the L2 learner solves certain aspects of the L2 acquisition problem in a manner comparable to that of a child L1 learner” (Flynn, 1996). This ‘parameter-setting approach’ thereby would dictate the

nature of recursive constraints in an interlanguage grammar, which, perhaps aided by 'general cognitive strategies,' would develop very much as L1 recursive constraints would. If the recursion permitted any human language is indeed a parameter, then matching parameters in L1 and L2 facilitate acquisition while a mismatch disrupts it (Flynn, 1989).

This Full Access scenario, however, encounters opposition. Schachter (1989, 1996) points out that, at the very least, the fact that L2 speakers' grammars are usually incomplete and that their phonological production is essentially nonnative; her studies demonstrating lack of L2 sensitivity to the Subjacency principle suggest lack of access to UG. As a result, L2 speakers would not have native access to recursive constraints.

The logical question of SLA as regards recursion must be addressed as well. Schwartz and Sprouse (2000) find a poverty of the stimulus problem in L2 analyzing the L2 German of a Turkish speaker. The interlanguage concerned contains elements which can be explained neither by transfer from L1 nor from input from L2. Furthermore, they point out that these elements, specifically concerning inversion asymmetry in Spec movement, is found in a natural language, French. Taken together, this, they argue, constitutes evidence for the full access standpoint, as UG must be the constraining factor giving rise to the phenomenon.

While the debate over degree of UG access and the extent of L1 transfer has provided a fecund ground for attempting to understand L2 from a theoretical standpoint, some (White, 2000; Belikova & White, 2009) suggest that thinking about the problem from the point of view of the standard dichotomy might be inherently limiting. This is due to "the difficulty of disentangling properties of the L1 grammar from properties of UG" because

we cannot “distinguish empirically between the possibility the UG-like knowledge comes only from the L1 (partial access) and the possibility that it comes directly from UG (full access)” (White, 2000, p.149). Thus the emergence of interlanguage recursive constraints which bear some similarity to L1 constraints (for example, recursive PPs in Spanish and English) cannot be deemed to have happened purely as a case of transfer from L1 without being able to know the degree of involvement of UG.

Processing phenomena and SLA create yet more perspectives to be examined. The Acquisition by Processing Theory (APT) detailed above for L1 by Truscott and Sharwood-Smith (2004) is designed to be carried over into L2. They acknowledge the contradictory nature of the evidence regarding UG access in L2, and account for these differences “may be explained by the presence of a second set of linguistic items co-existing with and competing with the first (see below), plus the much richer metalinguistic (extra-modular) knowledge that typically accompanies SLA” (p.4). Similar to the Fundamental Difference Hypothesis, the APT presumes a core UG-constrained LAD at the core of L1 acquisition; however, it also assumes that “[m]orphosyntactic acquisition occurs within the lexical sub-modules and possibly the interface processors, within the constraints imposed by UG” (p.2). This architecture is used in both the acquisition of L1 and L2. There remains, nonetheless, the problem with the critical period. Repeated exposure in L2 to recursive constructions should be enough to acquire the structure.

Whether or not UG access exists in SLA, and if so, to what extent, is often debated. If recursion functions as a component (or *the* component) of UG, then the role of UG in SLA is relevant here, too. As seen above (Roeper and Snyder, 2005) different languages

permit different recursive structures while disallowing others, suggesting that language needs input of specific types to allow that type to be/stay activated. With continued access to UG, an adult learner would simply need sufficient input of appropriate recursive structures to be able to process them adequately.

If one were to consider a full access/no transfer scenario, then the conditions previously proposed for L1 recursion growth would be carried over. Vigorous presence of recursive structures in the input would enable comprehension and eventually production of similar instances of recursion on the part of the L2 speaker. Similar recursive structures between L1 and L2 would not necessarily convey a processing advantage to the speaker, who would need to relearn the structure in L2.

2.6 Summary

Recursion's role in linguistic theory and first and second language acquisition is still debated and undecided. What started off as a loaner concept from mathematics has grown like an insatiable cancer to consume all of Hauser, Chomsky and Fitch's (2002) FLN, the defining characteristic of human language and UG. While some have questioned its universality (Everett, 2005) and its centrality to UG (Pinker and Jackendoff 2005), others have tackled the phenomenon from the processing perspective. Nearly all of this has thrown much-needed light on a topic that provokes strong disagreement. Furthermore, the body of work studying recursion in acquisition continues to grow as seen in the progress made by Roeper (2011) Roeper & Snyder (2005), Perez Leroux et al and others. As well as its effects on nouns, possessives, and adjectives, recursion's effect on PPs has been investigated. Nonetheless, the field of studying how recursion may affect PPs contains fecund, untilled soil which would benefit from spadework.

CHAPTER 3

A PROPOSED GRAMMAR TO DISTINGUISH INTERPRETATIONS

3.1 Introduction

To tackle the theoretical issues that arise in the studies which follow, a grammar must be laid out which makes explicit the distinctions between the various interpretations involved. The ideas put forth are largely a composition of others' and are noted accordingly.

Throughout, the studies focus on prepositional phrases (PPs); consequently, the grammar which attempts to describe them does as well. As discussed above, earlier studies have investigated various aspects of PP recursion in acquisition. Trueswell et al (1999) investigated PPs in their role as arguments and adjuncts in L1, focusing on PPs attachment to VPs or NPs (see also (Tutunjian & Boland, 2008), among others). Firstly, the present studies bypass the ambiguity inherent in “put the plant on the table in the corner,” wherein ‘on the table’ could be variously interpreted as an argument or adjunct of the VP. Instead, the present study involves “what is perhaps the very simplest problem of preposition-phrase attachment in English: the association of locative PP adjuncts with nouns...” (Langendoen, McDaniel, & Langsam, 1989, p. 534).

Firstly, the relevant structures involving two PPs, which allow for several variations, are described. As further PPs are added, however, the number of available permutations increases exponentially; those discussed here are limited to those containing three PPs and furthermore only to focus on those most directly associated with the present study.

Moreover, as the study concentrates on PP structures identical in English and Spanish, frequently representations will only contain English, for simplicity's sake, with the understanding that the Spanish parallel would be identical for all intents and purposes.

3.2 Overview

The structures involved parallel those of Langendoen et al (1989) as well as Roeper & Oseki so the grammars exploited are also going to be somewhat derivative in order to describe the nature of attachment possibilities they contain. The simplicity referred to, however, belies the ambiguity inherent in DPs such as “the triangle next to the square over the circle,” which produces numerous interpretations. Langendoen et al (1989) illustrate several of these, a number of which are reproduced here (in an adapted format).

The available interpretations are not limited to a binary division between recursion and coordination; an important third option which arises in that study they refer to as ‘stacking,’ which occurs when the last PP attaches to the entire preceding complex NP and not simply either DP independently.

Roeper and Oseki's proposal accommodates this tertiary divide in a revised path to recursive acquisition which starts at Direct Unstructured Recursion (DUR, here coordination/conjunction), passes through Direct Structured Recursion, (DSR, here stacking) on its way to Indirect Recursion (IR, here recursion). This is developed through the use of Minimal Search, which gives rise to Feature Sharing.

Merge typically would apply to form a labeled set:

$$20. \text{Merge } (\alpha, \beta) = \{\gamma, \{\alpha, \beta\}\} \text{ (Roeper \& Oseki, to appear)}$$

γ takes the label of α or β , whichever happens to be the head; this allows for hierarchical structures and permits the operation of recursion (indirect recursion) to take place. This type of labeled Merge, however, does not easily accommodate coordination, wherein XPs attach individually to the subject, which have been “a problem since the early days of the generative enterprise, since they seem to require infinitely many rules to avoid unwanted structure,” (Chomsky, 2013, p. 45). Chomsky here suggests that coordination is instead the result of Pair-Merge, which “can be applied infinitely often, adding individual predications without further structure,” (Chomsky, 2013, p. 45). Importantly, this is not semantically compositional, as the original head remains unaltered except for the series of adjuncts. This coordination is the basis for Roeper & Oseki’s DUR, which results when the operation of Merge is carried out without a labeling algorithm applied:

21. Merge (α, β) = { α, β } (Roeper & Oseki, to appear)

This may happen if both elements to be merged are phrases (e.g. PP, PP) and neither is a head; in this proposal, it remains unlabeled.

A problem arises in that leaving the syntactic object unlabeled is uninterpretable, however, at the sensorimotor interface as the syntactic object created is unidentified. “The solution may lie in the fact that the most prominent feature of α and β is shared,” (Chomsky, 2013, p. 45). Minimal Search then returns this feature F, which becomes the label of the set. This label now projects a further node which is both hierarchical in structure and compositional in semantics, unlike the unlabeled version above. This is the intermediary step of the proposal: DSR.

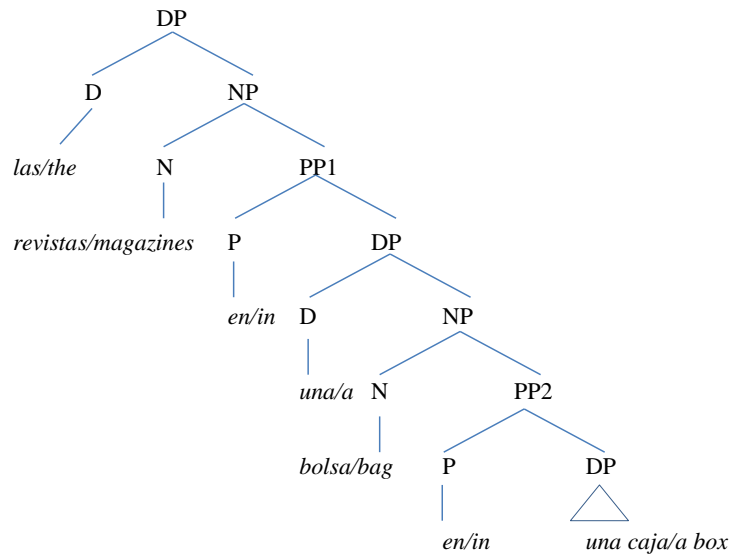
3.3 Recursion in two PPs

Here PPs embed themselves in other PPs by passing through alternating phases, from PP to DP and back again to PP, creating a fully hierarchical structure. In the following examples, each PP serves as the complement of the immediately preceding NP.

22. Las revistas en una bolsa en una caja

23. The magazines in a bag in a box

These phrases can be represented (identically in Spanish and English) by the structure below.



3. Two PP recursion

IR of this nature parallels the description by Roeper & Oseki (to appear), as it is both hierarchical in structure and semantically compositional.

A similar representation may be inferred for another NP containing two PPs:

24. [Un león [al lado de una cebra [debajo de un cocodrilo]]]

25. [A lion [next to a zebra [under a crocodile]]]

The lion and the magazines contain differences, however, to be explored below. Both examples, however, may be captured in a description incorporating phases (thus the *indirect* nature):

26. $XP \rightarrow X YP$

$YP \rightarrow Y XP$

3.4 Coordination in two PPs

The common alternative to IR above is illustrated with complex NPs such as ‘a lion next to a zebra, under a crocodile, over a giraffe, etc.’ Here each PP is predicated of the head NP, in this case, the lion. Structures of this nature “have been a problem since the early days of the generative enterprise, since they seem to require infinitely many rules to avoid unwanted structure,” (Chomsky, 2013).

The same phrases described above in recursion may be given an interpretation wherein both PPs attach to the NP of the phrase.

27. [Las revistas [en una bolsa] [en una caja]]

28. [The magazines [in a bag] [in a box]]

29. [Un león [al lado de una cebra] [debajo de un cocodrilo]]

30. [A lion [next to a zebra] [under a crocodile]]

Following the schema offered by Roeper & Oseki (to appear), this is presented as Direct Unstructured Recursion (DUR), which can be represented as seen in (31):

31. $XP \rightarrow XP XP+$ (Roeper & Oseki, to appear)

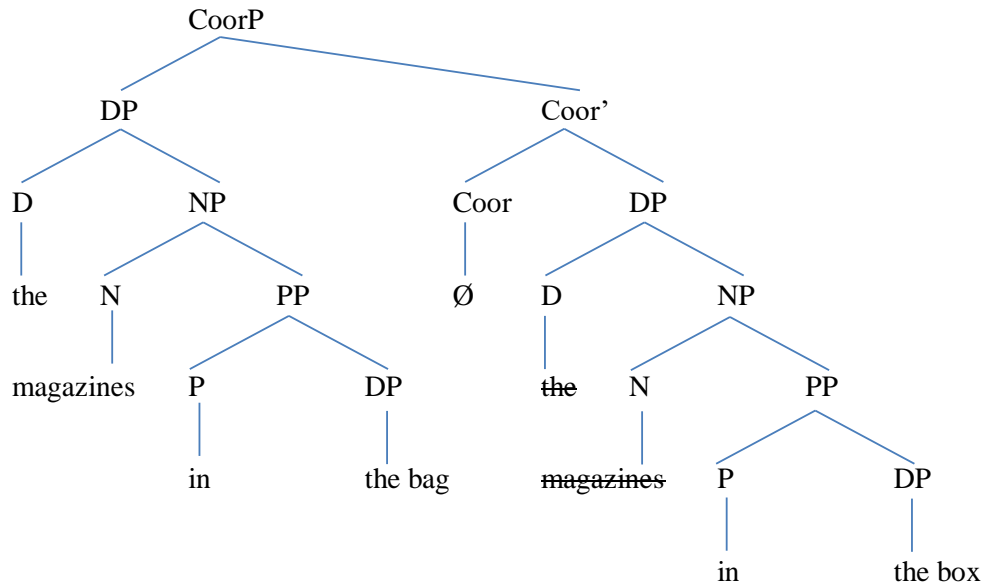
The nature of representation of coordination is still a hotly debated topic in linguistics, and one into which this study only intends to dip its toes as deeply as necessary. In deriving the appropriate representation for (27-30) above, several difficulties arise.

The problems potentially arise from at least two different sources: semantic symmetry and prepositional transitivity. The semantic issue is seen when, in (28), if both PPs instead conjoin with the head NP, this leaves us with one set of magazines in a bag and a separate set of magazines (unspoken) in a box—a similar version of PP coordination is seen in Maia et al (2013) testing processing in Karaja and Portuguese:

32. There is a fish on the rock and on the beach. (Maia, França, Gesualdi, Lage, & Oliveira, 2013)

This is illustrated with two fish, one on the rock and another on the beach (the presence of the overt coordinator *and*, which is presumed to surface at the sensorimotor interface and not belong necessarily to UG, is not pertinent to this parallel). Thus, the magazine example would be illustrated correspondingly, with each set of magazines restricted by one PP. However, in (30), the same structure involves only one lion, which is directly restricted by both PPs. As such, these examples that are superficially parallel in their recursive interpretations would require two substantially different representations in their coordinate ones.

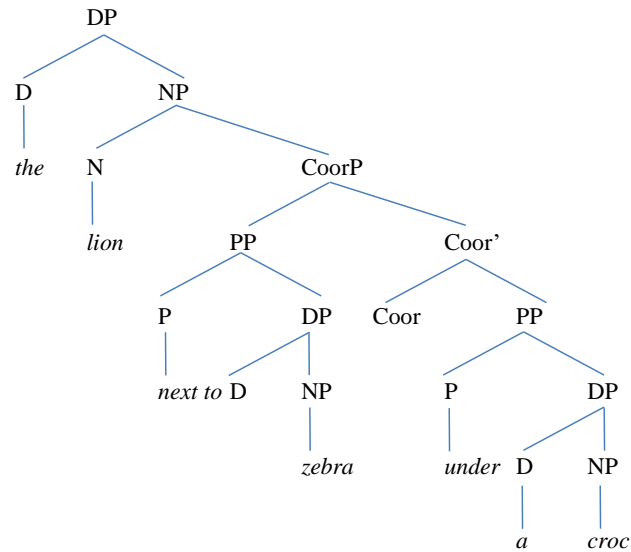
Tackling them one at a time, the *magazines* example might be represented as follows:



4. Coordination with Coordinator Phrase (CoorP), version 1

This creates two independent DPs to accommodate the separate semantic entities, deleting the redundant repetition. This version adheres to a stricter version of binary minimalism, incorporating a dominant Coordinate Phrase, advocated by Zhang (2010), among others.

The ‘lion’ in 30 would vary necessarily as the CoorP would obtain beneath the head NP (a lion), and could be represented in this manner:



5. Coordination with Coordinator Phrase (CoorP), version 2

Zhang (2010) provides a way to understand these two types of coordination, splitting them by their semantics into natural, non-distributive coordination and accidental, distributive coordination. Natural coordination takes place when elements “are closely related to each other [which] is indicated if any element in the context is semantically associated to the combined meaning of the conjuncts, rather than the meaning of each isolated conjunct” (Zhang 2010, pp.124-125). This coordination is non-distributive in that it does not distribute across discrete semantic entities. In (30), the PPs combine semantically to modify one element (the lion), which would qualify the phrase as “natural coordination.”

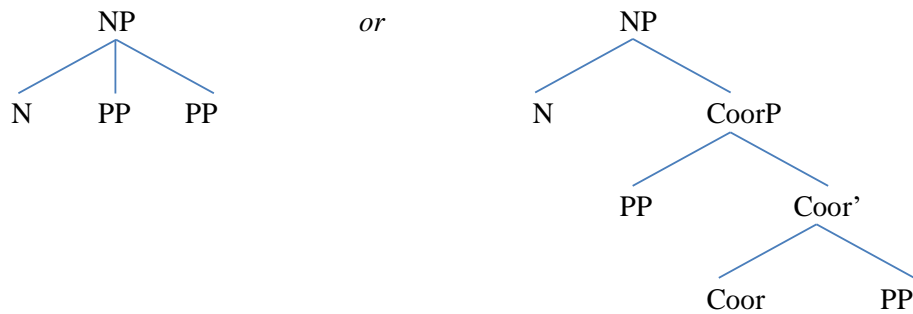
The “magazines” example, however, creates two distinct semantic elements; the conjoined PPs in fact have little to do with each other and are, in fact, “accidentally” adjacent both syntactically and pragmatically. The coordination, therefore, is

characterized as distributive, as the coordination carries over more than one semantic entity. Nonato (2013) distinguishes these types of non-clausal coordination as comitative and distributive:

33. Comitative coordination: The lion next to a zebra under a crocodile.

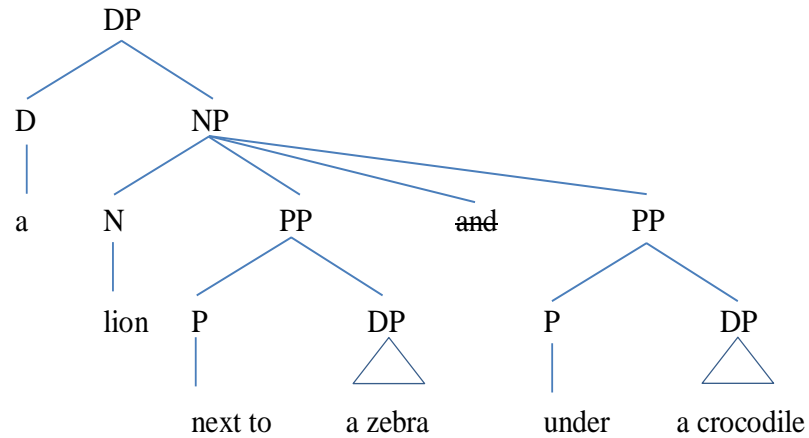
34. Distributive coordination: The magazines in a bag in a box.

Thus, there are at least two alternate versions of coordination which need representation. A further question which needs addressing is whether to adhere to a strict minimalist framework of binary branching or allow a form of “coordinate exceptionality” to license multi-branching structures.



6. Two coordinate options

If we extend the multi-branching to the *lion* example, we arrive at something such as this:



7. Multi-branching coordination

The coordinate node ‘and’ is included here, though it could just as easily be omitted.

Thus, the NP is ultimately formed by the union of noun with PP1, PP2 and

(hypothetically) PPn. There remains, nonetheless, the problem of explaining the non-terminal node NP and its branching.

Leivada (2015) proposes a variant analysis that might prove beneficial in this context.

She suggests that ‘x within x’ structures are more prevalent than strict minimalism would have one believe, and in fact are licensed across categories in a variety of languages. Her

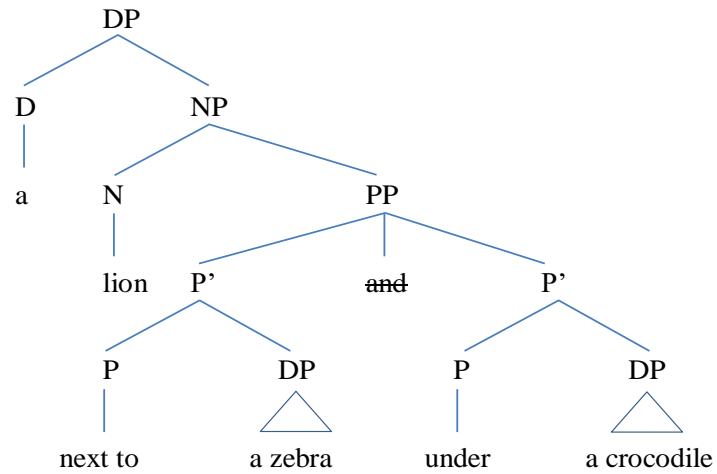
work presents data in both Greek and Dutch containing preposition doubling, and cites

Aelbrecht & den Dikken (2013: 41) who find evidence in Dutch of “two *immediately adjacent identical P-elements*” as well. An extension of this could be taken to include

adjacent P’-elements, effectively licensing:

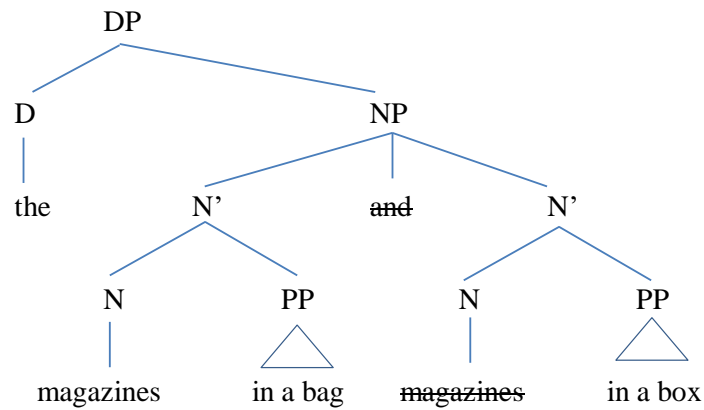
35. PP → PP (and) PP

This could be accommodated in the present representations easily:



8 A PP containing two PPs

The distributive coordination could be accommodated as well.



9. An NP containing two NPs

The project moves forward using a grammar that incorporates coordinate structures of the nature seen in (8) and (9) above.

Standard coordination tests refer to Ross's (1967) Coordinate Structure Constraint (CSC), which bars extraction of and from conjuncts without taking advantage of across-the-board extraction of or from all conjuncts. A quick examination of our examples indicates further differences.

36. *What are the magazines in a bag in *t* ? (coordinate)

37. *¿En qué están las revistas en una bolsa *t* ? (coordinate)

We can see that not only does this violate the CSC, but the target of the question (the magazines are in a box) is not the topic offered in the question (the magazines in a bag) and thus is clearly impossible. The recursive interpretation, however, seems plausible here; this is due to prepositional transitivity—if *the bag is in the box*, then whatever is *in the bag* is also *in the box*. Thus the target of the question is still the head NP, *magazines*, which happens to be modified by a restrictive PP *in a bag*. Consequently, the question targets a recursive interpretation *incidentally*.

This semantic division between discrete entities (two sets of magazines) is not an issue in the other example, which contains just one entity.

38. What is the lion next to a zebra under *t* ? (coordinate)

39. ¿Debajo de qué está el león al lado de una cebra *t* ? (coordinate)

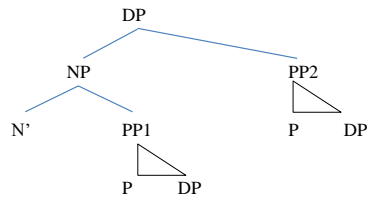
While this clearly violates the CSC, there is no clear semantic ban on these questions, as the answer to (38), the crocodile, is available and transparent. There are a couple of ways

around this, however. One is that the differences in extraction violations between the two types of coordination may be put down to the differences in semantic symmetry, i.e. that “el león/the lion” is modified by an asymmetric coordinate structure and “las revistas/the magazines” are modified by a symmetric one. “The magazines in the bag ~~and the magazines~~ in the box” is symmetric coordination because it involves two separate events (two sets of magazines, each restricted by one PP); “the lion next to a zebra under a crocodile” is asymmetric as it can be viewed as having one event semantics—there is only one lion, which is restricted by two PPs. Nonato (2013) proposes a unified semantics for the clausal and non-clausal coordination. He suggests that natural/comitative coordinates are “closer” to each other (following the semantic proposal of Zhang 2010) than accidental/distributive coordinates and, as such, should receive distinct denotations. In depth examination of the semantic distinctions is beyond the scope of the present project, but Nonato presents these in combination with extraction limitations between the two types to propose that only *natural, asymmetric* coordination allows violation of the CSC while accidental, symmetric coordination is bound by the CSC. This allows extraction from *the lion* but bars it from *the magazines*.

3.5 Stacking in two PPs

The other alternative that would allow this type of extraction was proposed by Langendoen et al (1989) as well, with their observation that full recursion and coordination are not the only interpretations available when dealing with an NP containing two PPs. Another involves PP2 attaching neither low to the NP in PP1, as in recursion, nor high to the head NP, as in coordination, but instead to the entity created by the conjoined head N and PP1. Langendoen et al (1989) call this “stacking”, which

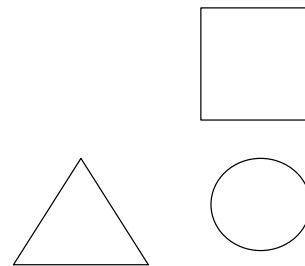
Roeper & Oseki (to appear) claim fits into their description of Direct Structured Recursion (DSR).



10. PP stacking

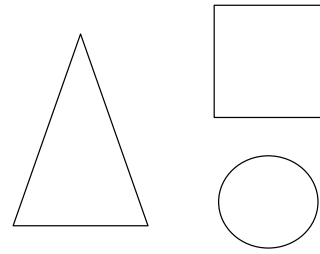
The fourth interpretation described by Langendoen et al they refer to as stuffing and happens when “the entire phrase following a particular noun modifies that noun” (Langendoen et al 1989, p538). To clarify the distinction with recursion, Langendoen et al’s own examples illustrate it best.

The triangle next to the circle below the square (recursive)



11. Recursion in Langendoen et al (1989)

The triangle next to the circle below the square (stuffing)



12. Stuffing in Langendoen et al (1989)

For a number of reasons, though, this interpretation will not feature prominently in this study. Firstly, it virtually never appears in the data and thus may be considered statistically insignificant. Also, the attachment of PP2 conforms to that of PP2 in the recursion example in that both attach low to the immediately preceding NP, which characterizes them as recursion. As such, it is difficult to arrive at a distinct representation that would be substantially different from that of recursion. In the end, this interpretation was not pursued and what few responses of this type were combined with those of recursion.

Three fundamental interpretations, therefore, arise in an NP containing a noun and two PPs: *recursive*, *coordinate* and *stacking*. When the NP contains three PPs, however, the number of possible interpretations grows significantly as each of the above three choices in PP2 again have the same three choices themselves; furthermore, PP3 has available one more node of attachment than does PP2, for a total of four choices to be made after PP2 attachment. As detailing these dozen potential representations would be both unnecessary and burdensome to the reader, the focus shall be on the most pertinent ones for the studies contained herein.

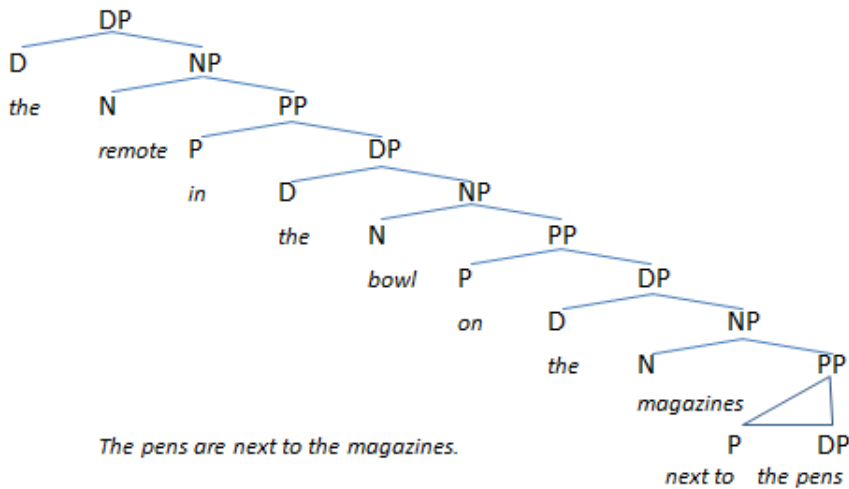
The available interpretations for PP3 keep the three existing names and add a fourth: *medial*. As before, recursion indicates lowest attachment, with PP3 restricting the noun

contained in PP2. Coordination has the highest attachment, directly restricting the head noun of the phrase. Stacking again interprets the information preceding it as a single semantic entity. The medial interpretation, as the name implies, attaches neither high to the head noun nor low to the noun in PP2 but instead to the noun in PP1.

3.6 Recursion + recursion

This is the most straightforward of all, adhering to right-branching structures throughout.

- *the remote in the bowl on the magazines next to the pens*



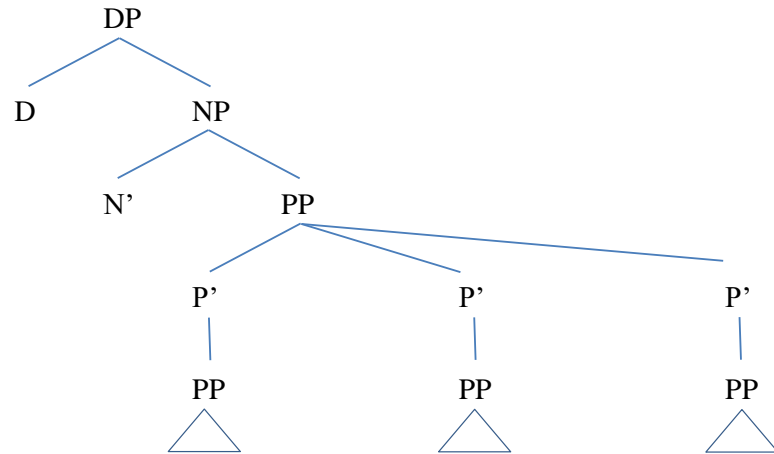
13. Three PPs, recursion + recursion

Each PP attaches to the immediately preceding NP, demonstrating a consistent line of interpretation which requires the most hierarchical structure possible.

3.7 Coordination + coordination

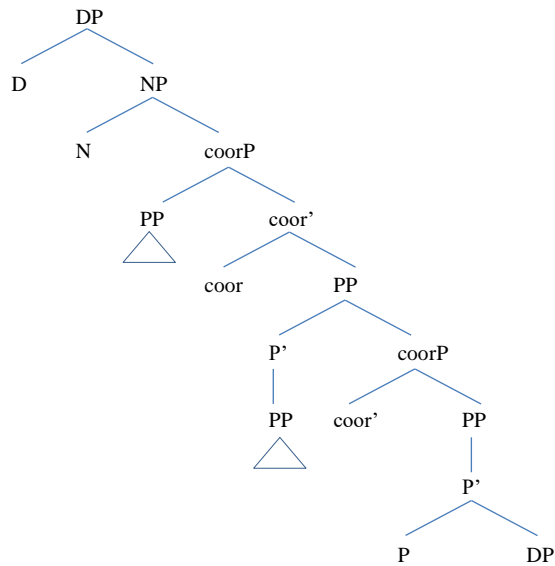
This interpretation represents another consistent line of interpretation, although of a flatter variety incorporating less hierarchy. Extending the propositions of both Nonato

(2013) concerning ‘accidental coordination’ and Leivada’s (2015) ‘x within x’ to a third PP, it is possible to speculate what would happen if all PPs attached high to the head NP.



14. Three PPs, conjunction + conjunction

The alternative to figure (14) using coordinate phrases becomes effectively little different as far as hierarchy from that of recursion + recursion, albeit with different labelling (15).



15. Three PPs, conjunction + conjunction (alternate)

As such, (14) will be the preferred structure.

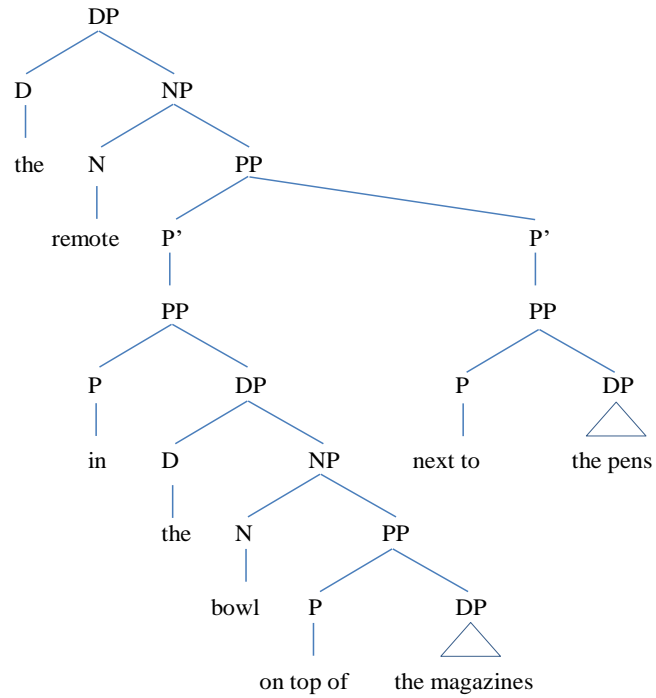
Although *stacking* was an important variation in interpretation for PP2, the one remaining consistent interpretation across PP2 and PP3, *stacking+stacking* will not be pursued here.

As it is hoped that the various combinations possible with coordination and recursion will be more fruitful, the remaining representations will focus on these. Firstly the structures presented are those that create a stronger hierarchy by using a recursive operation on PP2 before reverting to a flatter structure, either medial or coordinate, on PP3.

3.8 Recursion + conjunction

This interpretation involves first low, then high, attachment.

the remote in the bowl on top of the magazines next to the pens



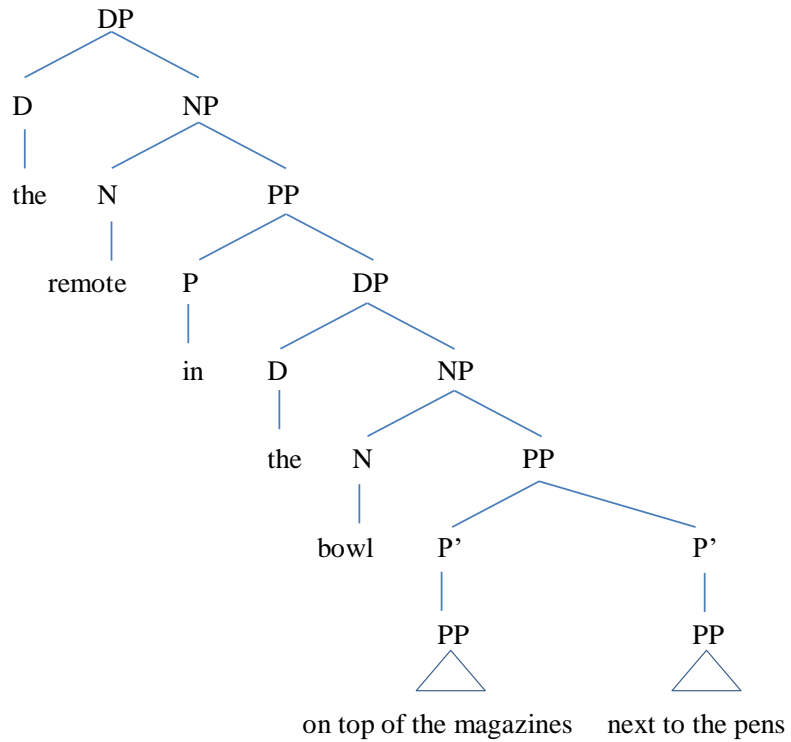
16. Three PPs, recursion + conjunction

As before, (16) continues with the ‘x within x’ proposal of Leivada discussed earlier.

3.9 Recursion + medial

This is the remaining principal interpretation that starts with low attachment on PP2; here it shifts not to fully high attachment to the head NP but instead to the NP contained in PP1.

the remote in the bowl on top of the magazines next to the pens



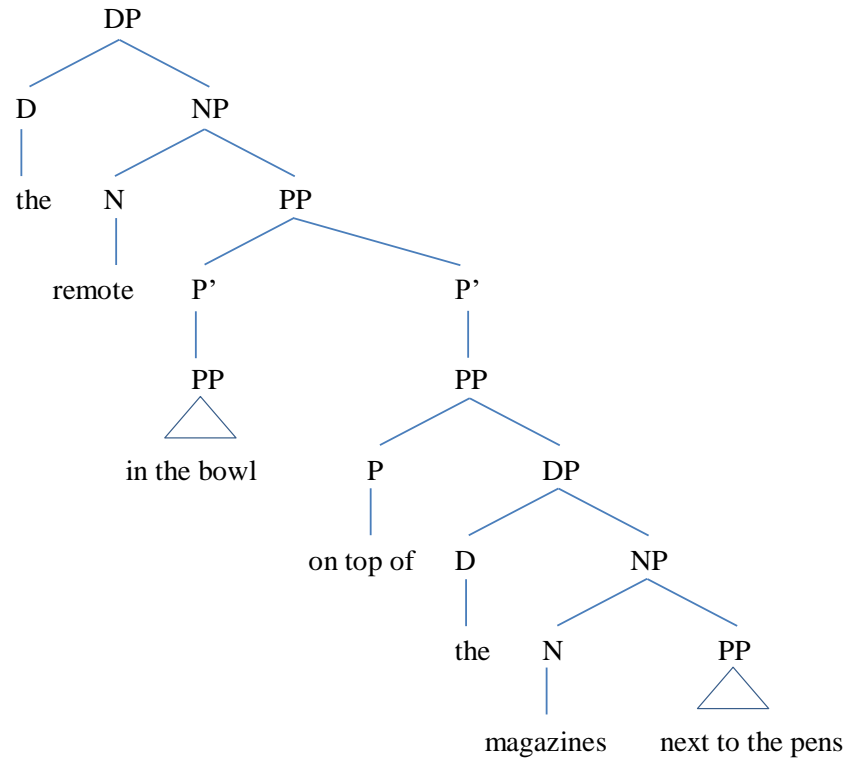
17. Three PPs, recursion + conjunction

In (17), *the bowl* is both *on top of the magazines* and *next to the pens*. There are also interpretations that avoid a deeper hierarchy with PP2 by choosing either stacking or coordination there but then attaching low with PP3

3.10 Coordination + recursion

As implied, here PP1 and PP2 effectively operate as a unified PP before a recursive operation takes hold placing PP3 within PP2.

the remote in the bowl on top of the magazines next to the pens



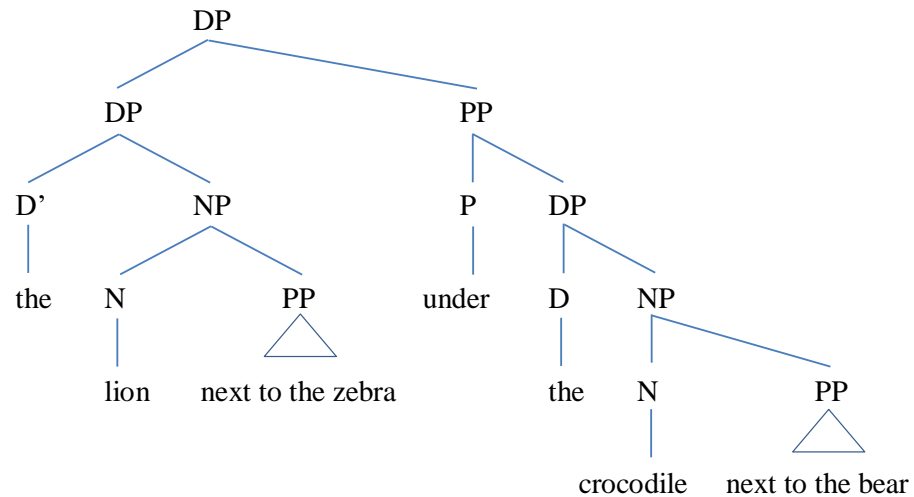
18. Three PPs, coordination + recursion

In 18, not only is the remote in the bowl but also on top of the magazines, which are next to the pens.

3.11 Stacking + recursion

This demonstrates a second example of an interpretation 'shift' into recursion after another, less hierarchical, form of interpretation has taken place.

the lion next to the zebra under the crocodile next to the bear



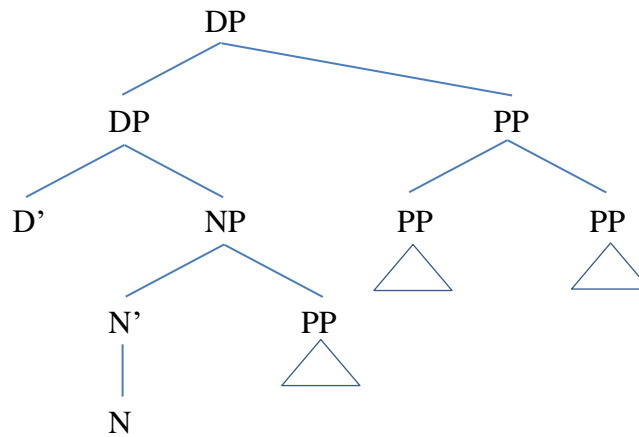
19. Three PPs, stacking + recursion

As is apparent in the representation, this is effectively two hierarchical DPs, the first c-commanding the second via a ‘broader’ PP: There is a DP ‘the lion next to the zebra’ which is located under ‘the crocodile next to the bear’.

Several combinations of these interpretations remain which will not be followed on here. Their structure can be surmised on rearranging the above representations of the various operations. As far as it focusses on structures, the study moves forward focusing primarily on those discussed above.

3.12 Stacking + conjunction

Lastly, a shift is possible into conjunction where recursive operations are effectively absent.



20. Three PPs, stacking + conjunction

3.13 Terminology

While the distinction between *recursion* and *conjunction* has been cleared up, and *stacking* explained, several other terms will reappear frequently throughout and require an explanation and shorthand expression for the sake of convenience. One potential point of confusion is the two experiments. The first experiment focused primarily on L2 (but also L1) acquisition, while the second experiment concentrated on L1. Henceforth they will be referred to as ExL2 (the first experiment) and ExL1 (the second experiment), in the hope that this will both streamline and simplify matters.

3.14 Summary

Chapter 3 has laid out the theoretical framework through which the results of the experiment will be filtered. This description of the differences inherent in interpretations such as recursion, coordination, stacking and their various combinations as phrasal

complexity grows provides a clear picture of what is encountered in the data provided by the two experiments, ExL2 and ExL1.

ExL2 measures, via multiple-choice tasks, the challenge presented by these PP adjuncts to adult L1 and L2 speakers of English and Spanish, which share the characteristic of the productive recursion of adjunct PPs. ExL1 measures physical DP ‘construction’ in a directed movement task with four different ages of children as well as adults.

The studies comprise multiple points of investigation over two distinct experiments; as such I would like to address the associated questions and hypotheses here within each of the experiments separately, although naturally some crossover will occur. Initially, the intent was to investigate recursion as it pertains to SLA to see if it presents an acquisition challenge. This was based on a theoretical claim that this acquisition challenge was present in child L1 (Roeper & Snyder, 2003); nonetheless, this claim had not been empirically demonstrated for the structures in question, adjunct PPs. Thus the original experiment was extended and adapted to investigate whether the acquisition path was indeed empirically identifiable in L1, which would potentially demonstrate the validity of L1 acquisition theory in L2 findings.

Chapter 4 below lays out the exact nature of ExL2, describing the goals, questions and hypotheses tested as well as the methodology used.

CHAPTER 4

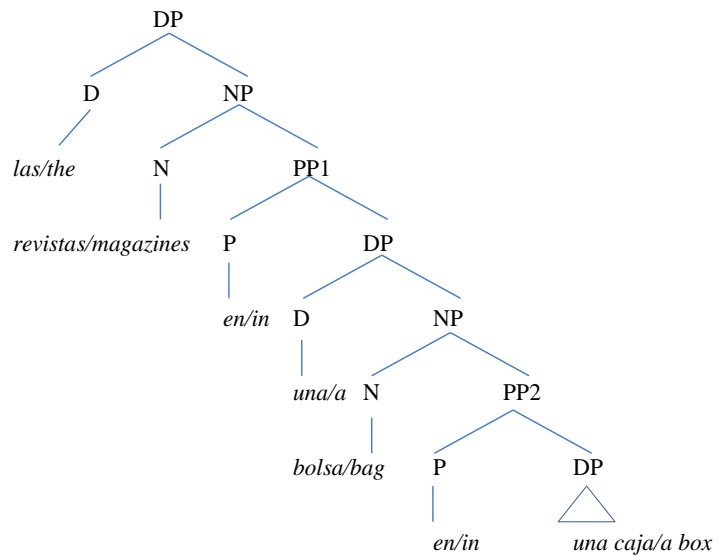
L1 AND L2 SPANISH AND ENGLISH EXPERIMENT (ExL2): QUESTIONS AND METHODOLOGY

4.1 Introduction

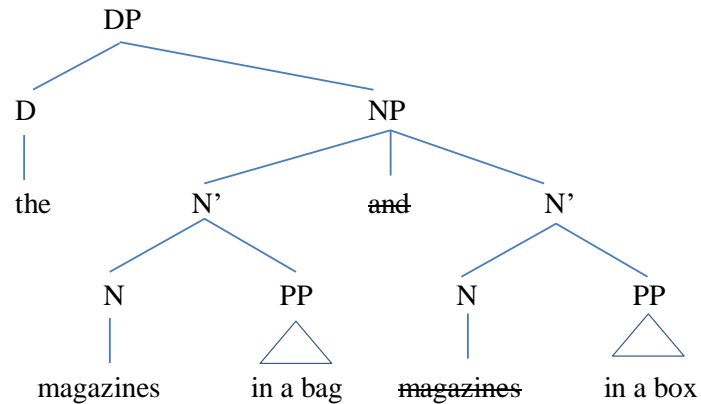
First and second language acquisition studies have tackled various aspects of recursion. Trueswell et al (1999) investigated PPs in their role as arguments and adjuncts in L1, focusing on PPs attachment to VPs or NPs (see also Tutunjian and Boland, 2008, among others). Limbach and Adone (2009) have shown how L2 learners may face additional challenges acquiring left-branching nominal/possessive recursion not available in their L1. Measuring oral production in descriptive tasks, Perez-Leroux et al (2012) has noted that children seem to face a greater difficulty acquiring this left-branching recursion than right-branching PPs. Maia et al (2013) have shown that recursive PPs present a processing challenge well beyond those of coordinate ones. Terunama and Nakato-Miyashita (2013) and others have noted that speakers encounter much greater difficulty at third-level recursion than they do at the first two levels. The present studies aim to contribute to this discussion.

Firstly, these studies bypass the ambiguity inherent in “put the plant on the table in the corner,” wherein ‘on the table’ could be variously interpreted as an argument or adjunct of the VP; as described in chapter 3, the current focus is on locative PPs. In order to get a broader understanding of this problem, it is tackled in two related but very dissimilar experiments.

These studies attempt to provide some insight into the interpretation of adjacent locative PP structures as seen from various angles and at their core explore whether recursion or conjunction is preferred in a variety of situations. The differences of these were illustrated in the previous chapter, which at their core boil down to those seen in (21) and (22) below.



21. PP recursion



22. PP conjunction

While not likely to provide a definitive answer on any particular aspect of recursion, these studies will help to shine a light on this important corner of the linguistic and acquisition studies.³

The following experiment, ExL2, was designed with the intention of addressing numerous questions regarding the interpretation of NPs containing series of adjacent PPs, and potentially illuminating what affected choices between recursion and conjunction.

4.2 Ubiquity of recursion

Do speakers, in fact, prefer recursive structures when allowed to choose between them and coordinate structures? This, of course, is at the core of this study, and it should be neither surprising nor controversial to predict that all speakers do prefer recursion in all types of items involving adjacent PPs.

³ Chapter 3 earlier provided an alternative coordinate representation for structures in which a single NP is modified by two PPs and which used an architecture very similar to that above; this difference between types of coordination is not pursued here as a path of investigation.

4.3 The acquisition path

The primary research question in ExL2 assumes that if there is an identifiable “path of acquisition” of recursion in L1 (Roeper, 2011), and furthermore if L2 acquisition follows that of L1, then this path should be apparent in L2 data. As Roeper and Snyder (2003) claim, appropriate recursive input is essential in natural L1 language acquisition, with a logical corollary that, as a child matures, their command of language-specific recursive operations increases as well. Thus, if one assumes that UG principles in L1 may be present in L2, as input increases in the adult language learner as measured by quantity of target-language university-level courses she has taken, so too should appropriate language-specific recursive interpretation.

A primary question to be answered is the degree to which recursion is, in fact, preferred to conjunction by both L1 and L2 speakers of both English and Spanish. The data should be both broad and deep enough to provide a conclusive answer to this.

Also, the study attempts to show what, if any, the effects are of being an L1 or L2 speaker on both recursive and conjunctive data. In the same vein, are advanced L2 speakers more biased towards recursion, an operation that is not taught yet nevertheless already activated in the L1, than are lower-level speakers? Do these lower-level speakers have a stronger preference for conjunction, as might be expected of children in their L1?

As a corollary to these hypotheses, I predict the reverse will be true with conjunction, which will be stronger among L2 speakers than L1 speakers, and stronger among intermediate L2 speakers than advanced L2 speakers.

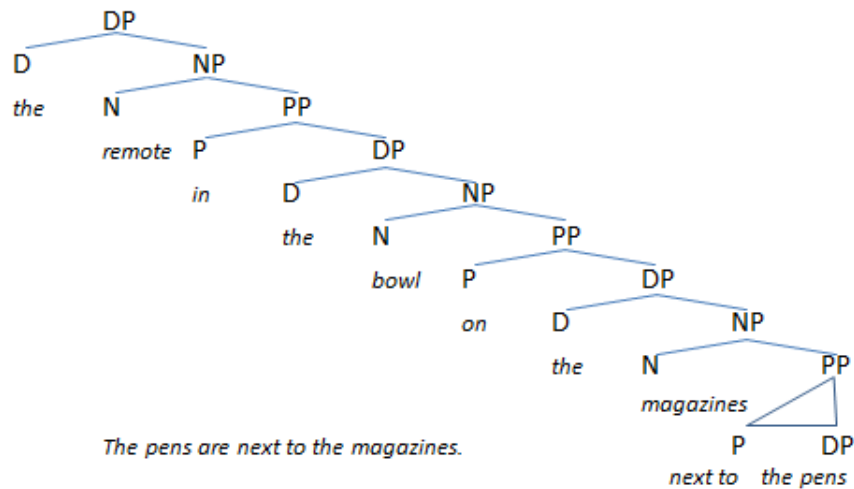
4.4 Number of PPs

Does the number of consecutive PPs affect the rate of recursive interpretation? In other words, what happens when the number of adjacent PPs increases from two to three? If PP3 is effectively ‘primed’ with a recursive preceding PP—that is, if PP2 attaches to the DP complement of PP1—how does that alter interpretation? The double PP found in the representation in (21) above would have a third PP attached as seen for example in (40):

40. the remote *in* the bowl *on* the magazines *next to* the pens

The representations from chapter 3, repeated here, differentiated these in a specific way. A fully recursive interpretation of (40) would involve recursion on PP2 to be followed by recursion on PP3, that is, recursion + recursion (23).

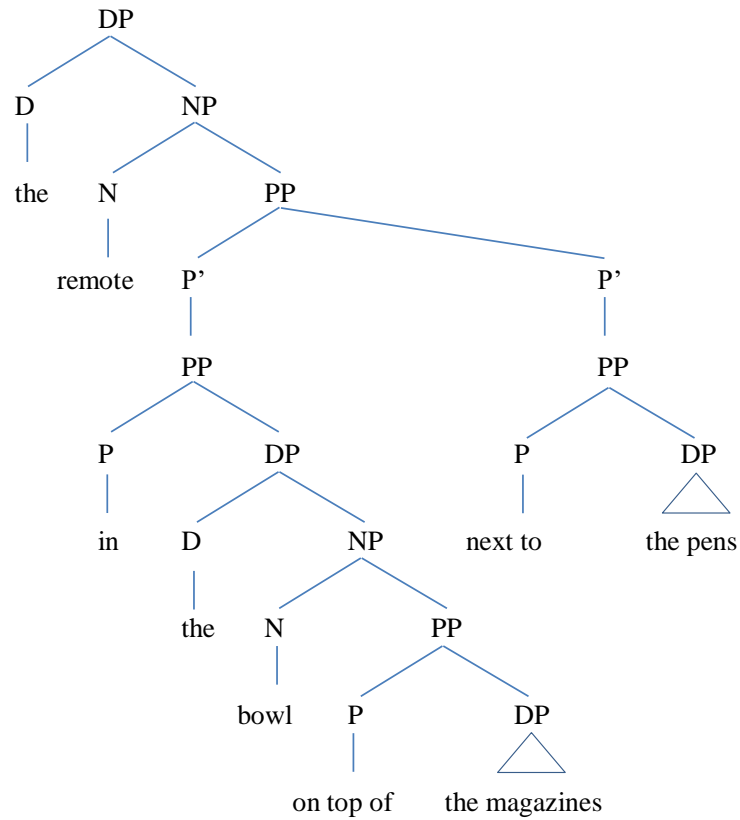
- *the remote in the bowl on the magazines next to the pens*



23. Three PPs, recursion + recursion

In a (semi-)coordinate interpretation of (40) (seen in chapter 3), PP2 attaches to the NP in PP1 via a recursive operation, but PP3 attaches directly to the head noun, parallel to the PP1+PP2 chain (24).

the remote in the bowl on top of the magazines next to the pens



24. Three PPs, recursion + conjunction

A contrast as described above in figures (23) and (24) might be illustrated as in (29)



The remote in the
bowl on top of
the magazines
next to the pens



25. Three PPs, recursion (left) and conjunction (right)

In this situation, it is my hypothesis that the recursive priming will trigger a stronger recursive response in PP3 than the responses to the questions containing only two PPs. More specifically, chains of three PPs (all containing different heads) will produce more recursive responses than two PP chains (both containing different heads). As before, the corollary regarding conjunction with two PPs applies with three PPs as well; conjunction will be higher among L2 than L1 and among intermediate L2 than advanced L2.

4.5 Heads of PPs

Do the prepositions themselves trigger an effect on recursivity?⁴ Specifically, if an NP contained two adjacent PPs headed by the same preposition, as in *the magazines in the bag in the box*, would this cause a difference in recursivity than if one contained two adjacent PPs headed by different prepositions, as in *the CDs in the box next to the books*?

The choices illustrated above in (21) and (22) for the expression *the magazines in the bag in the box* might find their real world distinctions in examples such as those in (26).

the magazines in the bag in the box



26. Recursion (left) and conjunction (right)

⁴ The insight that this potentially was a factor in recursivity was first brought to my attention by conversations with Magda Oiry.

As described earlier, there is an additional inherent difference in these two examples regarding their conjunctive interpretation, namely the inclusion of two nouns in the first one (two sets of magazines) and one in the second (one set of CDs). This, however, is not the result of the doubled prepositions, but instead of the semantic transitivity of the preposition *in*. The NP in (27), for example, contains a case of double prepositions without this distinction.



*The envelopes
under the
books under the*



27. Recursion (left) and conjunction (right)

In (26), the conjunctive option clearly includes two separate nouns—magazines in a box and magazines in a bag. In others, as described in chapter 2, the conjunctive option involves a single noun restricted by two PPs, as in (27).

Thus, how do identically-headed double PP chains such as those above fare when compared to double PP chains headed by different prepositions. As the difference here is semantic and not syntactic, the various combinations of PPs would employ the same stable of structures as seen above to choose from. Do examples such as (26) and (27) above trigger greater recursion than do those employing different prepositions, such as *the CDs in the box next to the books* (28).



the CDs in the box next to the books

28. Recursion (left) and conjunction (right)

The hypothesis is that yes, two adjacent PPs headed by identical prepositions do trigger greater recursivity than do two headed by different ones. Concurrently, the hypothesis is that this will be apparent in both languages tested, as the implied trigger is presumed to not be restricted by language specificity.

4.6 Locative vs comitative

The study also attempts to discern if any ambiguity might be isolated to locative PPs by comparing them with comitative non-locative adjunct PPs, as in (41).

41. the woman with the baby with the blue shirt

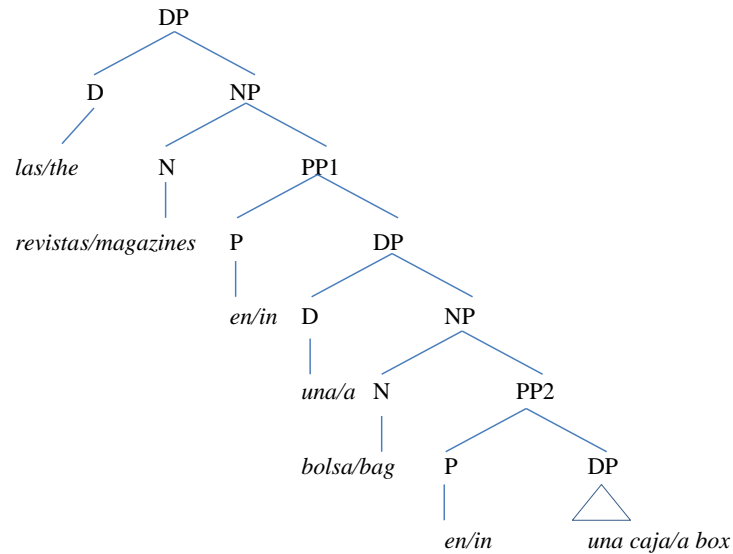
As these are identically-headed comitative phrases, they are only compared with the corresponding identically-headed locatives. The hypothesis is that locative PPs will allow for greater ambiguity than non-locative PPs.

4.7 Spanish vs English

What is more, this first study measures recursive operations that are effectively identical in the relevant L1 and L2, English and Spanish. Limbach and Adone (2010) suggested that structural differences between L1 and L2 may account for L2 learners' difficulties in processing L1 recursive operations; their study investigated recursion in the genitive 's structure of English as understood by L1 German speakers. Most often, the Saxon genitive 's is portrayed as a left-branching structure which allows recursion (although see Pérez-Leroux et al 2011 for a different viewpoint), a feature not shared by German possessives, thus presenting an L2 acquisition challenge for the subjects.

A core assumption that ExL2 makes is that the phenomenon is cross-linguistic as the similarity of structures in English and Spanish should provoke similar levels of ambiguity in L1s and thus in L2s. The data will show whether or not this is the case.

The present study investigates recursion in adjunct prepositional phrases, which are, for all intents and purposes, identically structured in English and Spanish. The default recursive interpretation, introduced in chapter 3, is repeated here as 29.



29. Parallel recursion in English and Spanish

Due to the superficial structural similarities, I hypothesize that Spanish and English will generate similar levels of recursion. This should be the case whether the comparison is in either L1 or L2 for either language.

4.8 Experiment L2

4.8.1 Background

ExL2 went through considerable trialing and piloting before being shaped into its final form. Initially, trial designs were floated for cross-testing in English and Spanish which tackled possessives, relative clauses, and more in addition to prepositional phrases. Building on the work of Limbach and Adone (2011) in English with Germans, the possessives contrasted these recursive operations in English (left-branching) and Spanish (right-branching). In the vein of Matthei (1982), adjectival recursion, which also may contrast in English and Spanish, was to be tested as well. It was decided, though, that the

data could be more concise were ExL2 to isolate just one type of structure. Locative prepositional phrases stood out as an excellent candidate for this, in fact, precisely because of their similarity in English and Spanish. If different recursive operations were available in different languages, as Limbach and Adone noted in regards to possessives in English and German, then this may explain differences between L1 and L2 speakers. What if the structures' potential recursivity were identical (or appeared to be) cross-linguistically? Would this aid the L2 speaker, or would differences persist? Moreover, a dissimilarity has already been noted between English and Spanish PPs more broadly (Gilboy, Sopena, Clifton, & Frazier, 1995) which found cross-linguistic differences in complex substance NPs (*a cup of sugar*) as well as certain types of genitive NPs (the father of the boy). Locative PPs suffer from no such dissimilarities, and can be presumed to function similarly in both languages; indeed, pilot materials indicated just that.

Reviewing potential designs for experiments that could measure recursion, some type of computer platform quickly became apparent as an ideal candidate for data collection due to the ability to record and store answers while running the experiment. Furthermore, using contrasting images of recursive and conjunctive interpretations of ambiguous adjacent prepositional phrases, preferences could be assessed differently than say Leroux (1999)'s focus on production of these types of phrases. Instead, subjects would hear the description of an item restricted by a series of prepositional phrases and then choose from an array of options which they thought best represented the item described. Early attempts at arranging on-screen items into adequate distinctions between recursion and conjunction proved unsatisfactory, however:



30. The toy cars behind the plant behind the chair

In various scenarios such as in figure 1, while the distinction was clear, the presentation was thought too artificial for adults, something which may have affected the authenticity of the results. Instead, almost every choice for ExL2 was carefully modeled and photographed to best illustrate the distinctions in as realistic a manner as possible.

Early attempts suffered from bluntness: Which are the toy cars behind the plant behind the chair? This both highlighted the structure such that the subject would have little doubt what was being investigated (again affecting authenticity, despite the presence of filler questions) and failed to provide much motivation to the subject to choose the ‘best’ answer. Instead, the target structures were buried at the end of very brief, encapsulated stories. The stories involved....

Animation of objects in the aid of telling the story also proved to be essential in allowing subjects to follow the narrative.

A pilot experiment was run with 70 intermediate students; this allowed some final problems to be localized and eliminated. These had to do with the timing of animations so that they would best coincide with not only the narratives but also the target structures as well as whether and when to repeat any complex target structures.

4.8.2 Participants and Setting

A total of 114 subjects each received \$10 compensation for their participation in ExL2; each belonged to one of five groups depending on L1 and/or L2. ExL2 was run in Spanish with L1 and L2 (L1 English) Spanish speakers as well as in English with L1 and L2 (L1 Spanish) English speakers. The high number of L2 Spanish speakers (57, half the total) allowed this group to be divided yet again depending on level of input as reflected in total number of university-level semester-length courses they had received. Two-thirds (38) of this group fell into the lower input group; initial results with only 19 (the same size as the other groups) showed a wider spectrum of answers (a higher SD) than the others, so the decision was made to double this one group. The 38 L1 speakers of Spanish were from a variety of countries, although the majority was from Spain. The average age of the L1 Spanish speakers was 28. Other factors, such as years of exposure to English were only controlled for the English version of the experiment. In total, there were five groups of participants, classified by both language of the test and subjects' relationship to that language, i.e., L1, advanced L2 or intermediate L2:

- Spanish test, L1 speaker (SL1)

- Spanish test, advanced L2 speaker (L1 English) (SL2A)
- Spanish test, intermediate L2 speaker (L1 English) (SL2B)
- English test, L1 speaker (EL1)
- English test, advanced L2 speaker (L1 Spanish) (EL2)

The L2 Spanish speakers, all students at the University of Massachusetts Amherst, were divided into two groups according to level of exposure/input they had received. The subjects in the more advanced group (SL2A), all L1 English speakers (n19), were on average 22.5 years old. They started studying Spanish at a mean age of 12.4 years old, had studied Spanish for an average of 9.3 years, of which she had 1.7 years of pre-high school exposure, 3.6 years of high school study and 10.1 semesters of Spanish-language university courses. This last characteristic, the most recent exposure to the language, was taken as the key independent variable in choosing candidates. This group had also typically been abroad in a Spanish-speaking country for an average of 5.9 months⁵ and claimed at least some measure of competence in .9 foreign languages other than Spanish.

The intermediate group (SL2B) of participants, all L1 English speakers (n 38), were on average 20.1 years old. They had started their Spanish studies at a mean age of 12.1 year old, had an average of 6.9 total years of Spanish study: 2 years of pre-high school exposure, 3.6 years of high school study and 2.5 semesters of Spanish-language university courses. This group had also typically been abroad in a Spanish-speaking country for an average of .3 months and claimed at least some measure of competence in .4 foreign languages other than Spanish.

⁵ This was higher due to the presence of outliers; some participants had spent over a year abroad.

The L1 participants in both Spanish and English were not controlled for any other variable, although all were students at the University of Massachusetts Amherst. The group SL1 had a mean age of 28 and its members were mostly from Spain, although several were from Chile, Argentina, Peru and Colombia. The average age of EL1 was 19.3; all were American English Speakers

The English level of group EL2 was determined to be as approximately as advanced as the Spanish of group SL2A for the purposes of the experiment. This determination was based on the fact that all members of this group were already successfully functioning in an English-speaking environment where they had lived for anywhere from a few months to many years.

The experiment ran at the University of Massachusetts Amherst from May, 2013 to May, 2014. ExL2 consisted of an audiovisual self-paced presentation in PowerPoint using earphones lasting approximately 30 minutes. The presentation was designed to be completely autonomous and contained a series of slides, each presenting a brief orally narrated illustrated story lasting 20 to 30 seconds and culminating in a multiple-choice question based on the narration. This was answered by clicking on the choice, which simultaneously recorded the answer via macros and opened the next slide.

4.8.3 ExL2 design

The experiment comprised 35 questions, containing 14 target items and 21 fillers (2:3 ratio), with fillers spaced evenly among the target items. All questions, both target and filler items, contained an inherent ambiguity that the subject had to resolve to proceed to the next question.

Each target question was carefully structured. Two characters were introduced in each question, and their discussion required one to ask the other which item/s they were talking about. The person replied with a description involving consecutive PPs which was to distinguish which option was under discussion. With the questions using two PPs, the description was not repeated; with 3 PPs it was repeated once. Finally, after hearing this description, subjects were never asked the target directly, as in “Which ones are next to the plates on top of the tray?” Instead, the subject was asked to choose what the protagonist was describing with a question such as “Which ones does she want?” Clicking on a choice carried the participant to the next question.

The images were carefully synchronized as well. Each story was accompanied by numerous images illustrating the relevant things, actions or emotions which would appear as they were introduced. Finally, before the target description was presented, all the images faded out and were replaced with the macro-linked photos representing the options to choose from. A moment afterwards, the target description was heard. Subjects had three seconds to look over the different options before hearing the question. The arrangement or layout of the choices (recursion, conjunction, etc.) was randomized so that none of the four types of questions offered repeated any pattern more than once.

The experiment began with two training questions which demonstrated the nature of the interface to the subject, after which they could ask the moderator any questions. The experiment then continued autonomously with a total of 35 questions, using a ratio of target to filler of 1:1.5 (14 target questions and 21 filler questions). Subjects listened to the audio through earphones to minimize noise and distraction. ExL2 used three different

randomized target question orders, although always maintaining them regularly spaced among filler questions.

4.8.4 Question types

Four specific types of target questions were used. The first type (four questions) involved two consecutive PPs headed by identical prepositions (1-4):

- en/in
- debajo de/under
- sobre/over
- detrás de/behind

The second type two headed by different prepositions (5-8):

- en/al lado de//in/next to
- delante de/encima de//in front of/on top of
- debajo de/encima de//under/on top of
- detrás de/en//behind/on

The third locative type used three consecutive PPs (9-12):

- encima de/cerca de/al lado de//on/near/next to
- al lado de/cerca de/en//next to/near/in
- en/encima de/al lado de//in/on top of/next to
- al lado de/en/detrás de//next to/in/behind

The final type used two consecutive non-locative PPs, both using con/con//with/with (13, 14).

There were both similarities and differences in the choices offered in the 14 questions. Firstly, all questions offered the basic distinction between recursion (PP attached unambiguously to immediately preceding DP) and conjunction (PP attached unambiguously to the head DP). The rest of the options varied slightly between each of the four question types.

The four identically-headed PPs (1-4) offered one option where the first PP was not interpreted and another option where the second one was not; including these options of non-interpretation was borrowed directly from the work of Limbach and Adone (2010). A fifth option (this was the only question type to offer five instead of four options) displayed the second PP attaching to the head DP, as if it were conjunction, but with PP1 potentially attached to the DP in PP2, as shown (in the actual experiment, of course no labeling text was ever used):



PP2 drop



conjunction



'left' conjunction



recursion



PP1 drop

31. The envelopes under the books under the pens

The four PPs using different heads (5-8) offered the same options as those using identical ones, less the final option where PP1 attaches to PP2, which proved unfeasible to arrange coherently without placing undue strain on the processing. This is due to requiring options which simply mis-assigned the first PP to the DP in PP2, causing the subject to decide which preposition attached to which DP. With identically-headed PPs, the shared phonetic content eliminates the confusion inherent in the other while preserving the ambiguity of which PP attaches where. Thus, there were four options: recursion, conjunction, PP1 deletion, PP2 deletion. This same set of options was used for the two non-locative questions (13, 14).



conjunction



PP1 drop



PP2 drop



recursion

32. The CDs in the box next to the book

The set of questions with three locative PPs (9-12) used two options in addition to the recursive and conjunctive ones. One involved the final PP not being interpreted at all, as with the other question types. The other option attached PP3 neither to the DP in PP2 (recursion) nor to the head DP (conjunction) but instead to the DP in PP1 (medial). There was no chance of ambiguity involving the attachment of PP1 or PP2 in the options, as all choices were carefully constructed to preserve a constant, recursive relationship among the head DP + PP1 + PP2; the only variance was with PP3.



medial



conjunction



recursion



PP3 drop

33. The remote control in the bowl on the magazines next to the pens

This was the only set of items that effectively ‘primed’ the subjects with a recursive item—above, all options display a remote ‘in the bowl on the magazines’.

4.8.5 Locative—comitative contrast

The illustration of the comitatives required showing a physical relationship that was not determined by location. Using *with*, for example, required showing recursive and coordinate relationships that were distinct yet involving items in an unobtrusive, ‘natural’ way (42).

42. the woman with the baby with the blue shirt

This ambiguity could be clearly illustrated, as in 34.

the woman with the baby with the blue shirt



34. Recursion (left) and conjunction (right)

4.9 Summary

As seen, ExL2 contains 14 items distributed across four separate categories, all of which offer a choice between recursion and conjunction, among others. It contains five distinct groups of subjects spread across L1 and differing levels of L2, as well as two languages sharing a recursive disposition in operations performed on adjacent PPs. The following chapter attempts to exploit these variables while analyzing the raw data which the experiment generated.

CHAPTER 5

L1 AND L2 SPANISH AND ENGLISH EXPERIMENT (ExL2): RESULTS AND DISCUSSION

5.1 Introduction

The results herein account for a considerable number of factors, as discussed in the previous chapter. Care has been taken to isolate variables as much as practical to present the clearest picture of any significance they may display. The data are presented broken into their multiple core elements according to the coding which follows. Each section contains a brief discussion about those particular results. Furthermore, a participant analysis provides some insight into individuals' performances and, for the truly dedicated, the data of the discrete items are presented and discussed to potentially identify any unique characteristics of specific prepositional combinations.

5.2 Coding

The coding is, of course, inherent in the structure of the choices, presented in the previous chapter. All items (14) were analyzed for interpretation of recursion and conjunction.

All double PP questions (1-8, 13, 14) were coded for non-interpretation of either PP while the triple PP questions (9-12) only offered non-interpretation of one, the final, PP. Internally in type 1 (1-4), results were coded for the alternative conjunction option apparently interposing PP2 between the head DP and PP1; in type 3 (three PPs)

questions, they were coded as well for the medial interpretation, attaching PP3 to the noun in PP1. Illustrations of all of these can be found in Chapter 3.

Among question types, the results of two identically-headed PPs (1-4) were compared with those of two PPs with different heads (5-8).

The results of two PPs with different heads (5-8) were compared with those of three PPs with different heads (9-12).

The results of two identically-headed locative PPs (1-4) are compared with those of two identically-headed non-locatives (13, 14).

There are five different groups of participants using one of two versions of the experiment (English or Spanish) which provide the data. The first letter of the name refers to the language of the experiment, the rest of the letters describe the speaker in regards to that language:

43. Spanish version, L1 Spanish speaker:	SL1
44. Spanish version, advanced L2 speaker (L1 English)	SL2A
45. Spanish version, intermediate L2 speaker (L1 English)	SL2B
46. English version, L1 English speaker	EL1
47. English version, advanced L2 speaker (L1 Spanish)	EL2

5.3 Results and discussion

The results here are presented in various manners. Firstly, frequency of recursion and conjunction are observed across all items in the study. After this, the analysis zooms in on length of syntactic structure, comparing the interpretation of NPs with two PPs to

those with three. Then the effect of specific prepositional combinations—identical or different—is measured and discussed. Also, a brief section compares identical locatives to identical comitatives. Finally, the chapter attempts to identify an L2 path of acquisition, as well as what might affect it and how. Thus, the incidence of recursion and conjunction is compared internally in each test language group (SL1 vs SL2A vs SL2B; EL1 vs EL2). What is more, Spanish L1 is checked against English L1 for any similarities or differences.

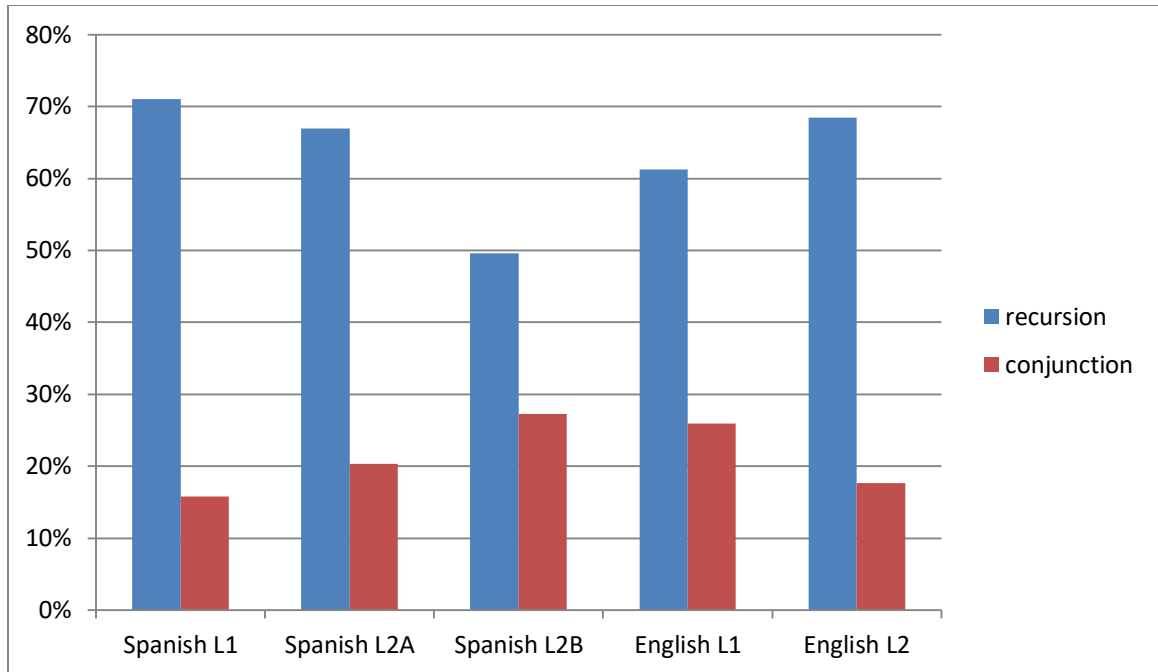
5.3.1 A note on statistical methods

Three different methods were routinely used to test the data for significance; they are summarized here to avoid having to repeat them at each step of the presentation. The data were non-parametric throughout, so the more powerful tests such as ANOVA were unavailable. Instead, for data comparing two variables, for example, recursion vs conjunction in a set of speakers, a paired sample Wilcoxon Rank Sum was used. Comparing two groups of speakers' preference for recursion, however, required an independent sample Wilcoxon Rank Sum test. If three or more groups, for instance SL1, SL2A and SL2B, are compared, then Kruskal-Wallis generates the p-value.

The statistics were obtained via Statistics Online Computational Resource (SOCR), an online service providing statistical computing applets.

5.3.2 Recursion vs conjunction

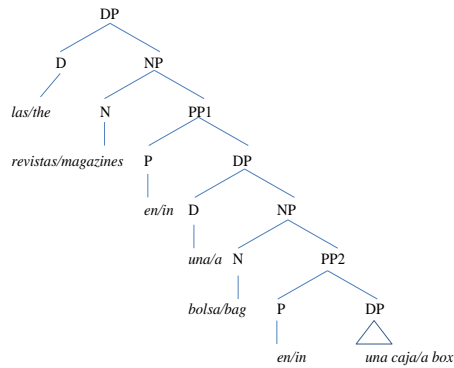
As seen in chart (35), the broad preference for recursion over conjunction is significant across all 5 groups ($p < .001$ in all groups). The widest difference was found in SL1 (71% to 16%); the narrowest in SL2B (50% to 27%)



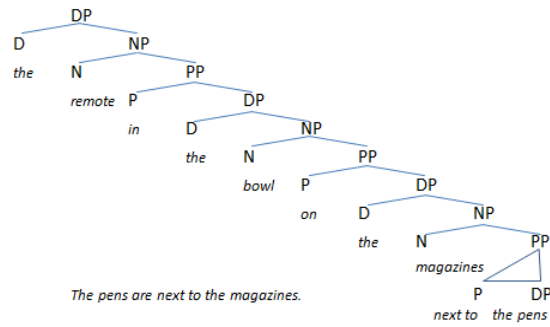
35. Recursion and conjunction across all PP types

The data affirm the initial hypothesis that recursion will be preferred to conjunction by all groups of subjects. Even the narrowest gap between recursion and conjunction, found in group SL2B, recursion was nearly twice as prevalent as conjunction, 50% to 27%, with a p-value well below .001. The fundamental preference for recursive representations such as those in (36) to ones such as those in (37) is abundantly clear.⁶

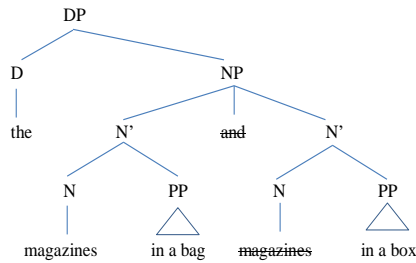
⁶ repeated here from chapter 2



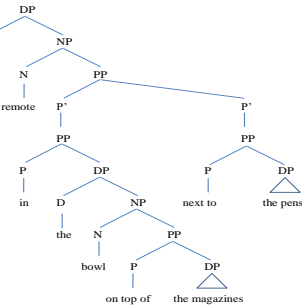
• the remote in the bowl on the magazines next to the pens



36. Two- and three-level recursive operations



the remote in the bowl on top of the magazines next to the pens

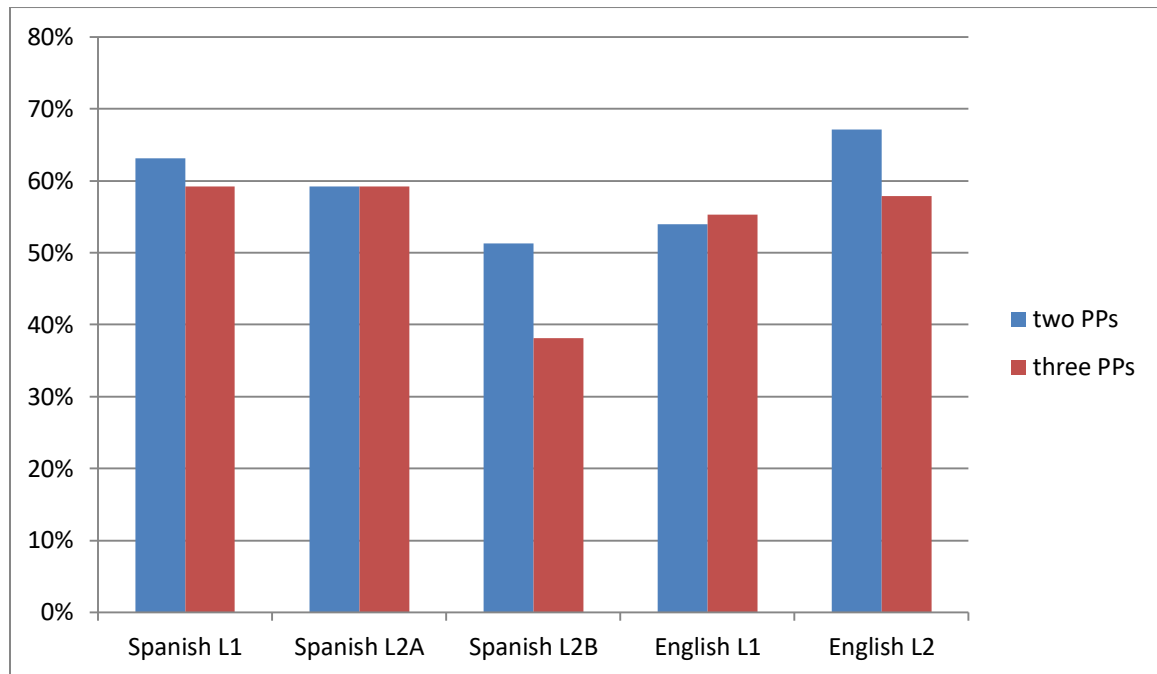


37. Two- and three-level coordinate operations

While these results are neither surprising nor controversial, their inclusion is important as their acceptance as fact is the foundation for any conclusions we may draw for any particulars down the line. Moreover, they underline the fact that despite the lack of an overt coordinator such as *and* or *y* (in Spanish), a conjunctive interpretation is not at all uncommon. None of the rest of the results, however, is anywhere near as unambiguous. In the data discussion which follows, while repetition is avoided where possible, some results must be discussed in several different contexts, making a certain degree of redundancy inevitable.

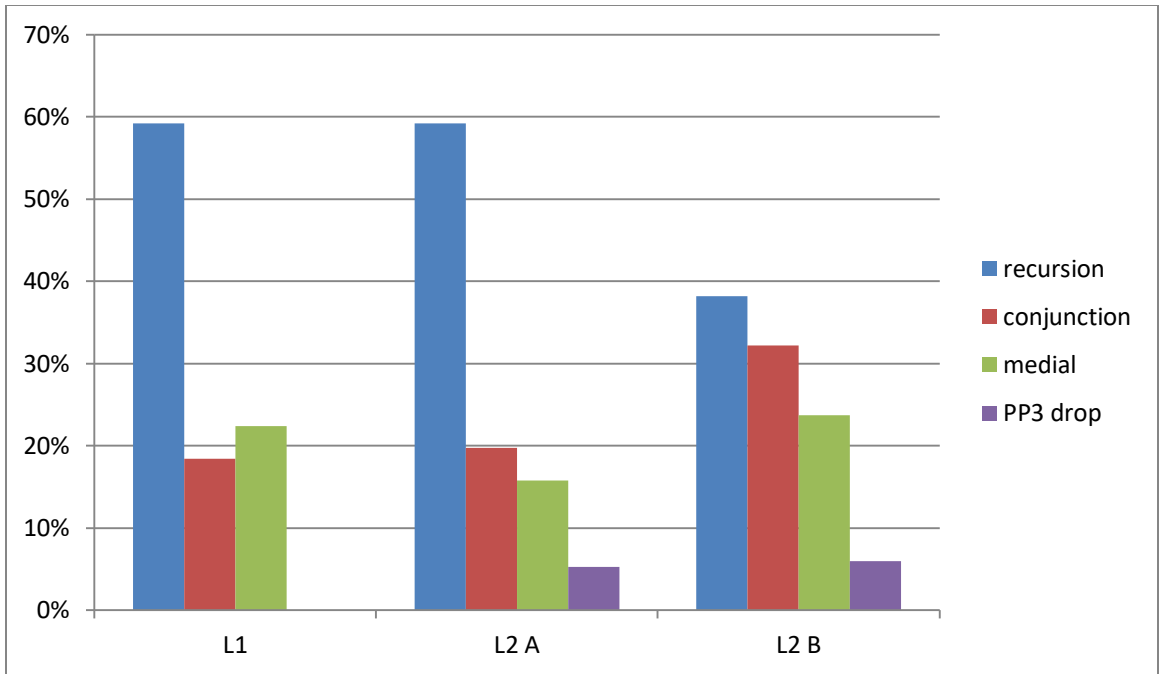
5.3.3 Number of adjacent PPs

The effect on recursion of number of prepositions was measured as well. Firstly, the interpretation of two differently-headed PPs is compared to that of three PPs across all five groups.



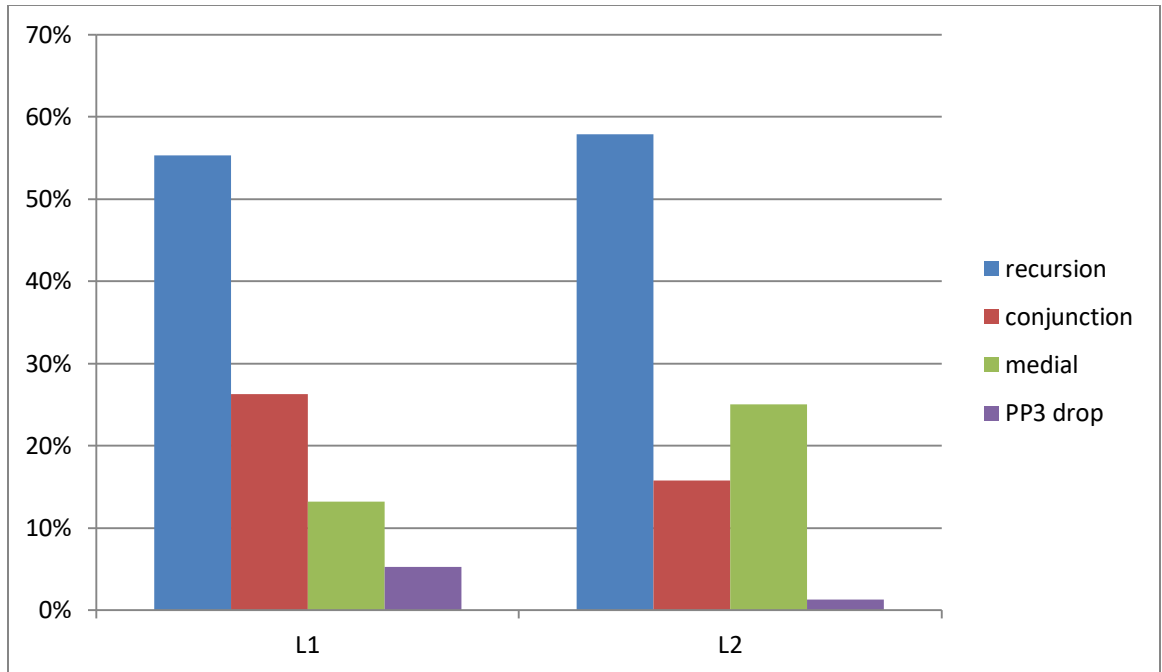
38. Recursion in two and three PPs

The differences were minimal in most cases. SL1 showed a slight decline from 2PPs (63%) to 3PPs (59%; $p = .319$, $z = .471$); SL2A showed no difference whatsoever, holding steady at 59% ($p = .453$, $z = .118$); and SL2B having the most substantial decline, from 51% to 38% ($p = .011$, $z = 2.33$). EL1 rose slightly with PP3, from 54% to 55% ($p = .412$, $z = -.222$), with EL2 declining by 9 points, from 67% to 58% ($p = .101$, $z = 1.278$).



39. Three different prepositions in Spanish

L1 and L2A chose recursion at identical levels (59%) with three PPs, a rate which declined significantly ($p = .01$, $z = 9.207$) to 38% with SL2B. The rates for conjunction of SL1 and SL2A were also at very similar levels (18% and 20% respectively), increasing to 32% with SL2B ($p = .054$, $z = 5.835$), with the significance lying in the difference between SL1 and SL2B. The medial choice showed a narrower range across the groups, with L1 and L2B similar at 22% and 24%, declining to 16% with L2A ($p = .501$, $z = 1.381$). Non-interpretation of PP3 ranged from 0 in SL1 to 6% in SL2B.



40. Three different PPs in English

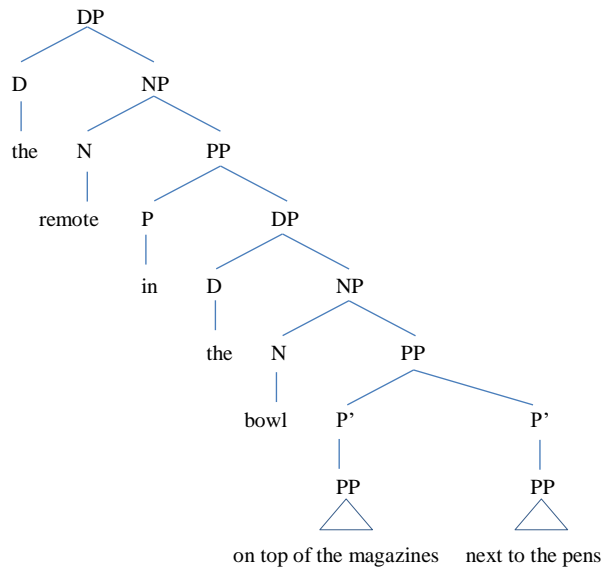
In English, recursive rates differ insignificantly by only 3% between L1 and L2 ($p = .396$, $z = .263$), but conjunctive and medial ones by far more. Conjunction declines significantly from 26% in L1 to 16% in L2 ($p = .048$, $z = 1.664$), while medial interpretations nearly double, from 13% to 25%, between L1 and L2 ($p = .044$, $z = 1.708$). Dropping of PP3 was very low in both groups.

5.3.3.1 Discussion

The data did not bear out the claim that recursive priming in PP2 would lead to even greater recursion in PP3 in both languages as far as L1 data go. Recursion in Spanish only changes from 63% to 59% ($p = .637$) moving from two to three PPs, and English from 54% to 55% ($p = .824$) (see figures (38, 39, 40, 54)). The probabilities here suggest that there is neither benefit nor cost to recursive interpretation imposed by increasing the length of the thread; this statement, however, comes with the proviso that the medial

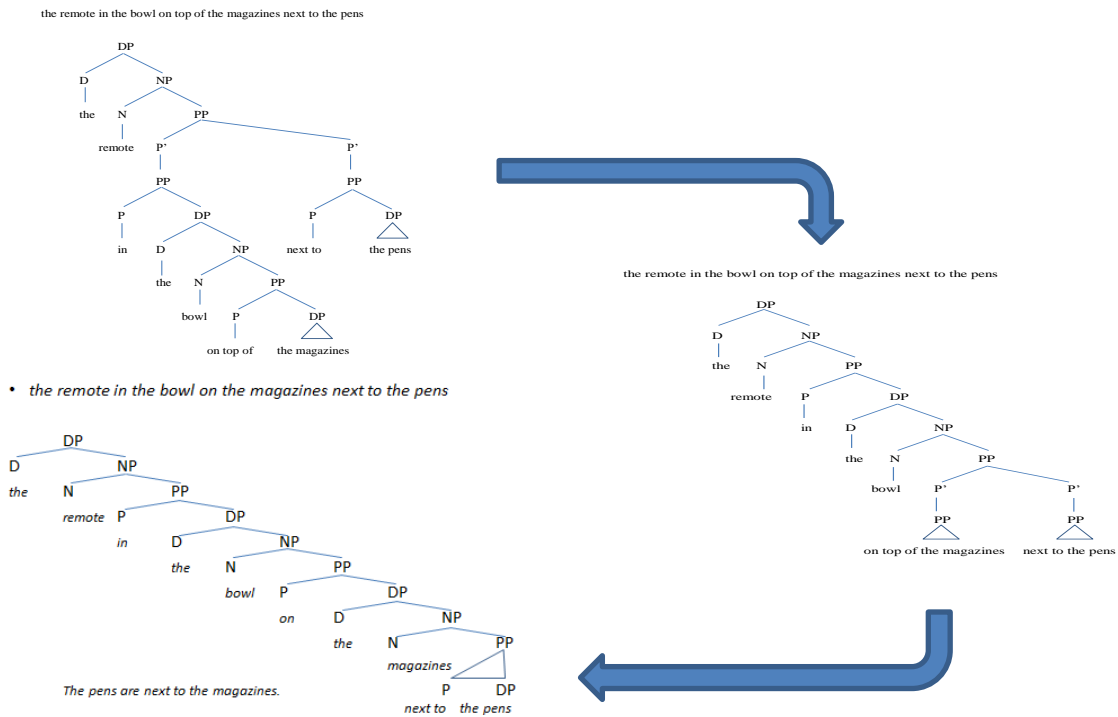
interpretation available with three PPs potentially had an effect on the outcome. The possible meanings of this are discussed below in the section comparing the two languages. The recursion + medial interpretation from the previous chapter is repeated here.

the remote in the bowl on top of the magazines next to the pens



41. Recursion + medial

In regards to the medial interpretation, if its availability can be seen as a ‘spoiler’ cutting into either straight recursion of conjunction, it seems to cut into the conjunction results most of all. As noted above, there is no significant change in recursion with three adjacent PPs (see (39) and (40)). As such, this would be stronger evidence towards considering it a variation on coordination than a potentially unique structure or a variation on recursion. It is not clear, nonetheless, that the path of acquisition may proceed from conjunction to recursion via medial (42).



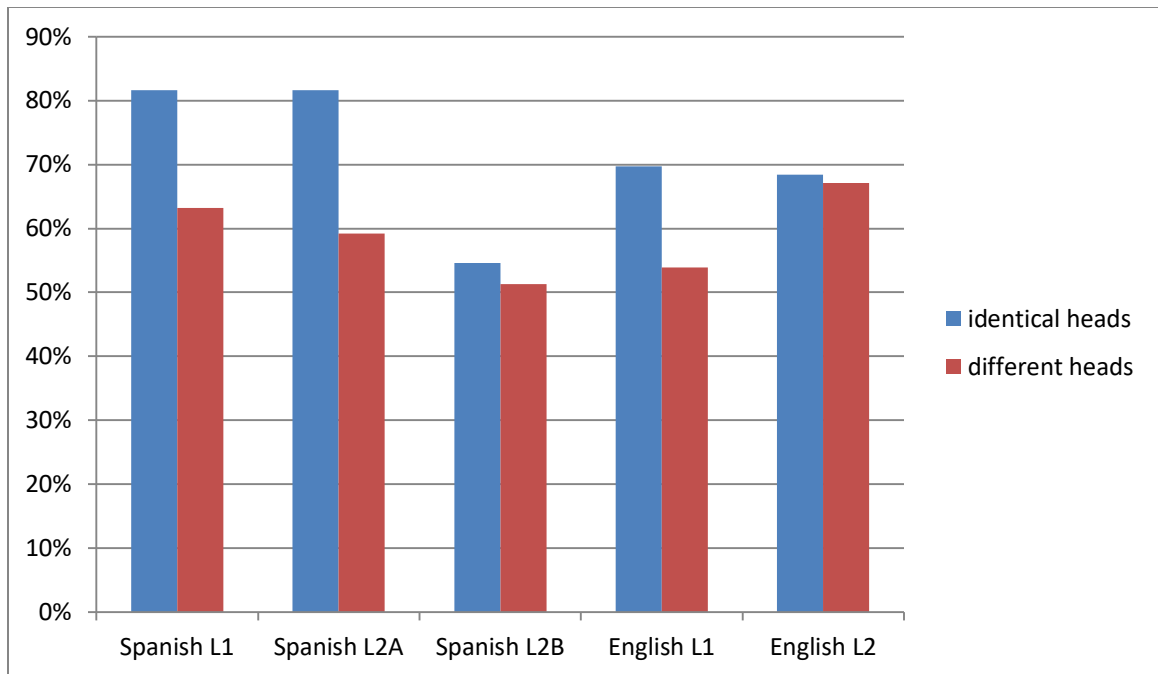
42. Three PP Path of acquisition?

The path suggested in (42) does not pretend that either of the preliminary phases is exclusive, i.e. that a speaker may produce first, coordination, then medial before crossing the threshold into recursivity; instead that the tendencies grow and diminish, with the first diminishing the most and the last notching up the greatest growth.

Recalling the primary finding of this chapter, longer PP chains containing recursive priming did not significantly affect recursive operations.

5.3.4 PP heads—difference among prepositions

Levels of interpretation of identical versus different heads of PPs varied somewhat across the five groups of participants.

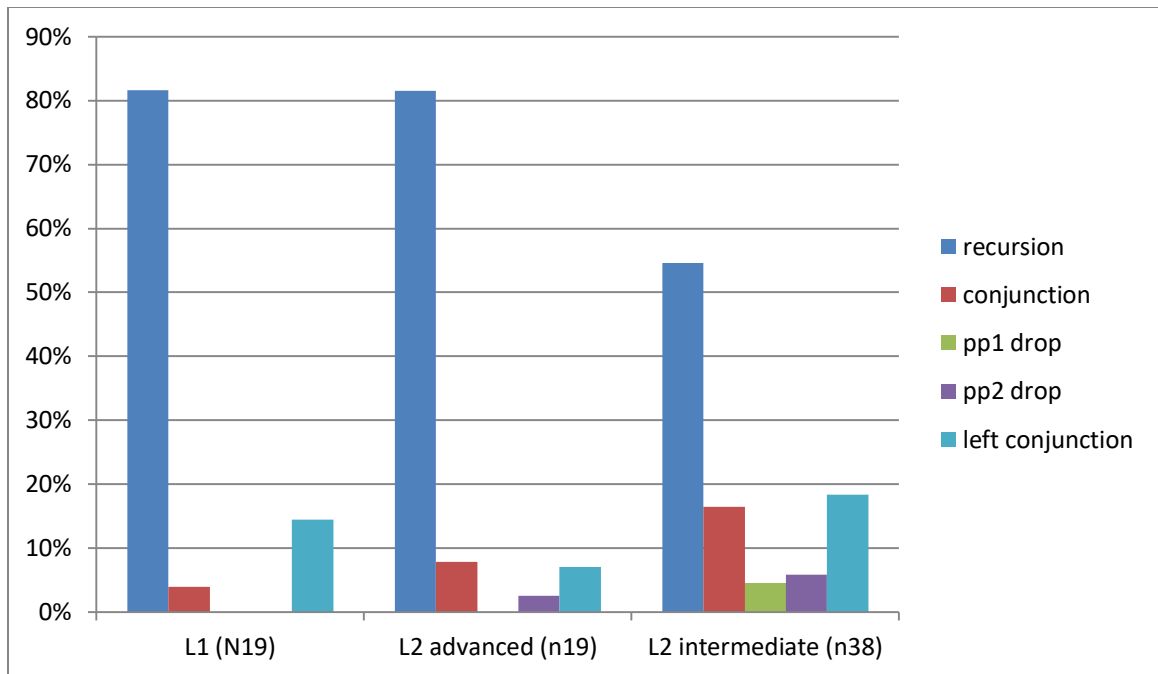


43. Recursion in PPs with identical and different heads

SL1 found identically-headed PPs significantly more recursive (82% vs 63%; $p = .009$, $z = 2.385$); SL2A had an even stronger preference (82% vs 59%; $p = .008$, $z = 2.417$). No significant difference ($p = .28$, $z = .584$) was found in SL2B's slight preference for recursion in identically-headed PPs (55% vs 51%). In the English groups, though both groups preferred recursion more strongly in identically-headed PPs, neither was found to be significant. EL1 preferred recursion 70% to 54% yet fell shy of significance ($p = .056$, $z = 1.586$); EL2 showed virtual parity between the two groups (68% vs 67%; $p = .431$, $z = .175$).

5.3.4.1 Two identical heads

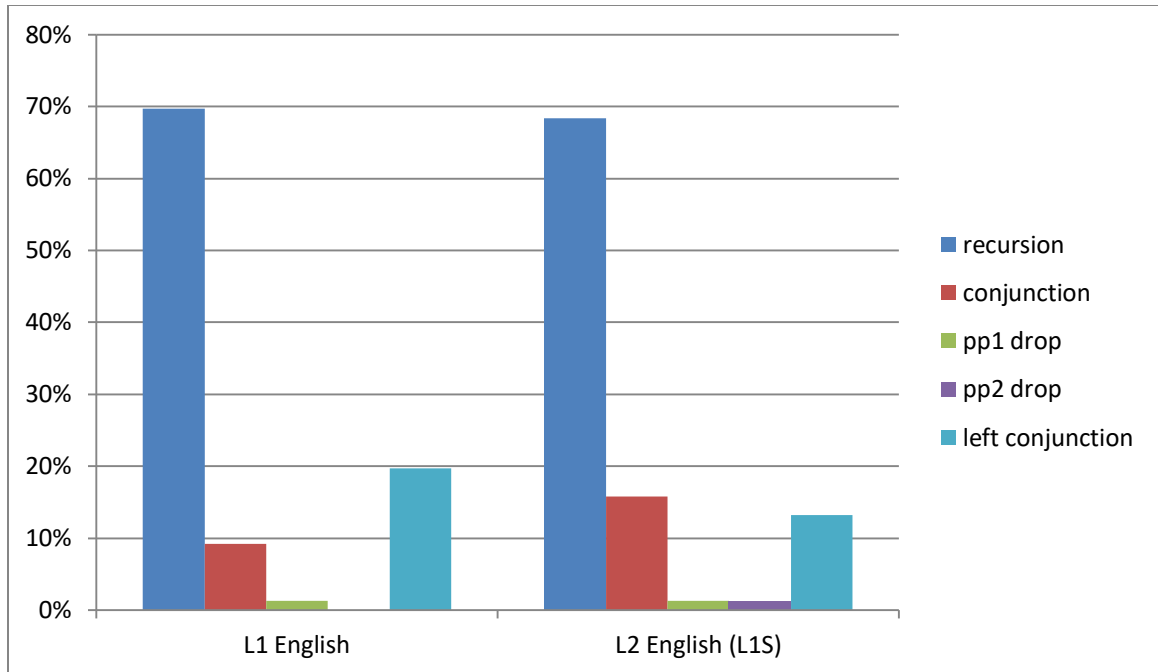
Examining each item type internally presents us with some finer shades of information.



44. Two identically-headed PPs in Spanish

While recursive interpretation in SL1 and SL2A is identical at 81%, the difference with SL2B, at 55%, is significant ($p < .001$, $T = 15.266$). The choice of conjunction of SL1 at 4% and SL2A at 8% also show a significant difference with the rate of SL2B at 16% ($p = .008$, $T = 9.740$). The differences in preference for ‘alternative’ conjunction, with SL1 at 14%, SL2A at 8% and SL2B at 18%, are not significant. Nonetheless, it must be observed that while the two SL2 groups had very similar rates for both types of conjunction, SL1 preferred ‘alternative’ conjunction nearly three times more than standard conjunction (when recursion was not chosen).

The English groups, while differing in rates of interpretation, did not achieve significance in any of the categories.



45. Two identical prepositions, English

As with SL1 and SL2A, EL1 and EL2 were similar in rates of recursion (70% to 68%; $p = .363$, $z = -.350$). Conjunction rates differed slightly more (EL1 at 9%; EL2 at 16%), though not enough to be significant ($p = .237$, $z = .715$). ‘Alt’ conjunction differences reversed, with EL1 at 20% and EL2 at 13%, still without rising to the level of significance ($p = .352$, $z = -.380$).

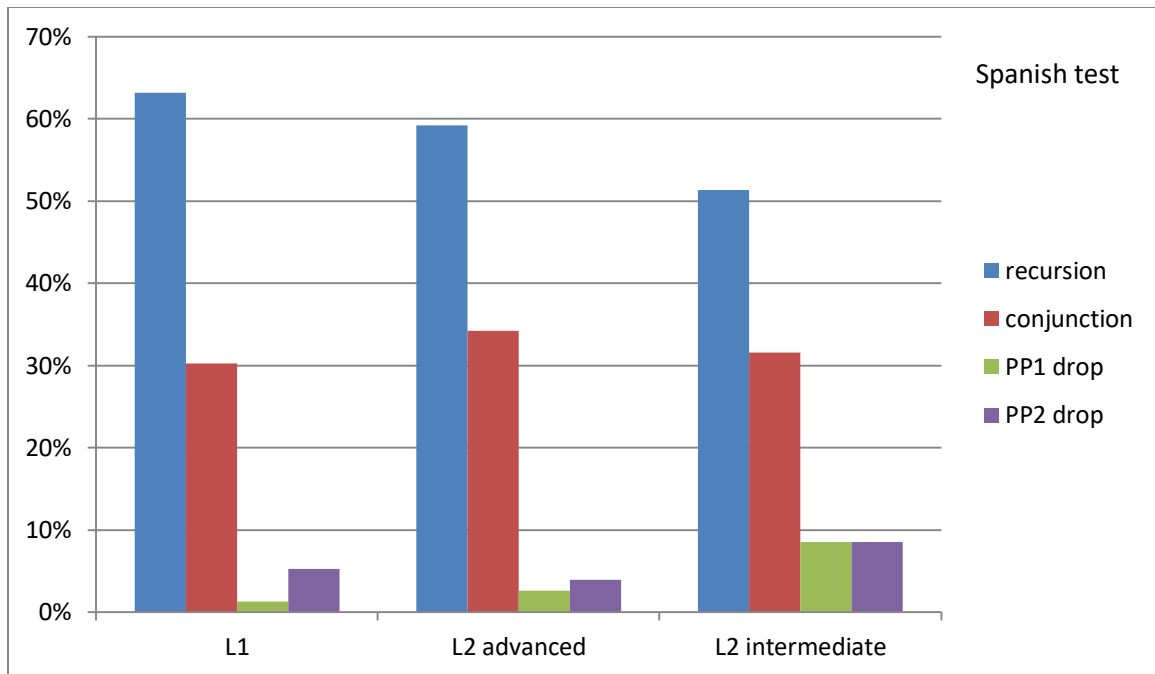
Nonetheless, as both English and Spanish L1 groups demonstrated a sizable preference for ‘alternative’ conjunction over standard conjunction, it is worthwhile to compare these results. In Spanish, a significant difference ($p = .014$, $z = -2.201$) is observed between standard conjunction (4%) and ‘alternative’ conjunction (14%); in English, the difference (9% to 20%), while it approaches significance, does not quite rise to it ($p = .071$, $z = -1.470$).

L1 and advanced L2 speakers had identical levels of recursion (81.6%), while intermediate L2 learners scored significantly lower than both (54.6%). The latter group also had the highest conjunctive levels (16.5%), with this declining to 7.9% with advanced and 4% with L1 speakers. L1 speakers never dropped a PP in this category (0 of 76), while advanced speakers never dropped PP1 and only dropped PP2 at a rate of 2.6%. Intermediates, on the other hand, dropped PP1 at 4.6% and PP2 at 5.9%. The ‘alternative conjunction’ option was highest with intermediates (18.4%), who scored higher in this category than in normal conjunction. L1 speakers, however, still preferred this option twice as much (14.5%) as did advanced L2 (7.1%).

Both L1 and L2 speakers in English strongly prefer recursion, and at nearly identical rates (70% and 68%, respectively). Conjunction was only chosen 9% of the time by L1, rising to 16% with L2 speakers. ‘Alternative’ conjunction was a significant alternative to either of these, chosen more than twice as often (20%) as normal conjunction by L1, declining to 13% in L2, slightly less than ordinary conjunction.

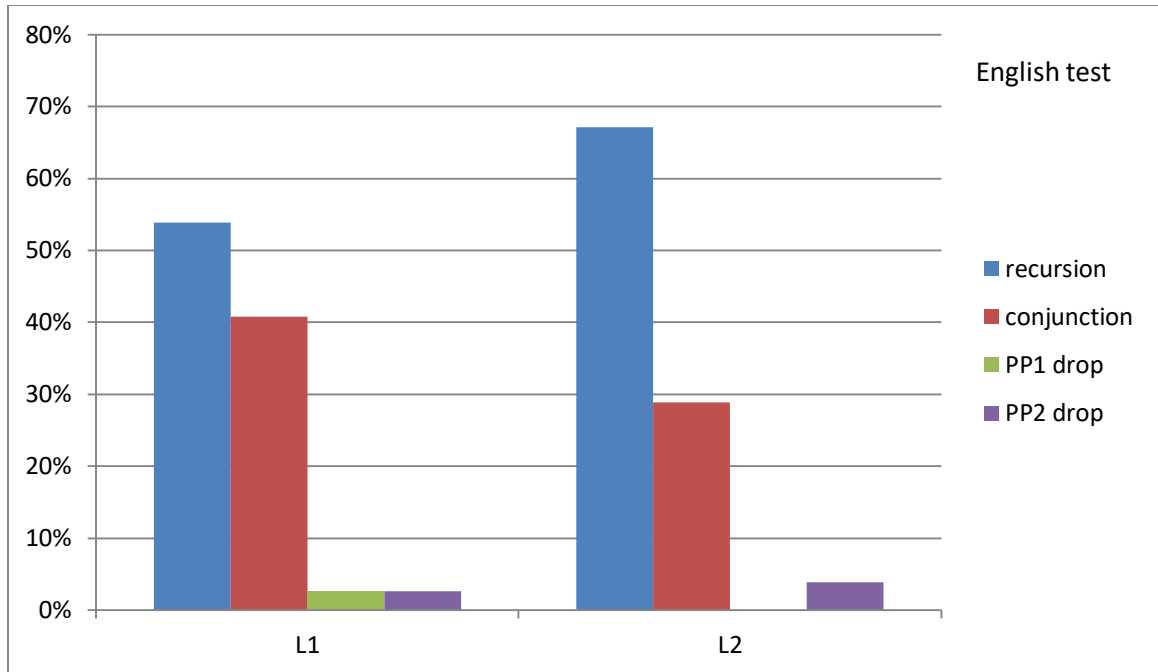
5.3.4.2 Two different heads

In the Spanish test, recursive interpretation in PPs with two different heads declined from L1 to L2A to L2B



46. Two different prepositions

As a group, there is a clear decline in recursive interpretations from L1 (63%) to L2A (59%) to L2B (51%), though the differences are not enough to be significant ($p = .235$, $T = 2.894$). Conjunction displayed less variety, increasing slightly from 30% (L1) to 34% (L2A) before declining again to 32% (L2B). Dropping either PP was minimal with the first two groups, although dropping PP2 was more common. L2B speakers dropped PPs more often, with both types not interpreted 9% of the time.



47. Two different prepositions in English

In English, recursive interpretations of two PPs with different heads actually increased from L1 to L2 (54% to 67%; $p = .054$, $z = 1.606$), the reverse of the observed tendency in Spanish. Conjunctive ones correspondingly declined (41% to 29%; $p = .050$, $z = -1.650$). PP dropping was minimal, from 0% to 4%.

5.3.4.3 Discussion 2

The data confirm the hypothesis that adjacent PPs headed by identical prepositions will trigger higher levels of recursion than adjacent PPs headed by different ones, although with qualifications. In SL1 and SL2A, the data very strongly support this premise. Both groups mark 82% recursion with identically-headed PPs, falling respectively to 63% and 59% with differently-headed ones, both with a p -value $< .01$; this higher recursion is achieved despite the fact that the items with identically-headed PPs offered a fifth alternative, and thus greater ambiguity (see below). SL2B, however, found scant

improvement, only favoring them 55% to 51% ($p = .28$). EL1 had a spread of 70% (identical) to 54% (different), a difference on the cusp of significance (.056), while EL2 subjects saw effectively no difference at all, 68% to 67%. Taken together, then, the hypothesis is certainly accepted, as far as Spanish is concerned, and provisionally in English for L1, provided further data confirm the findings. The results of the L2 groups however, bear more on the other hypotheses and will be dealt with in the sections pertaining to those.

What is more, the status of ‘alternative’ conjunction versus standard conjunction, a contrast only offered in questions featuring identical prepositions, can be seen here as well. In Spanish, in the 18% of responses that were non-recursive, 14% were ‘alternative’ while only 4% were standard ($p = .014$, $z = -2.201$). In English, the split was 20% ‘alternative’, 9% standard ($p = .071$, $z = -1.470$). Together these data suggest a preference even within types of conjunction, i.e. that ‘alternative’ conjunction, which gives a form of ‘preferential’ status to PP2 by attaching it physically closer to the head DP than PP1, is ranked higher than ordinary conjunction. It is also possible that speakers view this as a type of recursion given that it *appears* that each PP may attach only to one NP (meaning it has a physical similarity to standard recursion), as seen in (48).



48. The envelopes under the books under the pens, recursion (left) and alternative conjunction (right)

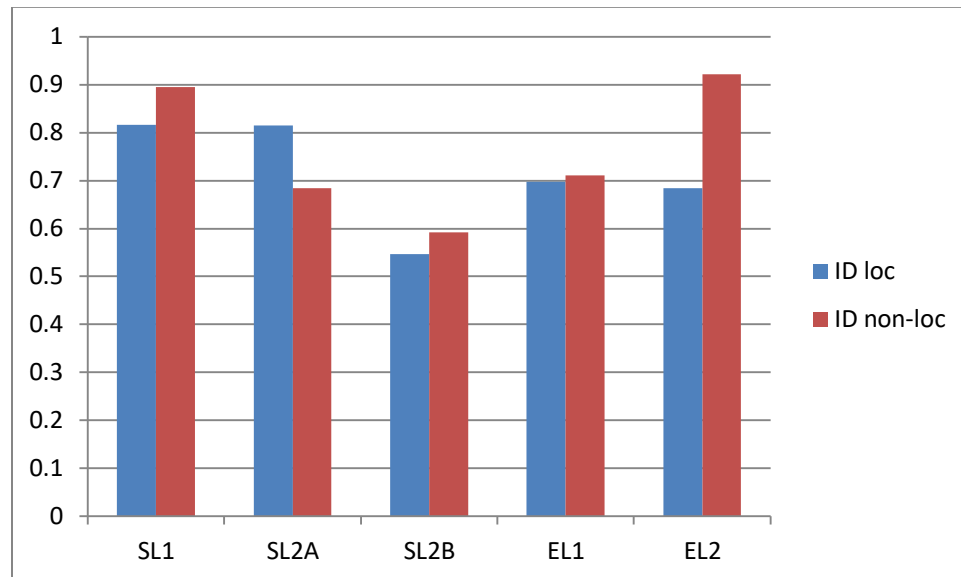
Despite several attempts, I did not generate any useful representations to distinguish alternative conjunction from ordinary two-level conjunction shown above in (37). Further studies would be needed to tease apart this difference.

The options for non-interpretation of either PP1 or PP2 obtained minimal results across the board; even SL2B, hypothesized to be the worst-performing group, only chose these in 5% and 6% of their responses respectively. It is likely that these responses reflected a broader confusion or misunderstanding of the material with this small minority of subjects in this group; in the other four groups of subjects this option returned 1% or fewer responses. Thus, at best, the inclusion of these options may have given a manner to identify confusion/non-comprehension levels among lower-level speakers.

5.3.5 Locative vs non-locative

Locative recursion for the most part was neither more nor less ambiguous than similar non-locative recursion. Comparing only the identically-headed set of PPs across the five

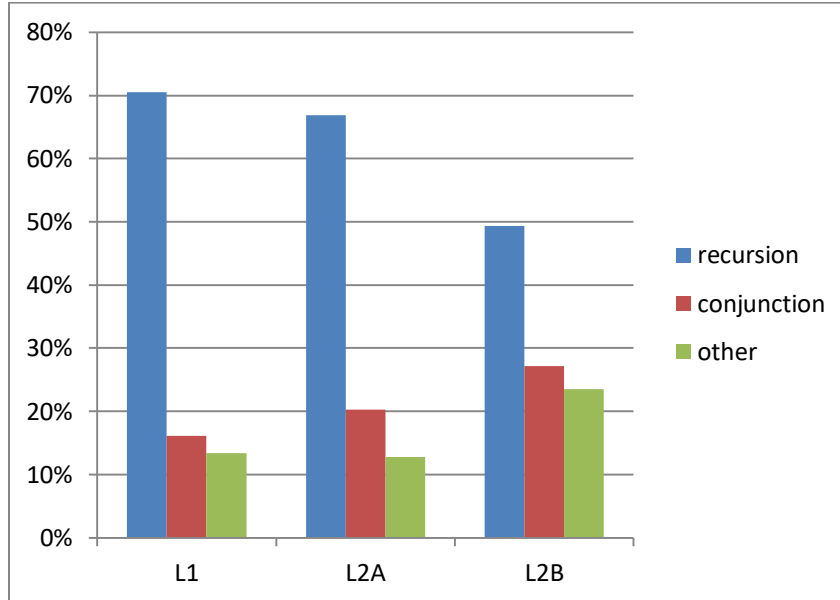
groups, L1 speakers of Spanish found the most recursive ‘benefit’ from the comitative with phrases, regardless of whether in L1 or L2 English.



49. Locatives and non-locatives

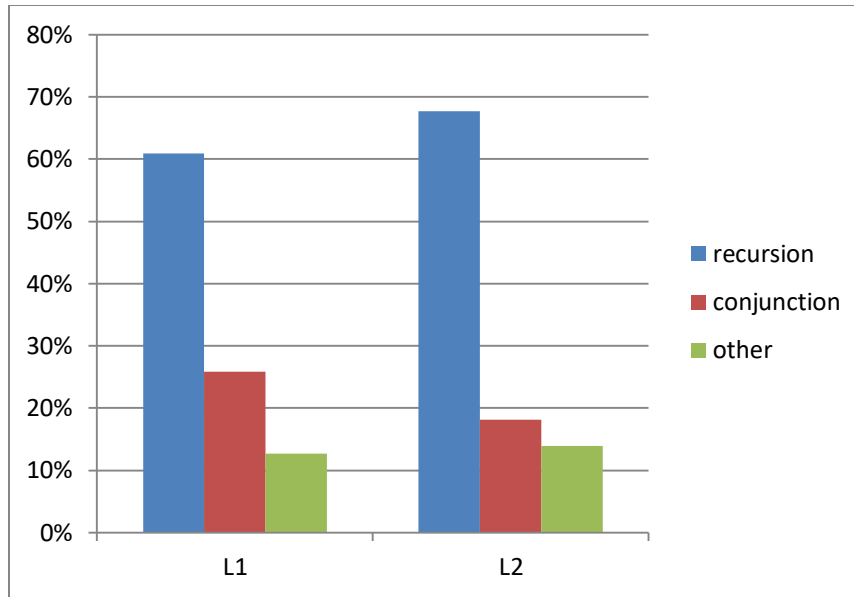
Although in SL1 non-locatives provide a slight bump in recursion, in EL2, the boost is quite strong (from 68% to 92%). SL2A actually suffers from the comitatives, dropping in recursion from 82% to 68%. There is nonetheless not enough here to suggest that locatives suffer from greater ambiguity than comitatives, as proposed. While it seems that may be true for L1 Spanish speakers regardless of language used (groups SL1 and EL2), it is unclear if that is an effect of the characteristics of the expressions in the language itself: in *the toy next to the cushion with the flowers*, it is possible that a flowered cushion is more strongly implied in Spanish than English.

5.3.6 An L2 path of acquisition



50. All PPs in Spanish

SL2B chose recursive answers the least often, at a rate of 49%; this rate rises to 67% with the advanced L2 learners (SL2A) and to 71% with SL1 speakers. The difference in recursive rates of the three Spanish groups (71%: 67%: 49%) was also significant ($p < .001$, $T = 17.3$), with significant differences between SL2B and both SL1 and SL2A. Their differences in conjunction (16%: 20%: 27%) were also significant ($p = .012$, $T = 8.872$), rooted in the difference between SL1 and SL2B.



51. All PPs in English

The difference in recursive rates (61%, EL1: 68%, EL2) between the two English groups was not significant ($p = .094$, $z = 1.314$); the conjunctive difference (26%: 18%), however, was significant ($p = .028$, $z = -1.912$). What is noteworthy, however, is that in English, L2 speakers have both higher recursion and lower conjunction than L1 speakers, the reverse of Spanish with L1 and L2A (see following section).

Intermediate L2 speakers also preferred answers other than recursion and conjunction more often than the other groups (24%); both L2A and L1 speakers opted for these answers 13% of the time respectively. However, as this 'other' category contains several options, it will be necessary to analyze it further as we begin to break down the questions into item types.

5.3.6.1 Discussion 3

In regards to the data comparing L1 and L2 speakers, in the broadest terms the hypothesis is both accepted and rejected. What is more, some differences arise as English and Spanish are analyzed that suggests that different operations may be at play.

Across all PP types, recursive rates are highest in Spanish L1, decreasing somewhat to SL2A and then significantly to SL2B; no significant difference was found between SL1 and SL2A. The results were similar for conjunction, although here the significance was rooted between SL1 and SL2B only (SL2A results did, however, fall between the two groups). The trend in preference for conjunction was reversed, with intermediate learners at 27%, advanced ones declining to 20% and native speakers at 16%. Analysis here only revealed a significant difference between groups L1 and L2B. Nonetheless, trends are important indicators, and the decline in conjunction moving from L2B to L2A to L1 should not be disregarded.

Lacking a 'lower level' L2 group, the English recursive results lacked any significant difference between EL1 and EL2, although conjunction did show significance. However, what the data show us in English is the reverse of what we learn in Spanish, as in English the L1 speakers have lower recursion (and higher conjunction) than the L2. Thus, the hypothesis in Spanish is partially accepted. SL2B speakers are found lacking in recursive ability compared to SL1 and SL2A; as a consequence, they tend to default more to conjunction. SL2A speakers, while marking marginally lower recursive and higher conjunctive interpretations, have nearly achieved 'native-like' ability in regards to recursive operations on PPs. In English, the hypothesis is rejected completely, as the

results are wholly reversed. What other conclusions we may draw from this are discussed below.

If the discrete item types are examined, we observe where L1 speakers gain the most, and the least, advantage. With identically-headed PPs (see figure (44)), SL2A have achieved identical rates of recursion to those of SL1, at 82%; these are far higher than the SL2B group, which only manages 55%. With a p-value below .001, this suggests that this type of PP structure is the easiest to acquire (or simply reactivate in an L2) in regards to its recursivity. Nonetheless, the two groups are split in terms of the two types of conjunction. SL2A chooses both types, standard and alternative, at equal rates, while SL1 prefers the alternative at more than three times the rate of standard conjunction.

In English (see figure (45), both EL1 and EL2 were virtually even in their recursive responses (70% to 68%). Interestingly, in this set of data, L2 English speakers no longer ‘outperform’ L1 speakers. There is still greater diversity in preference for types of conjunction. The combined data of English and Spanish would suggest that identically-headed PPs offer much greater facility for L2 speakers to achieve ‘native-like’ competence at recursive operations. Furthermore, the Spanish data would tend to support the hypothesis of lower-level speakers not achieving recursion on a par with more advanced, or native, speakers.

In PPs using different heads in Spanish (see figure (46)), we observe a (expected) decline in recursion from SL1 to SL2A to SL2B. The differences here are not statistically significant, though reflective of the overall trend. This could be seen as evidence that, while SL2A speakers have largely worked through the ambiguity inherent in two PPs,

grasping recursion with two different heads may take longer in the L2 than ‘reactivating’ the recursion with identical heads. The greatest drop in recursion is still seen in SL2B. Unusually, all groups have nearly unvarying levels of conjunction. In English (see figure (47)), however, the anomaly observed earlier reasserts itself. L2 speakers’ higher recursion and lower conjunction have p-values strong enough (.054 and .05, respectively) that the differences cannot be discarded. Nonetheless, while the Spanish data might provide support for the hypothesis, the English data wholly rejects it.

Group SL2B provides the key differences in examining three PPs (see figure (39)). While SL1 and SL2A again achieve identical rates of recursion (59%), the intermediate group only reaches 38%, a significant difference. The conjunction data supports this, with SL1 and SL2A almost identical (18% and 20%) and a large rise in SL2B (32%) that is nearly significant ($p = .054$). Both sides of the Spanish data, therefore, lend support to the broader hypothesis.

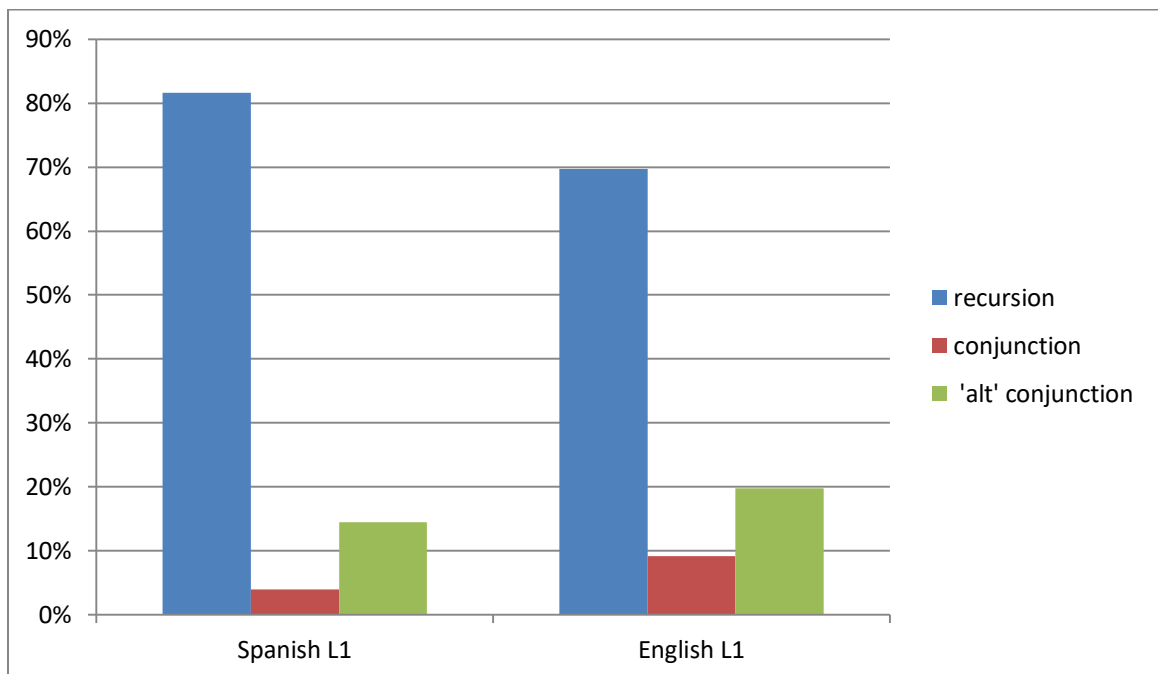
The English data (see figure (40)), however, again undermines what Spanish has shown. EL2 speakers are more recursive (58% to 55%); they are also less conjunctive (16% to 26%), a difference which reaches significance ($p = .048$). Taken together, the data from the two languages contradict each other, and Spanish seems to accept the hypothesis while English rejects it.

Nonetheless, apparently the strong recent exposure, as measured by University courses completed, to Spanish seems to be the decisive factor in increasing this ability. SL2A’s mean age was 22.5 years to SL2B’s 20.1; it is assumed that this small age difference was not a factor. Both groups first started studying Spanish around 12 years old. The

intermediate group in fact had marginally higher exposure pre-high school (2 years to 1.7 years) while both groups had an identical amount of high school input at an average of 3.6 years. There was not consistent enough information about study abroad or other foreign languages to make a confident claim concerning their effect. SL2A had over four times as much exposure when it comes to university-level courses in the target language, 10+ courses to SL2B's 2.5 course average.

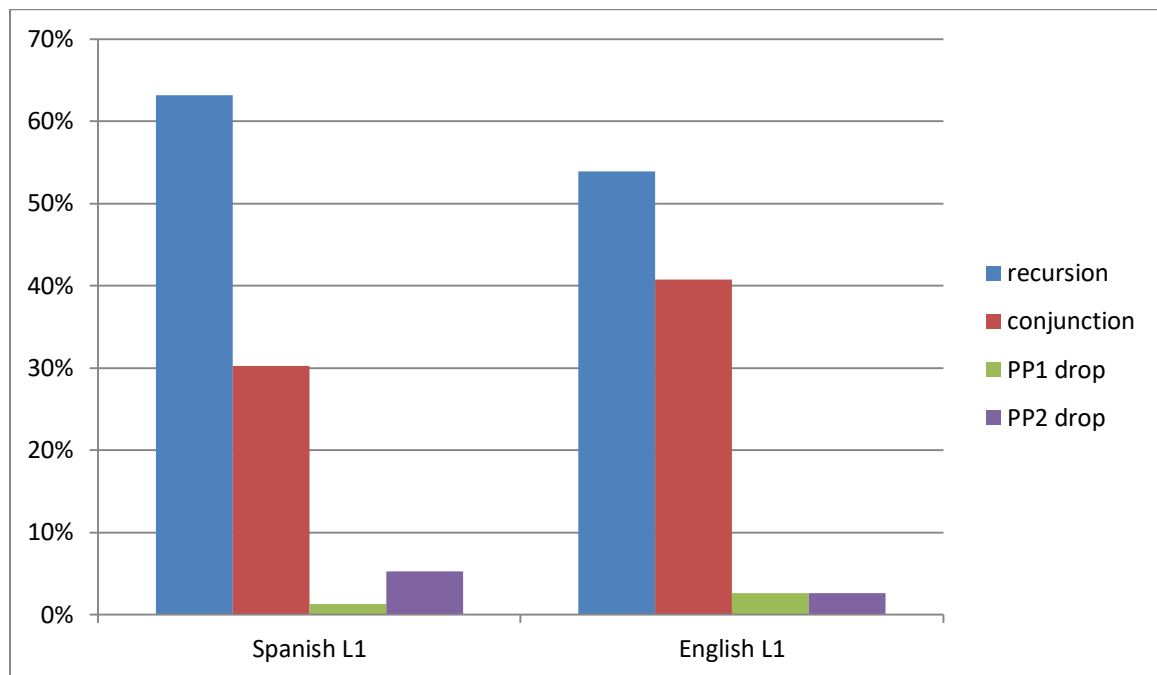
5.3.7 Spanish vs English

In comparing the full results of Spanish and English L1 tests, the recursive difference (71% to 61%) was found to be significant ($p = .049$, $z = -1.971$); even greater significance was observed in the conjunctive difference ($p = .013$, $z = 2.496$).



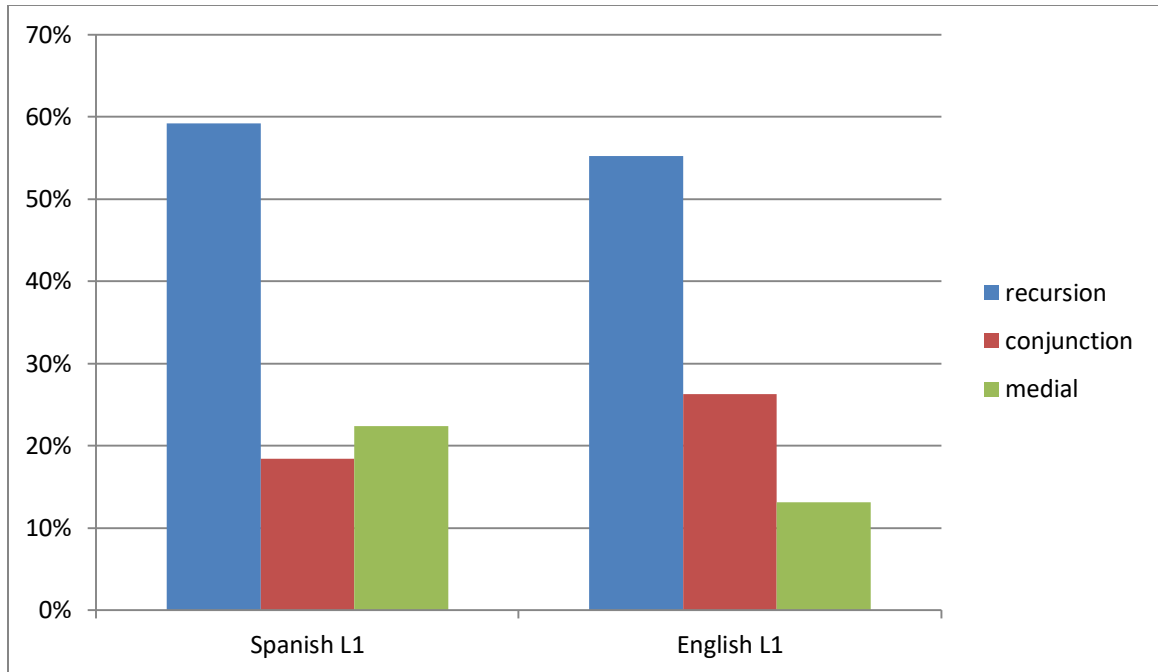
52. Two identical prepositions in Spanish and English

SL1 was recursive at 82% while EL1 only reached 70%, though the difference did not prove to be significant ($p = .343$, $z = -.949$). The difference in standard conjunction, while more pronounced at 4% to 9%, also lacked significance ($p = .381$, $z = .876$), as did the ‘alternative’ conjunction differences (14% to 20%; $p = .861$, $z = .175$). Interestingly, though, in both groups, ‘alternative’ conjunction was favored more than twice as often as standard conjunction.



53. Two different prepositions in Spanish and English

Comparing Spanish to English, there was some cross-linguistic variation. Spanish was more recursive (63%) than English (54%; $p = .14$, $z = -1.08$) while English was more conjunctive (41% to 30%; $p = .105$, $z = 1.255$). PP dropping was minimal across both languages.



54. Three PPs in Spanish and English

Across the two languages, Spanish L1 was slightly more recursive than English L1 (59% to 55%; $p = .693$, $z = -.394$), while EL1 was more conjunctive (26% to 18%; $p = .737$, $z = -.336$). The difference in medial interpretation was more pronounced, with SL1 at 22% to EL1 at 13% ($p = .148$, $z = -1$).

The comitatives have the most marked contrast between English and Spanish of all (see figure (49)). Spanish is here more recursive 89%: 71%, with a p-value of .08, while English prefers conjunction 29%: 5%, p-value at .025.

5.3.7.1 Discussion 4

Regarding the hypothesis that “recursive and conjunctive tendencies will be similar cross-linguistically,” the data are enough to reject it, at least as far as it can be seen as an absolute. As this comparison was made across several different points, each shall be assessed. Certainly looking at the combined results of all PP types, the hypothesis is

rejected, as a significant difference appeared not only in the stronger preference for recursion ($p = .049$) in Spanish but also in the preference for conjunction ($p = .013$) in English. L1 Spanish is fully 10% more recursive than L1 English (71% to 61%), while English is fully 10% more conjunctive than Spanish (26% to 16%). This suggests that factors other than the apparent surface similarity of structures and available recursive operations.

Identical prepositions also reveal a stronger preference for recursion in Spanish than in English (82% to 70%). English preferred not only more standard conjunction than Spanish (9% to 4%) but also ‘alternative’ conjunction (20% to 14%). While these data are mitigated by the fact that the smaller number of items meant that the differences did not achieve significance, they are nonetheless noteworthy in that they dovetail with the broader data just seen, i.e. the higher recursivity of Spanish and the higher conjunctivity of English, in relation to each other.

This is again observed with the set of different heads in two adjacent PPs. Spanish achieves 63% to only 54% of English, with conjunction flipping to 41% English, 30% Spanish. As before, this does not quite achieve significance yet conforms to the observed trend.

With the set of three PPs the trend is the same, though much less marked than before, Spanish being higher in recursion (59% : 55%) and English in conjunction (26% : 18%). The wild card in this set is the medial interpretation, which Spanish preferred more than English (22%: 13%). While the first two differences do not approach significance, the difference in medial is much stronger ($p = .148$). How much to read into this in regards to

the languages' preferences for recursion and conjunction is unclear, although certain possibilities present themselves. One is that if, in PPs, Spanish is 'more recursive' than English, which is in turn 'more conjunctive' than Spanish, a differing preference for medial may suggest how it is processed by the listener. To move beyond conjunction, the listener must at least process one level of recursion to make a medial attachment. Thus, if a language (Spanish) truly prefers recursion more than another language (English) in this scenario, then it should also prefer medial more than the other language; this is observed in the data. The alternative theory would be that a medial interpretation is presenting a form of conjunction wherein the PP is interpreted parallel to the preceding PP. In this version, if a language (English) were more conjunctive than another (Spanish), then it should also prefer a medial interpretation more strongly. This, however, is not suggested by the data, and would be considered unlikely.

Together these data suggest that Spanish is inherently more recursive than English as far as PP interpretation goes. The root of this difference may lie in the productivity of different types of recursive operations in the languages. As noted earlier, English productively licenses both right-branching recursion as seen here, and left-branching recursion (which is, however, less productive) such as the Saxon genitive 's'. Only right-branching recursion, however, obtains in Spanish. Spanish speakers, then, have only fully activated a right-branching recursive 'algorithm'.

5.4 Summary Discussion

As the results are seen in light of the original research questions and hypotheses we can see that some questions are more clearly answered than others, and that, while some

hypotheses are accepted, others are rejected; the data were not necessarily conclusive to determine the validity of other hypotheses.

These data, in fact, run against the hypothesis that L1 prefers recursion more and L2 conjunction more, the reverse of what was seen in the Spanish data.

Comparing the two sets of data (while excluding that of L2B in Spanish, which has no counterpart in the English data), recursion dropped slightly from L1 to L2A in Spanish (71% to 67%), yet increased from L1 to L2 in English (61% to 68%), suggesting that the hypothesis is correct in one language and false in another language. Thus, other forms of analysis are required. L1 recursion is found to not be identical in the two languages, despite the surface similarities. L1 Spanish is fully 10% more recursive than L1 English (71% to 61%), suggesting that consecutive PPs simply trigger higher rates of recursion in Spanish than in English. L1 English is also found to be fully 10% more conjunctive than L1 Spanish (26% to 16%), which suggests the logical corollary to the above, that English PPs are inherently more conjunctive than their Spanish counterparts.

If we make the assumption, then, that Spanish is more recursive and English more conjunctive, are there observable transfer effects in the data? L1 English speakers are recursive at a rate of 61% in English and 67% in L2A Spanish, suggesting that English speakers are able to surpass the L1 limitations of recursion while not quite able to reach the recursive levels of L1 Spanish. With conjunction, L1 English chose this 26% in English, the same rate as L1 English did in group L2B (L2A approached L1 Spanish speakers in Spanish).

L1 Spanish speakers are recursive at very similar rates in both languages, 71% in Spanish and 67% in English, with the rate in English significantly above that of L1 English speakers in English. This similarity carries over into conjunctive interpretations, which L1 Spanish speakers chose at 16% in Spanish and 18% in English.

This preliminary analysis of the data suggests several ideas. One is that the input hypothesis regarding recursion is supported by the evidence, partially. In Spanish, since the L2B group was recursive at a rate far below (and conjunctive far above) that of L2A, which was also below that of L1, input is likely to be a factor in recursive interpretations in L2. This input would also seem to be a key factor in the decline, if not the extinction, of conjunctive interpretations. The English data, however, do not support the hypothesis, but neither does it necessarily refute it, due to the absence of an intermediate L2 group in the English results. The fact that L2 English speakers are more recursive than L1 English speakers is very likely attributable to the higher (right-branching) recursive nature of the L1, Spanish, of these speakers. This can, in fact, be termed a form of ‘transfer’, as Spanish speakers carry over stronger recursive tendencies to English than L1 English speakers themselves use.

The raw data in Spanish suggest the validity of the primary hypothesis, that L1 speakers prefer recursion more than L2 speakers, and that advanced L2 prefer it more than intermediate L2. Concurrently, this trend is reversed with conjunction, which is preferred most often by intermediate L2 and least by L1.

5.5 Participant analysis

While the preceding analysis was the extent of the original intent of the project, considerable variability exists not only among the individuals' responses but also in the behavior of discrete items in groups—enough to merit a closer examination of the data along these lines. Charting the individual responses within groups by plotting recursion against conjunction reveals some interesting trends:

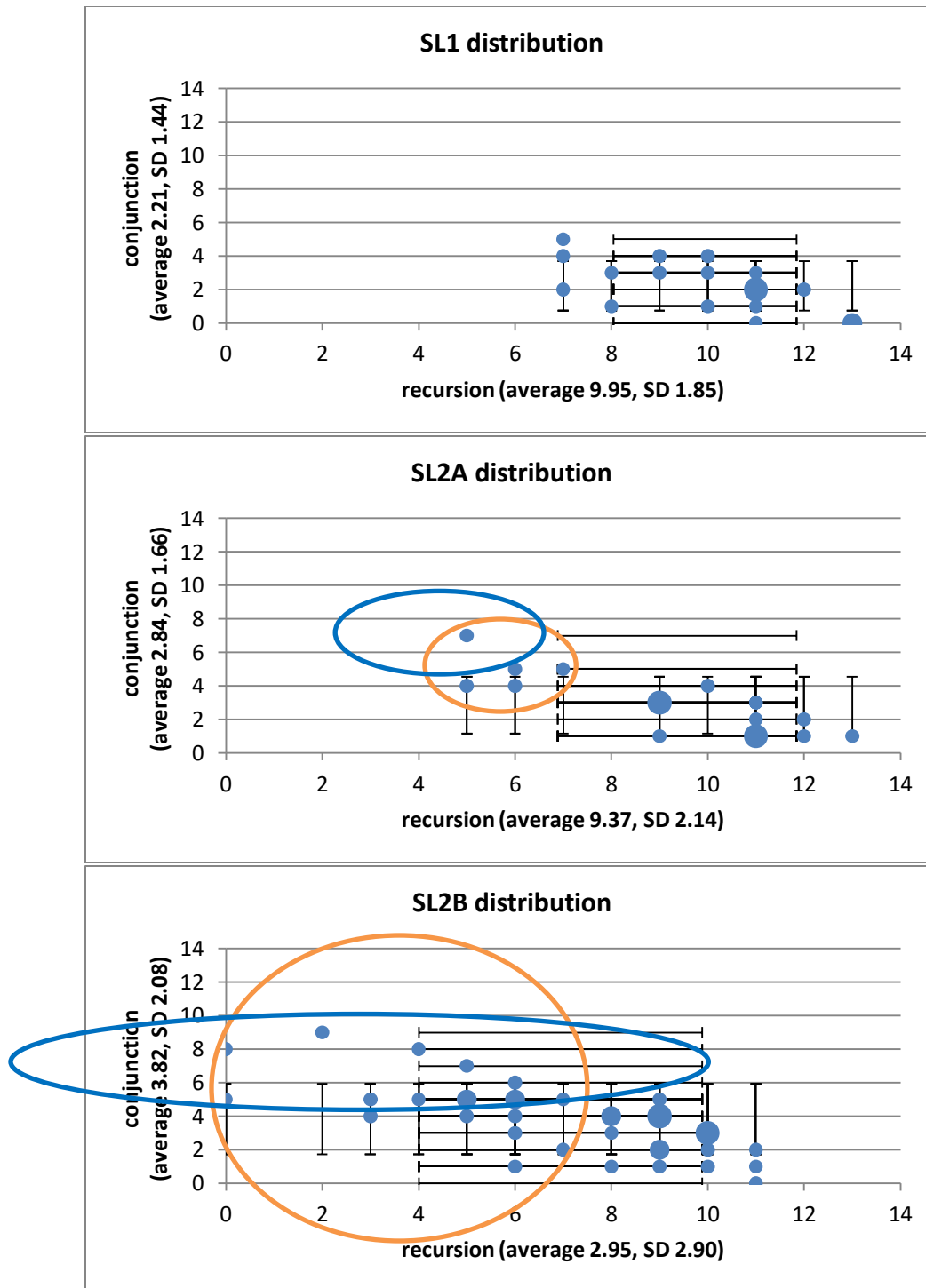


Table 1. Participant response distributions (Spanish)

In order to make some inferences here we must make some assumptions. If the data points in the top chart, that of Spanish L1 speakers, represent a ‘final state’ grammar

regarding recursion and coordination in PPs, then the limits described by the Standard Deviation bars are the boundaries within which we will find typical L1 Spanish speakers. Indulging in some rounding, that gives average ranges of conjunctive answers from 1-4 (out of 14) and of recursive answers from 8-12 (out of 14).

If there is a mechanism or algorithm that must be triggered to enable maximum potential in recursion, the sample data points above that are within the red ovals could be construed as to not have this mechanism fully operational in L2, whereas those outside of the rings are effectively no different from L1 speakers. The data points in the blue ovals are those whose conjunction use is still higher than L1. In SL2A, all but five subjects (of 19) display what are, effectively, SL1 levels of recursion and conjunction. All five fall short of target levels of recursion, yet only three surpass target levels of conjunction. In SL2B, nearly half (18 of 38) achieve L1 levels of recursion and conjunction, leaving 20 outside the bars. Of those 20, all but one are below target recursion while only 14 still exceed target conjunction (all but one of these are outside both SDs for recursion and conjunction. What this may indicate is that before the full activation of any mechanism enabling greater recursion takes place, a 'deactivation' of the preference for conjunction is already underway. Thus, in an L2 speaker striving (subconsciously, of course) for L1-like levels of conjunction and recursion, first they achieve L1 levels of conjunction by constraining that operation somehow, and afterwards fully enable the recursive device. It may not be too much to suspect that the relationship here is causal; i.e. first a speaker must learn to restrain conjunctive operations more before they can activate the recursive mechanism or algorithm.

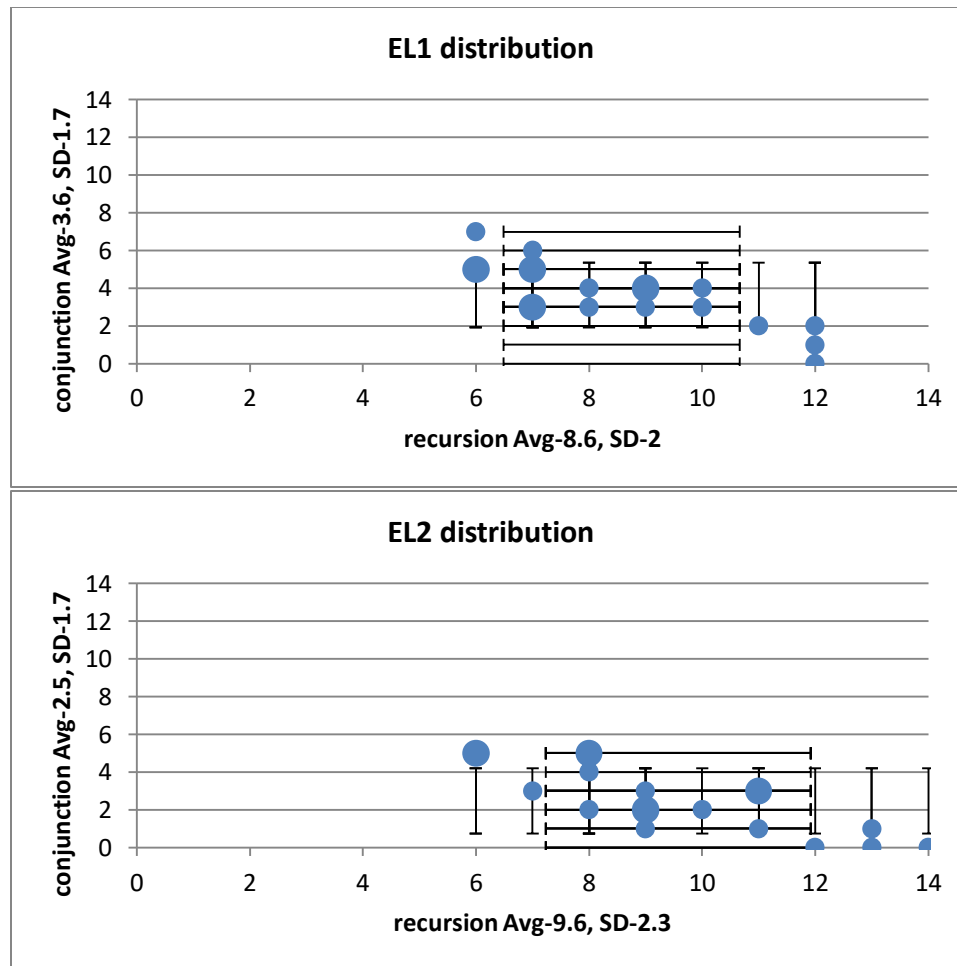


Table 2. Participant response distribution (English)

None of the speculation above, however, is evidenced in the English data. It could be argued, though, that L2 speakers here have already passed through both stages suggested above.

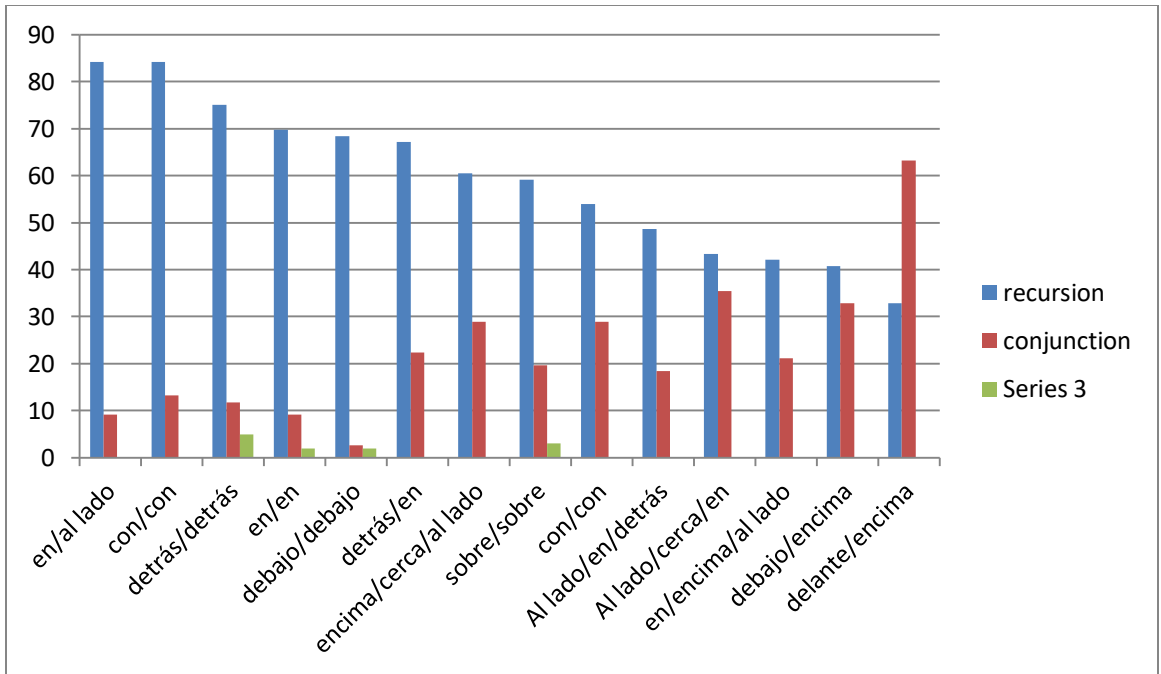
5.5.1 Discussion

Can any of this be seen as evidence of UG in SLA? Perhaps, or it simply may be a case of L1 transfer. Clearly the interlanguage grammar developing in L2 speakers demonstrate that something is happening akin to UG access while showing elements of L1 transfer, precisely the problem pointed out by White (2000, see above). L1 English speakers

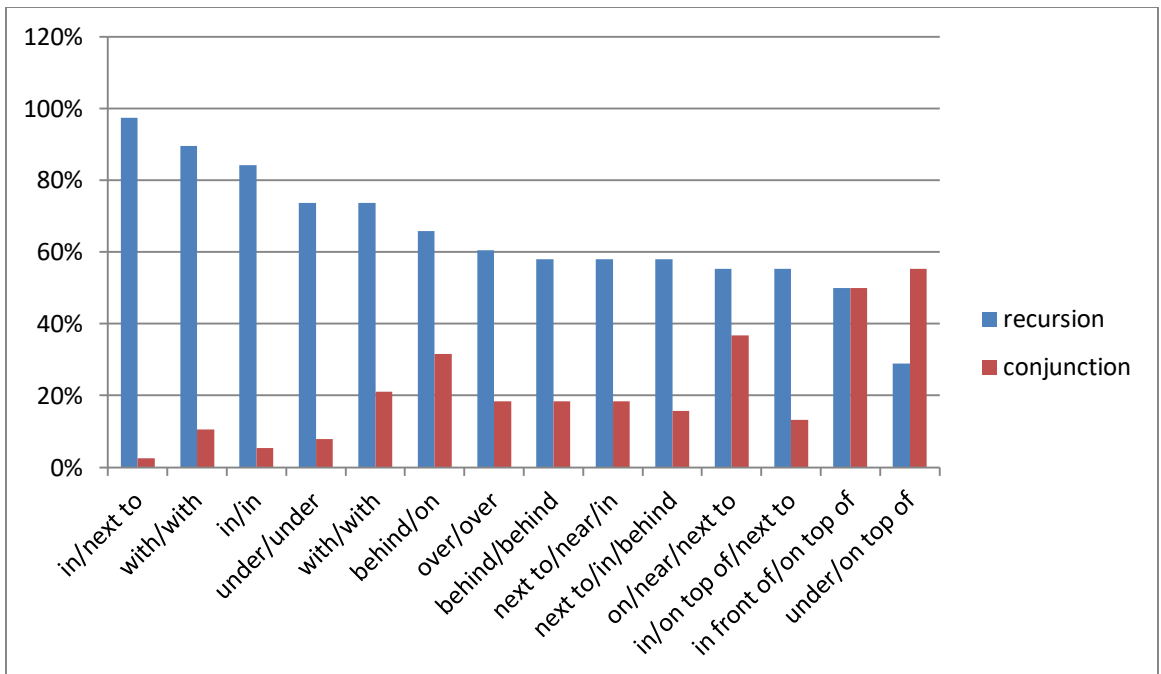
initially struggle to produce target levels of recursion in L2 Spanish before eventually succeeding (for the most part). L1 Spanish speakers, on the other hand, surpass target levels of recursion in L2 English, achieving levels nearly comparable to L1. This seems to argue more strongly for a case of L1 transfer. If corroborated by future work, the notion that Spanish more strongly applies recursive operations to right-branching structures (or at least to PPs) than does English, this would possibly explain L1 Spanish speakers' performance in L2 English.

5.6 Item by item analysis

Considerable diversity was apparent with the data for each question type; as such, the data were broken down into individual items to see what might become apparent. While the original design created the several groups across the two languages as described previously, additional trends were distinguishable as the items were teased apart into their discrete components.



55. Item breakdown in Spanish



56. Item breakdown in English

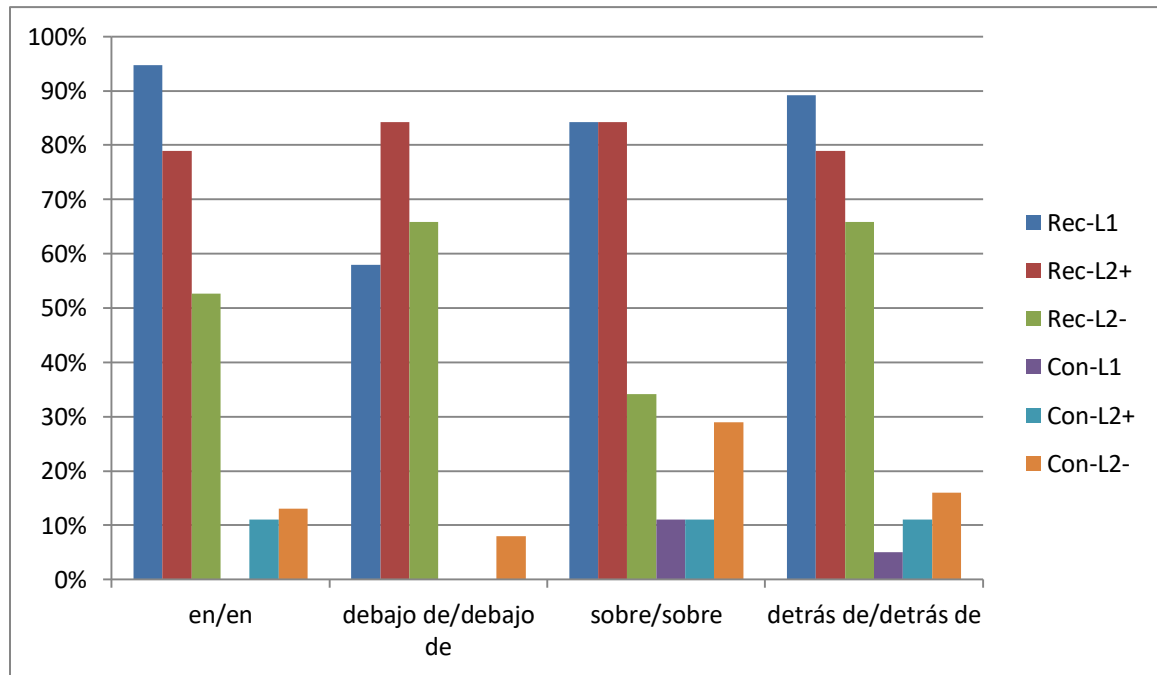
Item by item, clear similarities are apparent in the data from the two languages. Most obviously, the items at the left and right sides of the charts are the same. On the left side, *en/al lado de* and *in/next to* trigger the highest rates at 84% and 97%, followed by *con/con* and *with/with* at X and Z respectively. On the right, the same two items also coincide in both languages, *debajo de/encima de* and *under/on top of*, and *delante de/encima de*, *in front of/on top of*, for the lowest recursion of all, with all items only triggering from 25% to 50%. These items containing PP2= *on top of/encima de* were equally the most conjunctive by a very wide margin

Clearly, the individual heads of each PP convey much more than simply location. Some prepositions are transitive: if x is over y and y is over z, then x is also over z; while others are intransitive. If x is next to y and y is next to z, then x is not necessarily next z (although it may be). Given the evidence above, then, transitivity would be a hindrance on recursion, while intransitivity would favor recursion.

Despite the clear differences evident between results in the data separated by question type, internally, these types do not enjoy much homogeneity in their preference for recursion and conjunction. Further differences exist between the individual items themselves and must be discussed. For the sake of clarity, the data are broken up by PP heads, first focusing on the main contrast between recursion and conjunction, afterwards examining the alternative interpretations.

L1 speakers demonstrated very high (>84%) rates of recursion with three items, yet one, *debajo de/debajo de (under/under)* was lower at 57.9%; this item did not have the same

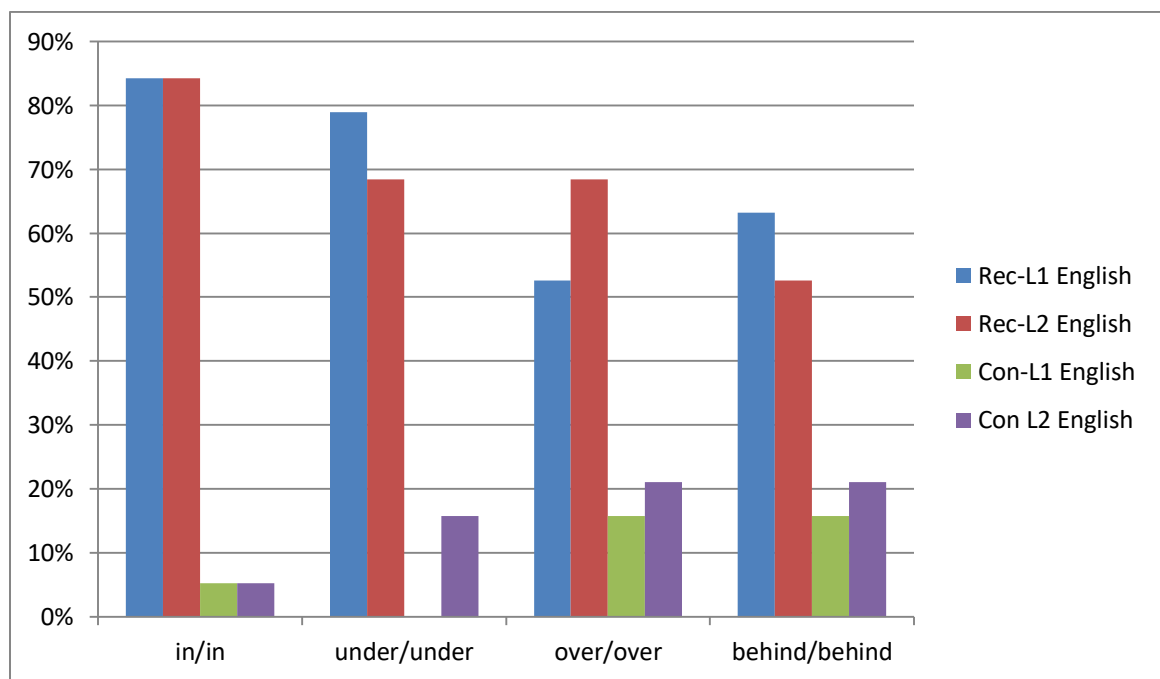
effect with either group of L2 speakers. Advanced L2 produced uniform rates of recursion across the four items, ranging from 78.9% to 84.2%.



57. Recursion and conjunction by item in two identical preposition items in Spanish

The hypothesized decline in recursive interpretation from L1 to L2 advanced to L2 intermediate is apparent in two items, *en/en* and *detrás de/detrás de* (*in/in* and *under/under*); these two also show a corresponding increase in conjunction over the same groups. *Sobre/sobre* (*over/over*) is identical for the first two groups at over 80% yet 50% lower for the intermediate speakers. Nonetheless, this latter group scores higher (65.8%) than L1 speakers (57.9%), who have the lowest rate of recursion, in the remaining item, *debajo de/debajo de* (*under/under*), while advanced L2 speakers scores the highest of all, at 84.2%.

L2 intermediate speakers had higher rates of conjunction in all items than did the other groups. The increase in conjunction from L1 to L2 intermediate is effectively reversed in the same two items that showed the steady decline in recursion above, *en/en* (which in fact had 0% conjunction with L1) and *detrás de/detrás de*. *Debajo de/debajo de* had 0% conjunction for L1 and L2A.

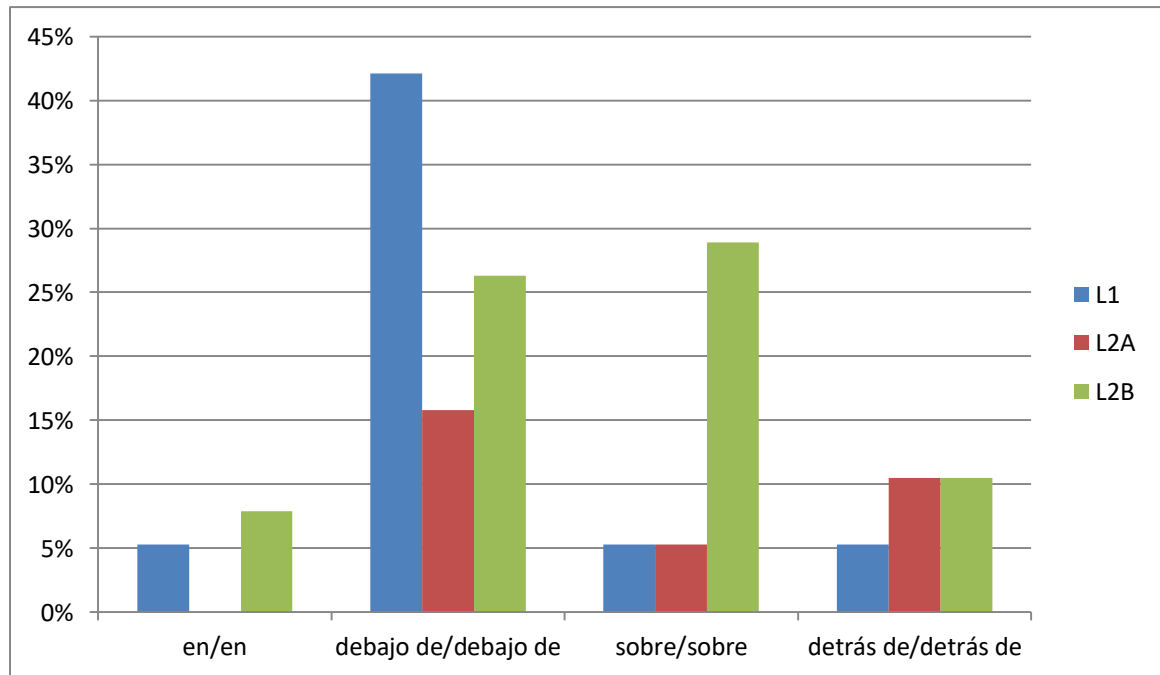


58. Recursion and conjunction by item in two identical preposition items in English

In English, the two PP chains which show a ‘standard’ progression are *under/under* and *behind/behind*, both of which show recursion declining and conjunction increasing from L1 to L2. *In/in* had the highest rates of recursion (84%), which were identical for both groups of speakers, as well as identically low rates of conjunction. *Over/over* data are somewhat anomalous; although the conjunctive readings match with those of

behind/behind, the recursive trend is reversed, with L2 speakers preferring it at 68% but L1 at only 53%.

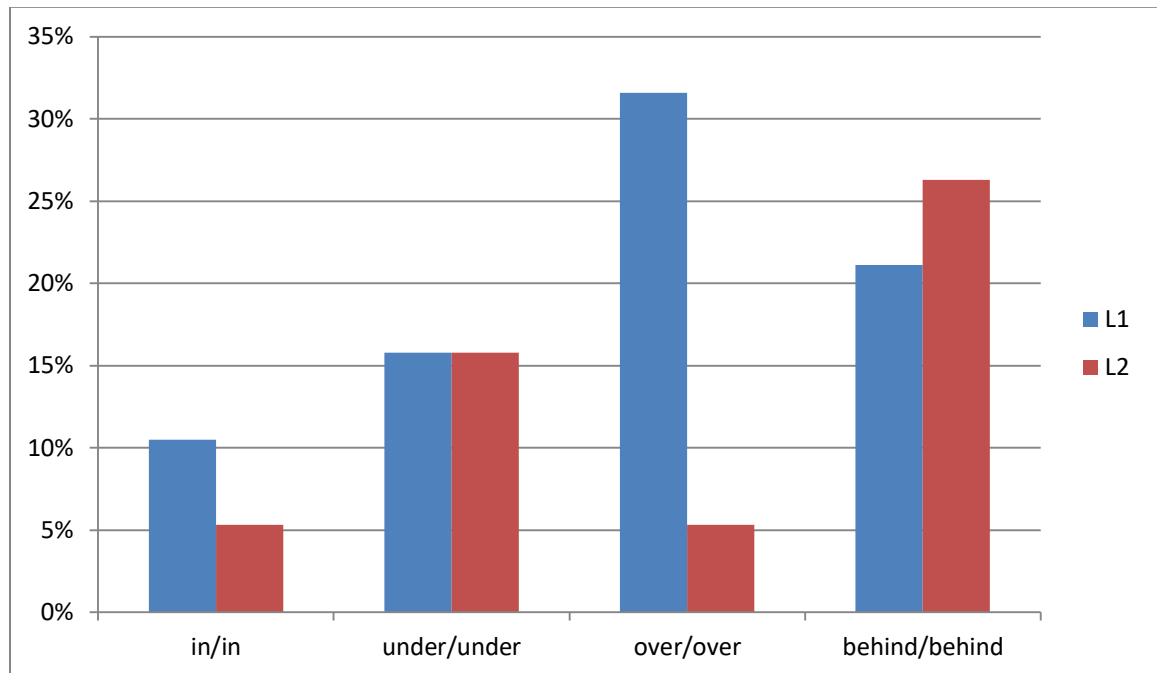
The data suggest that language-specific recursion may boil down not only to types (locative PPs, for example), but also to individual prepositions. While *under/under* triggers strong recursive responses in English, its counterpart in Spanish, *debajo de/debajo de*, lags far behind the other Spanish items with identically-paired prepositions. Meanwhile, the case is perfectly reversed with *over/over*, high in Spanish but low in English.



59. ‘Alternative’ conjunction by item in two identical prepositions in Spanish

L1 speakers only chose this option 5% of the time with three of the pairings; L2 speakers were marginally higher, except with *sobre/sobre* (*over/over*), where L2B speakers reached 29%. The clear standout here is *debajo de/debajo de* (*under/under*), with L1

speakers at 42%, the only option chosen by them for this item other than recursion. This declined to 16% with L2A before increasing to 26% with L2B.

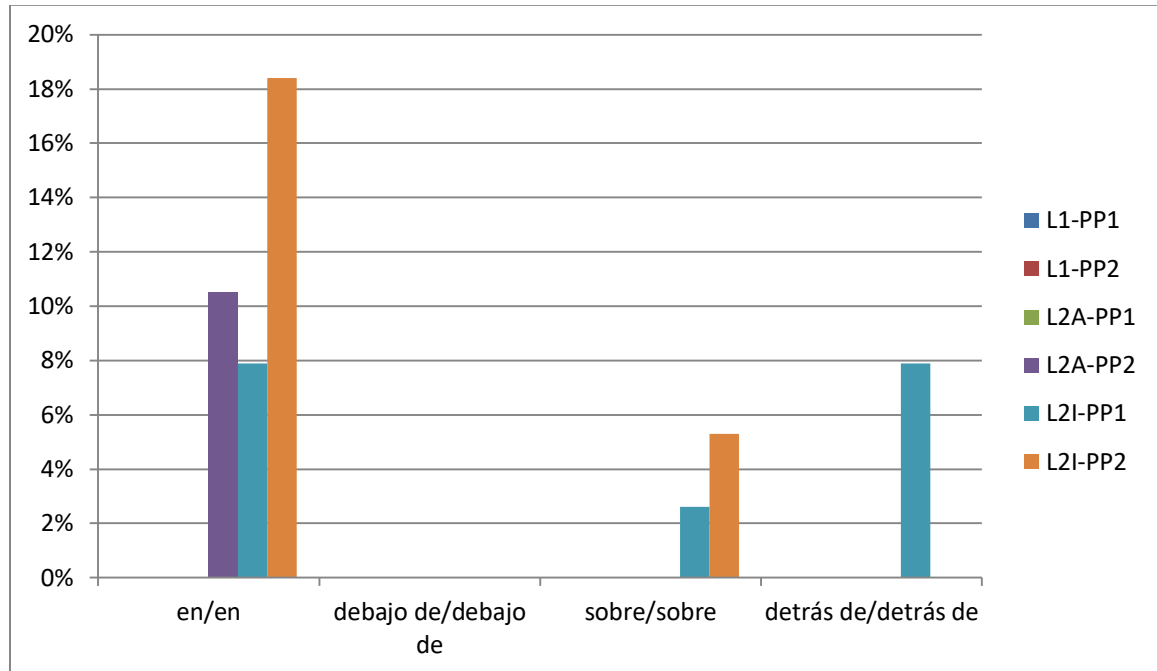


60. 'Alternative' conjunction by item in two identical prepositions in English

The preference in English for this type of conjunction does not mirror that of Spanish. *In/in* shows the lowest level, although L1 chooses this at twice the rate of L2 (11% to 5%). *Under/under* showed none of the disparity of its counterpart in Spanish, *debajo de/debajo de*, with both groups at 16%. *Over/over* found wide disparities between L1 (32%) and L2 (5%); this effectively represents a reversal of the tendency seen in Spanish, where L2B speakers chose the Spanish equivalent at much higher rates than L1 and L2A.

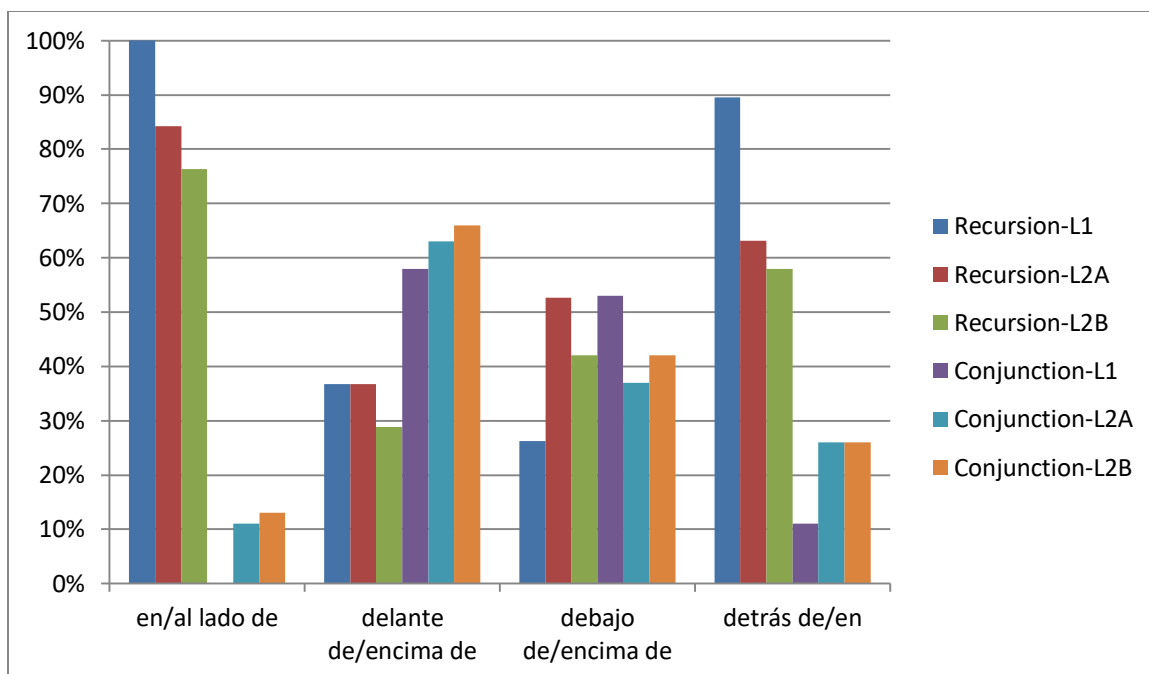
As with recursion, *under/under* and *over/over* display marked incongruities across the two languages. In Spanish, *debajo de/debajo de* is the *only* PP set which triggers a strong 'alternative conjunction' response; its counterpart in English, *under/under*, however, is unremarkable; while *over/over* stands above the rest for this response in English, in

Spanish its translation *sobre/sobre* returns minimal responses. Perhaps the key lies with SL2B, the only group to return a high response rate for both items.



61. PP 'dropping' by item in identical prepositions in Spanish

L1 speakers always interpreted both the prepositional phrases across the four items. L2A speakers only dropped a PP in one case, *en/en* (*in/in*), and then only the second one, at 11%. L2B speakers dropped more PPs in this item than elsewhere, dropping PP1 8% of the time and PP2 18% of the time. L2B also dropped PP2 more than PP1 with *sobre/sobre* (*over/over*), but only PP2 with *detrás de/detrás de* (*behind/behind*) at 8%. The greater need to ‘simplify’ these operations by deleting PPs was most noticeable in *en/en*.

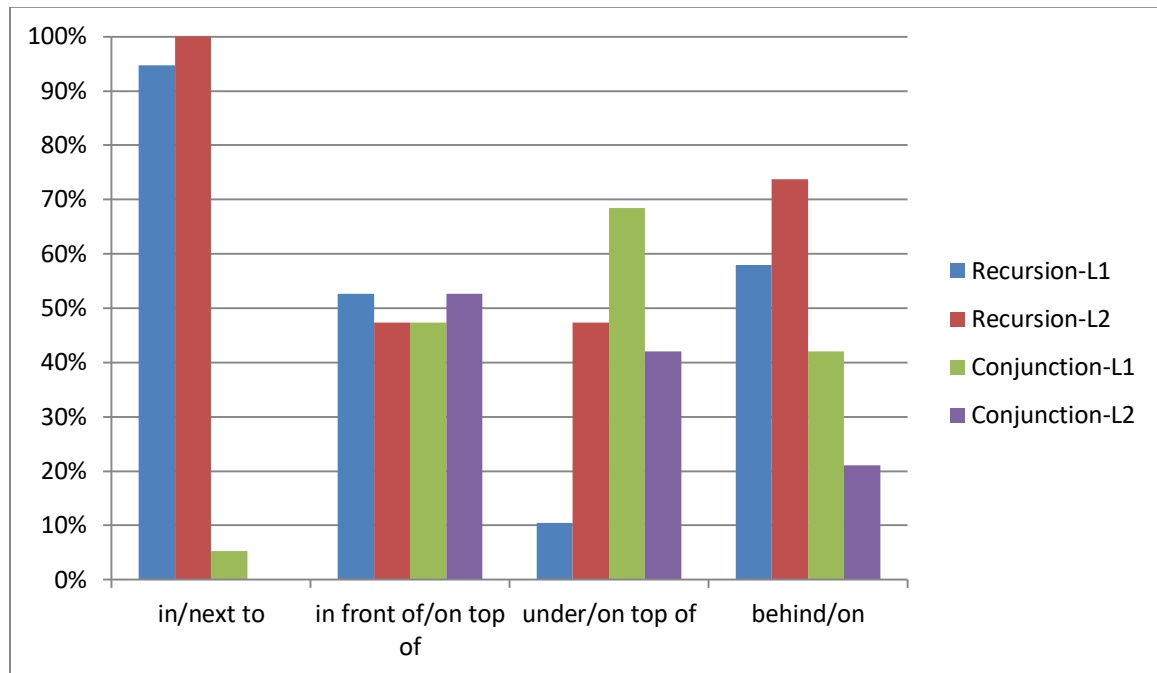


62. Recursion and conjunction by item with two different prepositions in Spanish

As with identical prepositions, only two pairings showed steady increase in recursive interpretations along with input, *en/al lado de* (*in/next to*), which was unique in achieving a 100% recursive rate in L1) and *detrás de/en* (*behind/in*); these were also the two with the highest recursion in all groups. The other two had markedly lower rates, with L1 and L2A speakers only at 37% for *delante de/encima de* (*in front of/on top of*), declining to under 30% for L2B. *Debajo de/ encima de* (*under/on top of*) showed a doubling of recursion from L1 (26%) to L2A (53%) before dropping to 42% with L2B.

Delante de/encima de (*in front of/on top of*) triggered the highest conjunction, increasing from 58% in L1 to 66% with L2B. *Debajo de/ encima de* (*under/on top of*) also reached above 50% conjunction with L1, yet here declining to 37% with L2A and 42% with L2B. L2 speakers chose conjunction 26% with *detrás de/en* (*behind/in*), well above L1

speakers at 11%. Finally, *en/al lado de* (*in/next to*) was not conjunctive at all in L1, and only at 11% and 13% with L2A and L2B respectively.

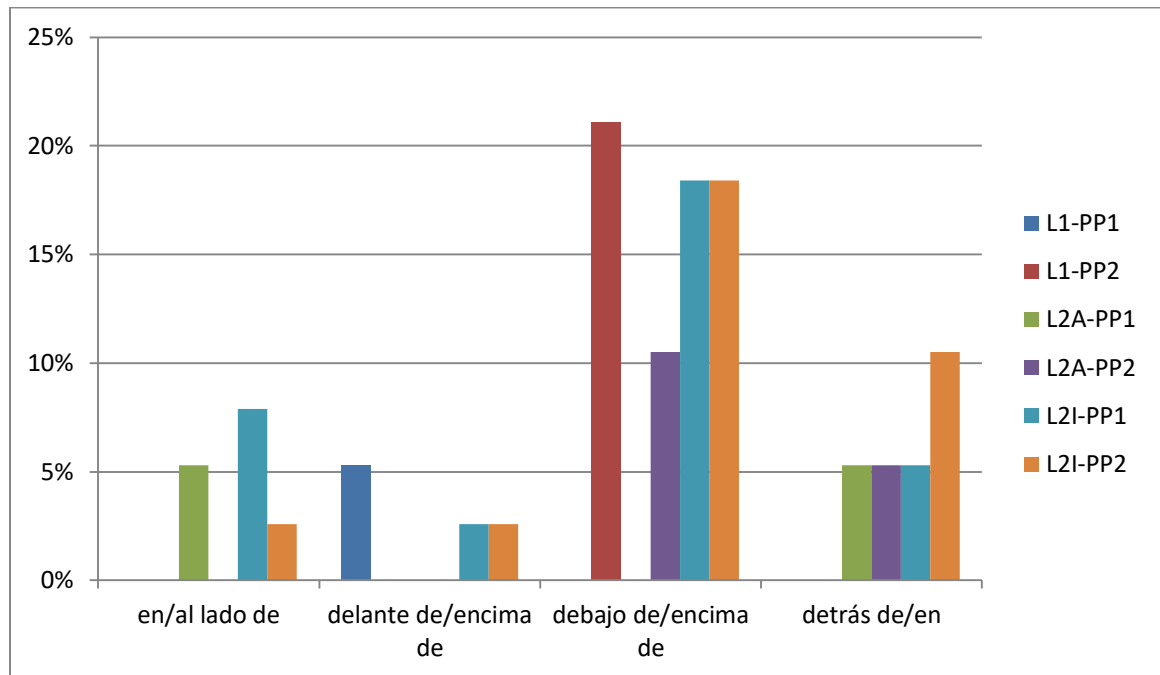


63. Recursion and conjunction by item in two different PPs in English

In/next to reached the highest recursive interpretations for the set, with L1 at 95% and L2 at 100%; the remaining 5% in L1 were all conjunction. The other items were all much lower in recursion, but hardly uniform in their results. *In front of/on top of* displayed virtually equal interpretations for recursion and conjunction, varying from 47% to 53%. L1 found *under/on top of* recursive only 11% of the time, strongly favoring conjunction at 68%. L2, on the other hand, were recursive 47% and conjunctive only 42%. The increase in recursion from L1 to L2 was observed as well in *behind/on* (58% to 74%), as was the decrease in conjunction, which halved from L1 (42%) to L2 (21%).

Most notable here is the parallel between *in/next to* in English and *en/al lado de* in Spanish, as they consistently triggered the highest rates of recursion. Indeed, this was the

only item to reach 100% response rate with any group, and it was reached with 2 groups: L1 Spanish speakers (both groups SL1 and EL2) preferred recursion to the exclusion of all else regardless of what language the prompts were in.

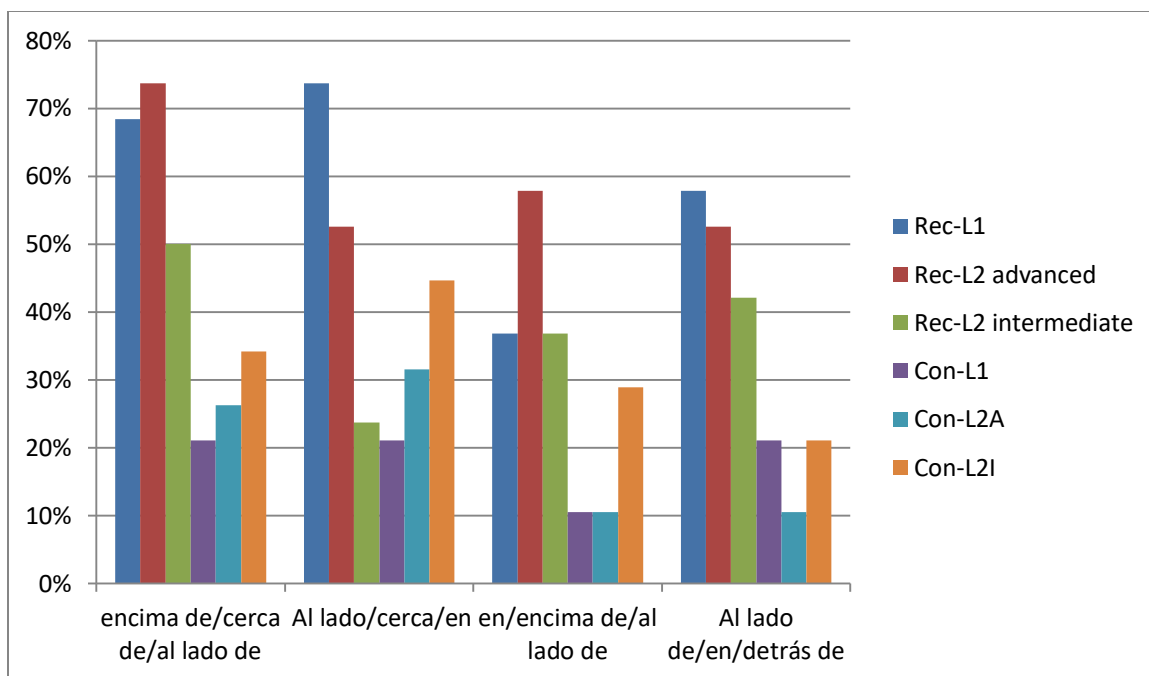


64. PP 'dropping' by item in different prepositions

In Spanish, only one item, *debajo de/encima de* (*under/on top of*), displayed a noticeable amount of PP dropping. Here, whereas all groups dropped PP2, L1 did this the most often at 21% of the time. The L2B dropped both PPs equally at 18%.

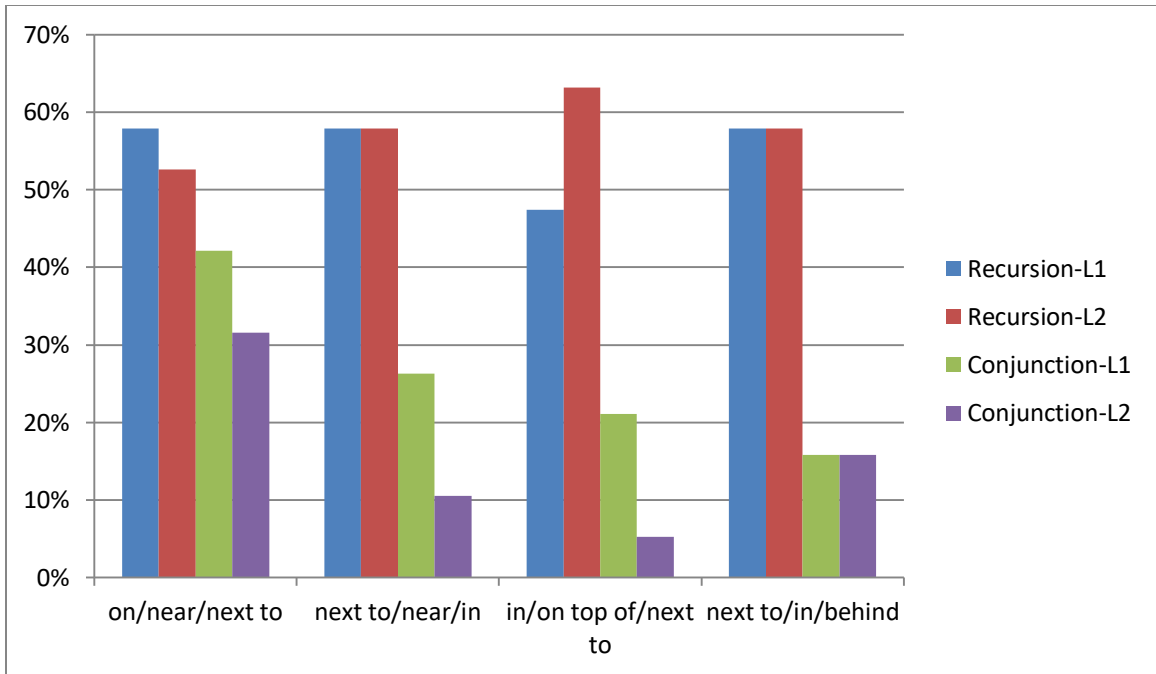
In English, PP dropping was very rare, not occurring in 6 of 8 items with each group, with the remaining ones at 10% or less.

In the English version, only three singleton answers spread over three different items were chosen.



65. Recursion and Conjunction by item in three PPs in Spanish

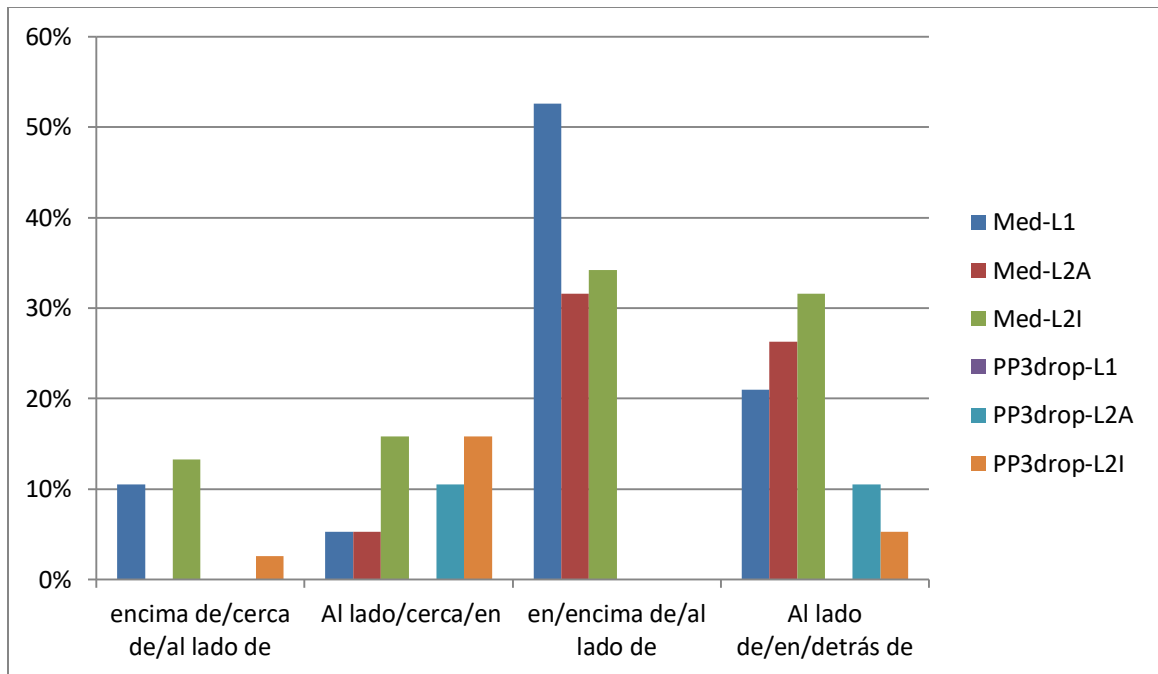
In Spanish, the four items largely conform to the pattern of recursion increasing and conjunction decreasing with input. *Al lado de/cerca de/en* (*next to/near/in*) follows quite closely, while also producing the highest recursive rate in L1, 74%. This item also marked the steepest increase in recursion by input, jumping from 24% to 53% from L2B to L2A and then more than 20% higher again in L1. *Al lado de/en/detrás de* (*next to/in/behind*) stepped up progressively as well, although with much smaller differences in recursive rates of the groups; L2A had the lowest conjunctive rates, while L1 and L2B were identical at 21%. *Encima de/cerca de/al lado de* (*on top of/near/next to*) showed a slight decrease from L2A to L1 (74% to 68%), but otherwise followed trends. The most notable anomaly, perhaps, was *en/encima de/al lado de* (*in/on top of/next to*), which showed a much more substantial decrease from L2A to L1 in recursive interpretations, from 58% to 37%. The other three items displayed a rough uniformity.



66. Recursion and Conjunction by item in three PPs in English

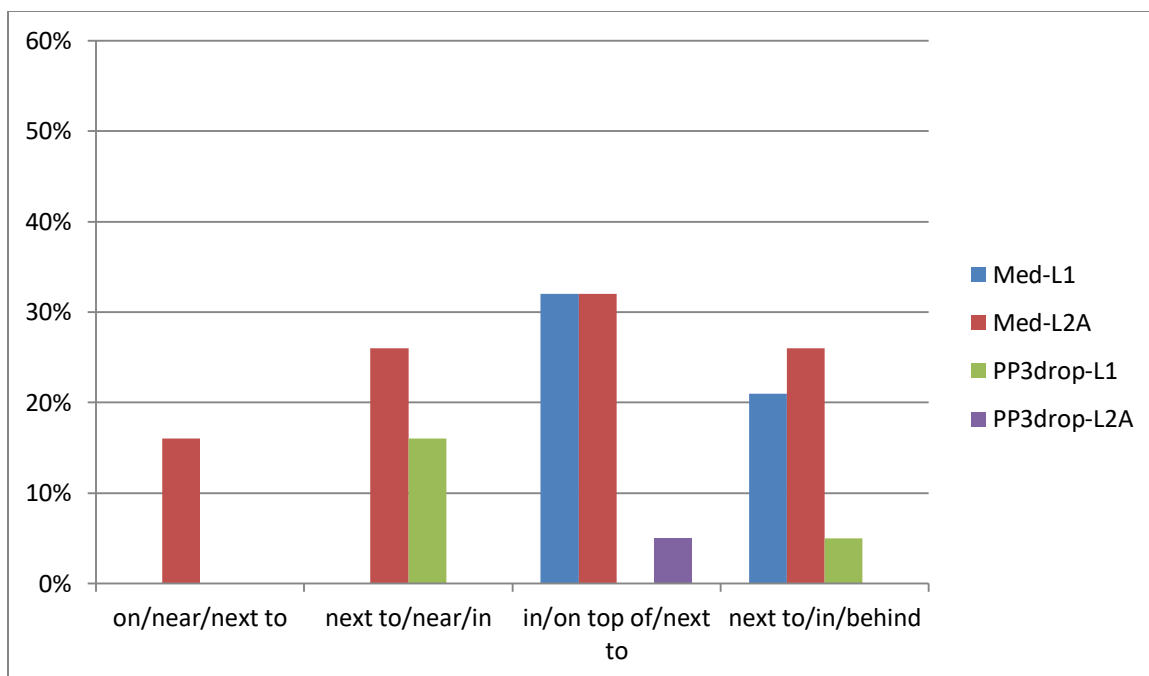
In English, three items return very similar response rates, suggesting a stronger homogeneity in their type. One item, *in/on top of/next to*, displays a notable jump from L1 to L2 in recursion (47% to 63%). While the other show similar or identical recursive rates for the two groups, three of the four groups show an increase in conjunction from L2 to L1 of between 10% and 15%.

In this question type, another cross-linguistic uniformity seems to appear, in that the same item returns lower recursion in both languages.



67. Medial and PP3 drop interpretations in three PPs in Spanish

The data show that a medial interpretation is a tiny minority, presumably deviant, interpretation for the first two above; still its adoption by SL2B no less than 13% for one item to as much as 34% with another suggest that it may form at least a portion of the substrate of the acquisition path. Yet its role as the dominant interpretation in the third item above, where L1 speakers chose it more than half the time, and L2 speakers a third of the time, certainly stands out from the rest of the graph. In fact, L2 speakers also chose medial at a similar rate on the last item as well, while SL1 now preferred this option less than a quarter of the time. Dropping PP3 was an uncommon option for L2; meanwhile SL1 never chose this option at all.



68. Medial and PP3 drop interpretations in three PPs in English

The English data are most interesting cross-referenced with the Spanish data above in (67). While EL2 choose this option across all items, it is most interesting that the parallel item in English which in Spanish stood out so strongly here too is remarkably strong, with a third of EL1 and EL2 choosing it; the fourth item, as before, triggers more than 20% interpretation in both groups. Thus the expression below in (48) and (49) may possibly contain a ‘medial trigger’ which enables this interpretation.

48. the remote in the bowl on the magazines next to the pens

49. el mando en el bol encima de las revistas al lado de los bolígrafos

Subjects in both languages were presented with the same options, seen below in (69), which may or may not be seen to contain an over trigger.



recursion

medial

conjunction

69. The remote in the bowl on the magazines next to the pens

5.7 Summary

The data presented in this chapter contain a number of points of light concerning how recursive and conjunctive operations are involved in the interpretation of PPs. The broad assumptions about its dominance were borne out, while some of the more detailed research questions required correspondingly detailed analyses and explanations. While input clearly seems to be a factor in L2 Spanish, conflicting data in English undermines potential conclusions which may be drawn. The different results between Spanish and English for what are superficially identical structures, if fact, suggest that something much more profound may be affecting interpretation. What is apparently a much stronger right-branching recursive rule in Spanish than English comes as a surprise. The fact that while English distributes its recursive productivity across both right-branching (the present study) and left-branching (the Saxon genitive), Spanish suffers from, or enjoys, the complete absence of a productive left-branching recursive rule. This disparity may drive stronger right-recursion in Spanish than English.

The study also points up other aspects. Increasing the number of PPs from two to three did not produce higher recursion, as projected. What is more, not only do the

prepositional semantics of the described groups play a role, but the individual pairs clearly are themselves potentially unique in their relationship to recursion and coordination. These aspects are among the questions explored in the experiment 2. The following chapter describes how these questions and others are explored in its study of child L1 acquisition. After discussing those results in chapter 6, the topics discussed here will be reviewed to see what sort of a synthesis can be achieved from the data of the two experiments.

CHAPTER 6

A PILOT EXPERIMENT IN L1 CHILD ACQUISITION: QUESTIONS AND METHODOLOGY

6.1 Introduction

This L1 study arose from a desire to check the validity of an assumption inherent in the hypotheses of ExL2 (see chapter 3). That assumption in L2 was that, to move from a default conjunctive interpretation to one applying greater recursive operations, increased exposure/input was essential. This growth of recursion in L2 is a corollary of similar claims for L1 (Roeper & Snyder 2003, Roeper 2011) i.e., appropriate input increases recursive capacity in children. Thus, ExL1 attempts to corroborate some of the proposals tested in ExL2, but with L1 child and adult language. Observing growth of prepositions' interpretation is important because they "present a considerable challenge to children in the course of language acquisition" which "appear in the child's speech later than all major types of content words" (Leikin, 2002). Consequently, the questions explored for the most part reflect those investigated in ExL2, though this was not designed to be an exhaustive replication of the previous experiment.

6.2 Recursion vs conjunction

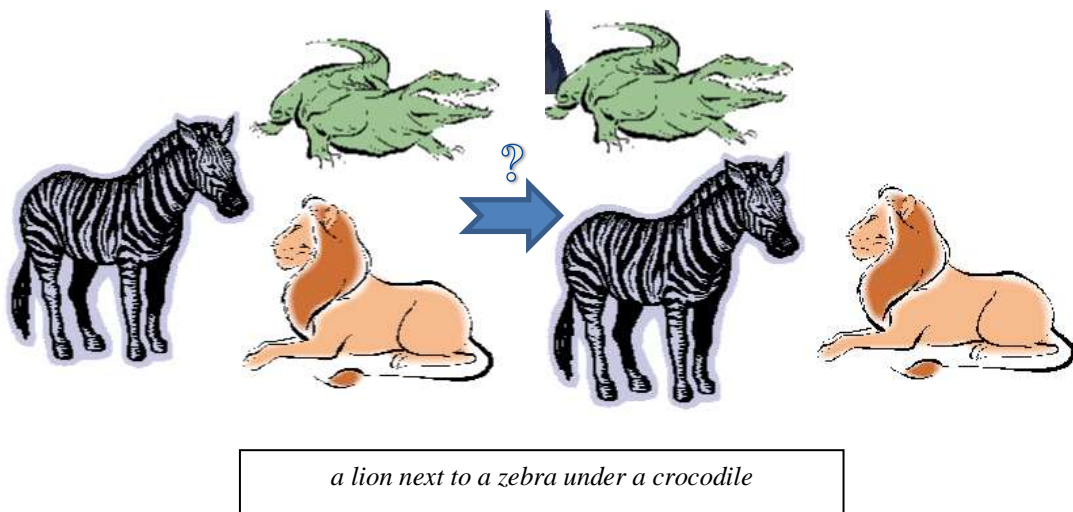
ExL2 unequivocally demonstrated the broad preference for recursion across all types of items. An undeniable condition, however, was that the format of the test, multiple-choice, inherently limits the options available to the subjects. What do they produce when given free rein to interpret as they see fit? Nonetheless, the strength of the results of ExL2

naturally forces a continuation of that hypothesis, that recursion will prevail across the board.

6.3 The acquisition path

Is there an identifiable acquisition path to recursion in child L1 speakers? Does the LAD stride confidently out of the gates of coordination and, as a child ages, reach towards an asymptotic recursive ideal which remains just over the horizon? Little work has been done demonstrating differential rates by different ages; ExL1 should be able to illuminate how preferences shift with age. If appropriate recursive input is required in order to perform more recursive operations, then this should be evident in the data, regardless of the type of recursion occurring.

Thus, were a subject asked to compose an image of “a lion next to a zebra under a crocodile”, their preference to locate *a zebra under a crocodile* would increase with age compared to their preference to show *a lion under a crocodile*, which would correspondingly decrease (70).



70. Conjunction (left) and recursion (right)

The hypothesis takes the input proposal as true, and thereby predicts that recursion will increase, and conjunction decrease, concurrently with the age of the subject. The ages explored here are 5-8, with a control group of adults. Thus, this predicts that the process of acquisition, or perhaps activation (if considered in light of previous proposals regarding algorithms), will not have finished before the age of five, and in fact will continue to grow through all of the ages covered, with adults being the most recursive of all. As explored in ExL2, this assumes a progress in representations from flat (conjunction) to hierarchical (recursion). Direct Structured Recursion (DSR, (Roeper & Oseki, to appear)), or stacking, was not initially factored into the hypotheses as its potential role in the acquisition path was uncovered in the analysis of the results.

6.4 Number of PPs

How can increasing numbers of PPs affect interpretation in the new, unrestricted format?

As the previous experiment rejected the hypothesis that a third PP increases recursion over a second PP, will that continue to be true? Chapter 2 presented numerous

alternatives to recursion all the way down. In chapters 3 and 4 the combinations of recursion (PP2) + conjunction (PP3) and recursion (PP2) + medial (PP3) were explored and although not as popular were found to be viable alternatives to recursion (PP2) + recursion (PP3). Does that hold true under the current conditions of open interpretation?

Furthermore, what happens beyond a PP3? How are a PP4 and even a PP5 successfully processed? If so, where are the attachments made? Another factor regarding this point is staged input. What happens when time is given to process up to three PPs and create corresponding images before a fourth PP is given? Does that help to entrench recursive or coordinate paths that were already committed to?

The presumption here is that, observing the outcome of ExL2, a third PP will be as likely to undergo recursive operations as a second PP. However, increasing information in the form of additional PPs presented in stages after interpretation has taken place will indeed activate the aforementioned algorithms at a greater rate. As such, recursion will increase the more PPs are added and the farther the current PP gets from the head noun.

6.5 Heads of PPs

ExL2 tested the interpretation of numerous sets of both differently- and identically-headed PPs. While this produced some interesting results, it suggested that the individual semantic content of each preposition potentially had a very strong effect on recursion and conjunction. The broad sweep of prepositions, however, made it difficult to draw any conclusions about any one preposition. This time the decision was made to instead shine a spotlight on a much smaller, tightly-defined set of prepositions concentrating on a core of locational relationships. What will this tell us about the recursivity of these few prepositions and their relationship to each other? If the experiment only uses the prepositions *over*, *under* and *next to* in their various combinations, how will the effect on interpretation be observed? What will comparing mirrored pairs reveal about the nature of these prepositions (50 and 51)?

50. X next to Y over Z

51. X over Y next to Z

The study goes forward with the null hypothesis for these types of comparisons—(50) will trigger similar interpretations to (51).

Langendoen et al (1989) also introduced alternatives to ordinary recursion and conjunction, explaining that *stacking* (see chapter 3 for a full description) appears regularly in subjects' answers (*stuffing* appears, but to a very minor degree). How does this interpretation relate to the chief cobbles in the path, coordination and recursion?

As ExL2 suggested strongly that identically-headed PPs trigger more recursion than do those with different heads; the hypothesis for ExL1 therefore extends that to L1 child speech as well.

6.6 The experiment

6.6.1 Background

The design of ExL2 seemed inappropriate for young children, as listening to brief, decontextualized 'stories' and asking them to choose images likely would likely have caused confusion and boredom. Worse, it may have limited them to choices not including ones which they would have preferred. Thus, a redesign was necessary. A naturalistic production experiment would be a much better way to capture children's developing understanding of recursive structures, allowing them free range to express their understanding of the operation while maintaining more or less the characteristic of ExL2 requiring subjects to interpret a sentence that they hear to answer the question. For ExL1, then, children were given a set of objects (in this case, common zoo animals) and asked to arrange them according to verbal prompts using adjunct locative PPs.

Initially, the plan was to mirror the methodology of Langendoen et al (1989) and have children draw images in response to prompts using the target PPs. This path was discarded after it was suggested that children may easily become distracted and off task

when asked to draw their own images⁷, so a task was crafted wherein subjects would be presented with prepared and familiar images which they may arrange as best fits the prompt.

6.6.2 Participants and setting

The child participants were selected from schoolchildren aged 5-8 in the Amherst area. The adults (as a control group) were drawn from the UMass community; the diversity in ages was considerable and more covering ends of a spectrum as opposed to an even distribution. This is because around half were still students and half were in their 50s and 60s. Each group contained 10 participants:

Age	number
5	10
6	10
7	10
8	10
adult (mean: 37)	10

Table 3. ExL1 participants' age distribution

The experiment with the children was run in the schools themselves, using available office space. The adults did the experiment on the campus of UMass Amherst.

6.6.3 ExL1 design

The interactive platform chosen was an app, Educreations, on iPad adapted for the purposes of the study. A drawback of using this platform is that it was not possible to create a self-contained and self-guided experiment which logs answers to a series of questions, as in ExL2; instead, the constant involvement of the researcher is required. Originally developed as a flexible platform for creating classroom presentations,

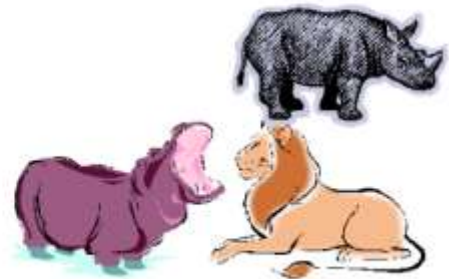
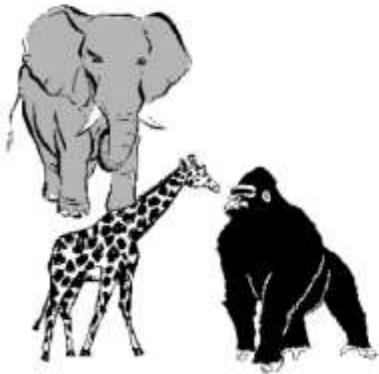
⁷ Thanks to Barbara Pearson for this guidance.

Educreations possesses several characteristics which, combined, make it ideally suited to the needs of the experiment. One is the ability to upload images quickly, allowing one to test a series of participants without much time being lost in the changeover, as each run of the experiment effectively began with a blank slate. Additionally, the app allows one to move images around on the screen into different spatial relationships with each other. In and of itself, this feature is not particularly impressive, but it is paired with the ability to record a video (via wifi to the cloud) of everything that happens on the screen of the iPad in the app. Furthermore, while recording the movements on the screen, a microphone captures the complete oral exchange that takes place. Thus, the researcher obtains a complete audio/video record of the participants' responses to the prompts without the need of a camera. Many experiments depend on filming the participants to obtain similar results, but that adds an additional level of complexity and complication to the entire process which is not justified in the present case. Videos of the children themselves would be superfluous in this context as the relevant data is contained in what they do on the screen; moreover, obtaining permission for videotaping decreases the available participant pool as parents are less likely to grant this than they are participation in an experiment without videotaping.

The raw material for ExL1 was carefully chosen as well. As the participants would be as young as five years old, the objects had to be easily identifiable to them. Pilot studies (to this pilot study) showed that random common objects, such as house, tree, dog, cat, sun, moon, etc. were found to be inadequate due to semantic restrictions: when asked to position things in over/under/next to relationships, suns and moons lend themselves more to 'over' relationships, dogs are more likely to be 'under' or 'next to' trees and 'next to'

cats, but not over them, etc. Thus, it was decided that the group must be of a more specific semantic group, broad enough to allow some variety yet common enough to make them all easily recognizable. The variety was considered important as this served as a primary distractor from an overt focus on form. A set of common zoo animals fulfilled these requirements.

Images of ten zoo animals were stored in a Dropbox folder accessible from within the app. The images were assigned a fixed initial layout which had been printed out as an image to serve as a blueprint for all subjects. As the nature of ExL1 was such that it was necessary to arrange the images according to the layout each time in the presence of the child, the child was given the printout and asked to ensure that the researcher set up the experiment correctly, following the layout (allowing them a greater level of interaction), and was asked to identify the images as they appeared on the screen (though the animals used are common, it was still helpful to establish an awareness of the core lexical content of the experiment, outside of the prepositions, that the subjects would encounter). After all the images were arranged on the screen, the subjects had a 'hands-on' opportunity to move the menagerie around at will to practice what they would have to do in the data phase of the experiment. Afterwards, the app contains a 'back' button to reset the screen.



71. ExL1: the initial layout for all subjects and items

This consisted of the interlocutor giving a set of prompts one-by-one, each asking the subject to “show” a particular spatial relationship for three or more of the animals using consecutive prepositional phrases, which the subject would respond to by moving the images about on the screen accordingly (the microphone feature of the app was primarily valuable in recording the prompt that accompanied each arrangement; participant oral production was optional). The experimenter demonstrated an initial relationship (though not one using consecutive PPs to avoid priming an answer strategy) before turning the iPad over to the participant, only reading the prompts and touching the screen to reset it after each one (ensuring that all prompts started with the same setup for all participants. The prompts consisted of both target and filler questions. In fact, due to time constraints, the ratio of target to filler was slightly greater than 1:1. The experiment was kept to about 8-12 minutes in length, depending on the participant; even this was capable of straining

the attention limits of some subjects. The stories used to provide a context for the questions in ExL2 were eliminated entirely, as they would have limited substantially the number of target questions possible. Instead, treating it more as a game involving a variety of challenges, children were presented with direct prompts such as:

52. I see a lion. Show me a lion next to a zebra under a crocodile.

The phrases were always introduced with the phrase *I see an X* to draw attention to the topic of the sentence and the locus which would command any following description. The intonation was carefully controlled, with the interlocutor pacing the PPs evenly. Even extremely brief pauses before subsequent PPs were found in trials to prompt a conjunctive interpretation; the slightest emphasis on the object of the first PP prompted specifically a recursive one. A neutral tone and pacing avoids overtly encouraging one or the other, but is still one for which the adult L1 speaker strongly preferred recursion in preliminary trials. Nonetheless, as the prompts were given ‘live’, some undesired variation must have occurred.

There was no limit on repetition, when requested, of the prompt. It was fairly common that, while trying to find all the relevant animals in a phrase, the child would forget the prepositions involved. One condition attached to all repetitions of any prompt, however, was that they be repeated in their entirety, starting with *Show me...* Often, a child would successfully connect the first two items in some form of relationship and want to hear just the last PP, which would have explicitly favored recursive interpretations. Thus, to avoid that, the entire prompt was always used.

6.6.4 Question types

The only prepositions used in target questions were *over*, *under* and *next to*. Pilot studies showed that some other prepositions contain inherent semantic ambiguities which may impede processing and unintentionally affect recursion. *In front of* and *behind*, for example, create a two-fold ambiguity for items on the screen. Used as they were in ExL2 would require subjects to create depth on the screen, something that is possible but cumbersome and limited. A subject, though, may also perceive these prepositions to refer semantically to the direction the animals might be facing: *in front of* a rightward-facing gorilla could be to the right of it (and not *between* the subject and the gorilla); *behind* a zebra could be found near its tail. Unwanted ambiguities arise as well with *on* and *on top of* while still others such as *in* would require an on-screen manipulation that was too burdensome. Limiting the prepositions used to the three listed while applying them in a full range of combinations will allow a more careful analysis of the discrete elements involved in each item, as discussed earlier, while allowing more direct comparisons with the data from Langendoen et al (1989), who worked with a similar set of prepositions; similar analysis in ExL2 was not as readily accessible. Various types of filler questions balanced the targets. A total of 12 target questions were used, containing a total of 19 opportunities for recursion; spaced out evenly were nine filler questions.

A variety of question formats were tested for, all using some variety of consecutive PPs. As in ExL2, there were questions with two consecutive locative PPs which used identically-headed PPs (*under, under; over, over*) as well as questions with PPs with different heads. For the questions using different prepositions, *next to* was always paired with *over* or *under* (*under/over, next to; next to, under/over*).

Combinations of three, four and five PPs were also tested, which always followed the above alternating pattern of prepositional choice (*over + next to + under, next to + over/under + next to, etc.*). This examines not only if simply the length of the modifying phrase affects interpretation (is PP3 more or less likely to be attached to the preceding DP than PP2 in shorter phrases?), but also studies how parsing decisions already made within the larger phrase affect decisions made later on (if PP2 is interpreted recursively (or conjunctively), how does that affect the parsing of PP3 (if at all)?).

While PP3 was always presented together with the full clause, PP4 and PP5 were not. Instead, these involved giving the initial triple PP prompt, as above, and allowing the subject time to arrange the animals as they saw fit. Once completed, the interlocutor provided PP4 for them to attach somewhere on the existing structure. The intention was to avoid converting the problem into simply a processing issue, which would likely become burdensome if asked to interpret a DP restricted by four PPs all at once.

The total distribution of types was the following:

- 53. *over x over z or under x under z.* (2 items, one of each)
- 54. *next to x under/over z.* (5 items)
 - 1. + *next to y.* (2 items)
- 55. *under/over x next to z.* (5 items)
 - 2. + *under y.*⁸ (2 items)
 - i. + *next to w.* (2 items)
 - 1. + *over v.* (1 item)

⁸ This only attaches to phrases wherein PP1 is headed by *over*.

Thus, the lengthiest one, containing five PPs, looks like this:

56. I see an elephant. Show me an elephant over a crocodile next to a hippo under a gorilla. (pause) Next to a tiger. (pause) Over a bear.

Unlike in ExL2, the coding of answers to target questions could not be anticipated in advance, but instead must come out of the results themselves. Thus, the complete coding scheme is presented with the results in Chapter 7; naturally, it follows closely that used by Langendoen et al (1989).

As with the L2 study, the design of adequate filler questions was somewhat problematic, as they would ideally contain at least a *perceived* ambiguity as well, whether in fact one existed or not. In the end, the filler questions asked for interpretations of spatial relationships as well. With just two animals, a single PP could be used as a type of cognitive rest between more complex phrases. With three or more animals, different combinations were possible while avoiding the consecutive PP format:

57. Show me a lion and a tiger with an elephant.

58. Show me an elephant and a rhino. They're between a zebra and a hippo.

These provided similar interpretation challenges to those of the target questions (is the tiger with the elephant or are the lion and the tiger both with the elephant? As for the second prompt, it was startling how many zebras and hippos found themselves between and elephant and a rhino) but served to distract from the focus on consecutive prepositional interpretation. The results, in fact, of the filler questions may prove fruitful to analyze, although they are not treated in the present study.

6.7 Summary

This chapter has presented the questions which ExL1 intends to explore, as well as the corresponding hypotheses as to what the data will show us. It also presents the methodology used to obtain the data used in addressing these questions and hypotheses. The following chapter will take advantage of the data collected in ExL1 to aver whether and how any of the questions may be answered.

CHAPTER 7

L1 EXPERIMENT: RESULTS AND DISCUSSION

7.1 Coding:

As it was a production experiment, some factors which arose in the course of the experiment were unanticipated. Some of these did not affect the central premise of the experiment, and thus were not factored into the results. Firstly, the correlation of the choice of animal to that requested in the prompt was disregarded. Frequently, a hippo would be chosen where a rhino was prompted, or a lion for a tiger, mistakes made not only by the children but by the adults as well (though to a lesser degree). As long as it was clear that each animal they chose corresponded to a particular one in the given prompt, the response was coded normally.

Another coding decision is perhaps more controversial, but equally justified. This involved what can perhaps be described as a syntax/semantics disconnect which apparently ‘reversed’ the prepositions so that *a zebra under a giraffe under a bear* would be represented by positioning the giraffe under the zebra and the bear under the giraffe. After careful consideration, the decision was made not to discard these results either; the rationale for this decision can be found at the end of the chapter, where the data are presented and possible explanations discussed.

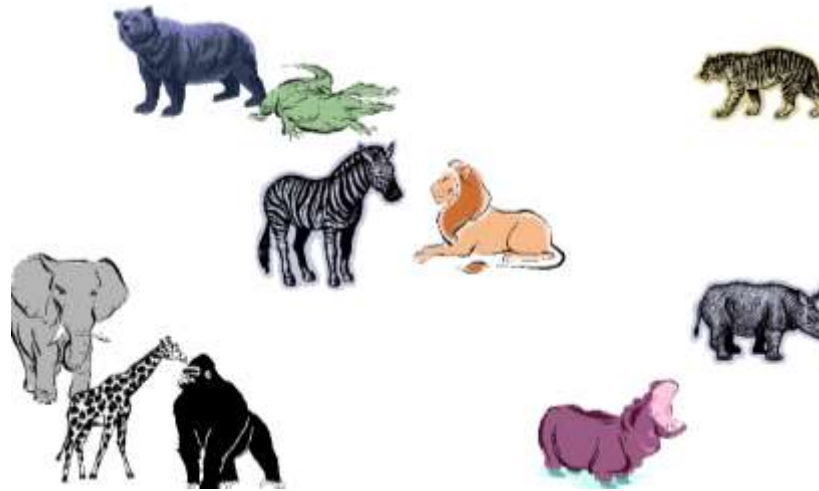
7.1.1 Two PP coding

The coding of the results follows that of Langendoen et al (1989), who used four primary codes (my notation):

- alternating (recursion)—PP2 attaches to preceding DP in PP1
- coordination (conjunction)—PP attaches to head DP of phrase
- stacking—PP2 attaches to both preceding DPs
- stuffing—preposition 1 heads the object formed by its immediate complement DP and PP2

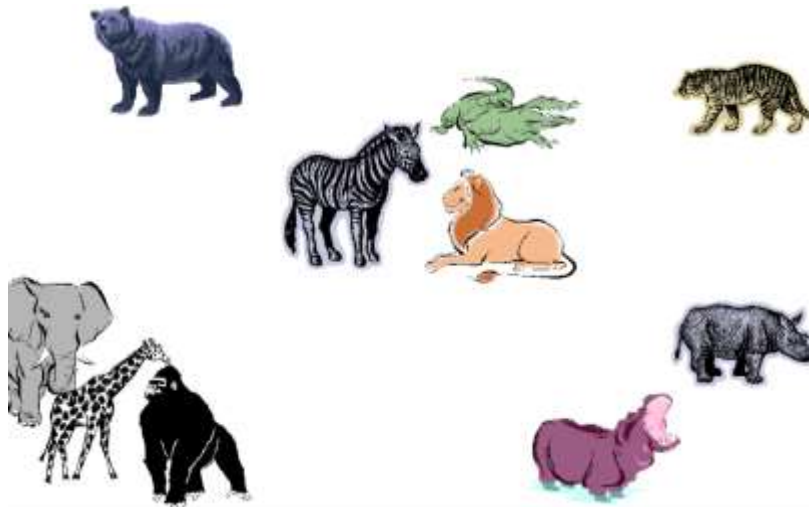
The recursive and conjunctive parsings demonstrate the same relationships as in the L2 experiment. Below we can see examples of each type. What is here referred to as recursion occurs when the PP attaches to the immediately preceding DP.

In *recursion*, the zebra is under the crocodile which in turn is next to the gorilla:



72. Show me a lion next to a zebra under a crocodile (recursion)

Conjunction occurs when PP2 bypasses the preceding DP to attach to the head DP of the sentence, the argument of the verb, resulting in a picture wherein the zebra is both under a crocodile and next to a gorilla:



73. *Show me a lion next to a zebra under a crocodile (conjunction)*

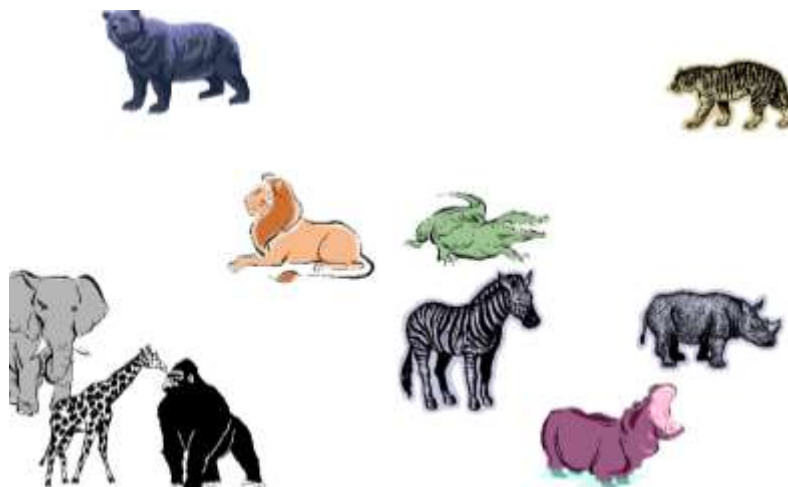
Stacking may be viewed as a variation on recursion, in that the final PP does attach to the immediately preceding DP, yet the fact that it simultaneously attaches to the DP higher up in the structure—effectively attaching to both items as if they were a single unit—lends this a conjunctive flavor as well and favors giving this a unique interpretation. Thus with our example above, the lion is next to the zebra, *both of which* are under the crocodile:



74. Show me a lion next to a zebra under a crocodile (stacking)

The interpretation in (74) conforms with Direct Structured Recursion (DSR) described by Roeper & Oseki (2013) and laid out above. The semantics are clearly compositional and its architecture is consequently more hierarchical than coordination while less so than recursion (see section 3.5 above).

A *stuffing* interpretation, the least common of the four, occurred when “the entire phrase following a particular noun modifies that noun” (Langendoen et al). In our example, therefore, the lion is next to the entity ‘a zebra under a crocodile’:



75. Show me a lion next to a zebra under a crocodile (stuffing)

However, given that stuffing accounted for a only 5% of answers, and that the core criterion of PP2 attaching to the DP in PP1 has been met, it was decided to combine these results with recursion.

Other than recursion and conjunction, the coding for the identically- and differently-headed groups changes, and must be analyzed separately. This is due to one interpretation available in each type which is not present in the other type: stacking and alternate conjunction. PP stacking, which describes PP2 applying to both preceding NPs, is either unavailable with identically-headed PPs, or simply uninterpretable from the results. Why this is so becomes apparent on closer analysis of an example of a standard recursive interpretation of one of these items:

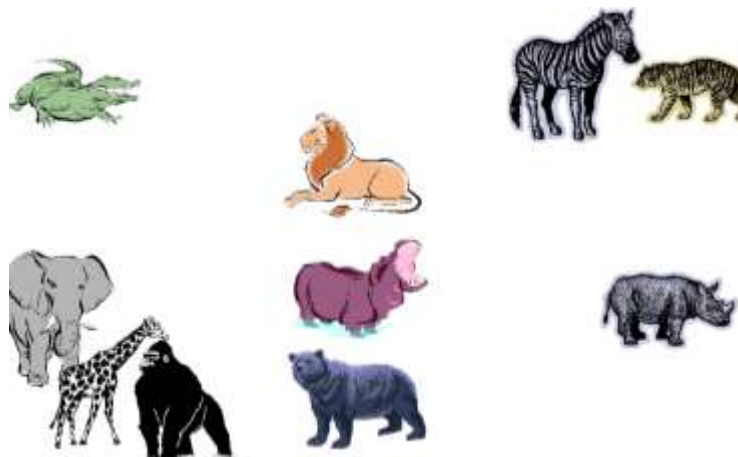


76. Show me a zebra under a giraffe under a bear (recursion)

As seen in the figure, once the zebra is positioned under the giraffe, there is little room to place the bear so that under the bear could be conspicuously attached to both the zebra and the giraffe equally. Of course, it is entirely possible that such a ‘stacking’ interpretation was intended by the subject, i.e. that the entity *a zebra under a giraffe* is

found *under a bear*. Nonetheless, it would be impossible to discern from the results, as this is indistinguishable from a recursive reading.

Furthermore, another possibility arises with the identically-headed PPs which is not found in the others, yet was seen in the L2 experiment coding as ‘alternative conjunction’. PP2 attaches to the head DP, as in normal conjunction, but PP1 appears to attach to the DP in PP2:



77. Show me a tiger (lion) over a bear over a hippo (alternative conjunction)

While this superficially resembles stuffing, it must be considered a variation on conjunction, based on the primary criterion of where the target PP attaches (here the subject substituted a lion for a tiger). Additionally, the way in which this minority answer (4 of 80) was arrived at suggests conjunction as well. The subject would first position *a tiger over a bear* and then, while considering the second PP, enlarge the gap between the two and insert the third animal, creating *a tiger over a hippo* as well. It remains unclear whether, after this movement, PP1 is still intended to attach to the head DP or to that of PP2.

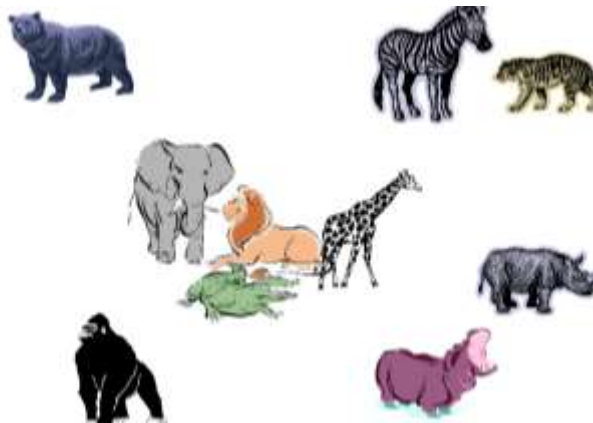
7.1.2 Coding for three or more PPs

Prompts using a third, fourth or fifth PP (see (59)) were coded for a fifth answer, *medial*, as well, as they present yet more interpretative options to the subject.

59. Show me an elephant next to a lion over a crocodile next to a giraffe.

Medial attachment, originally

Medial attachment, originally proposed in the previous experiment as one of the four multiple-choice options available, occurs when the third, fourth or fifth PP attaches in none of the ways described above, but instead to a DP that is neither the head DP of the entire NP nor that of the preceding PP. In figure 78, PP3, *next to a giraffe*, attaches neither to the head DP, *an elephant*, nor that of PP2, *a crocodile*, but instead that of PP1, *a lion*.



78. Show me an elephant next to a lion over a crocodile next to a giraffe (medial)

A further aspect was coded for the items with three PPs, in that the operations performed on both PP2 and PP3 were recorded and compared. Thus, it shows whether a subject used *recursion + recursion* or *conjunction + conjunction*, or something else.

7.2 L1 Results

The data are analyzed from several different perspectives, wherever possible following the format used in the L2 experiment results analysis. Firstly, the combined results of all types are examined, followed by those according to types of preposition head, followed by number of PPs.

7.2.1 A note on statistical method

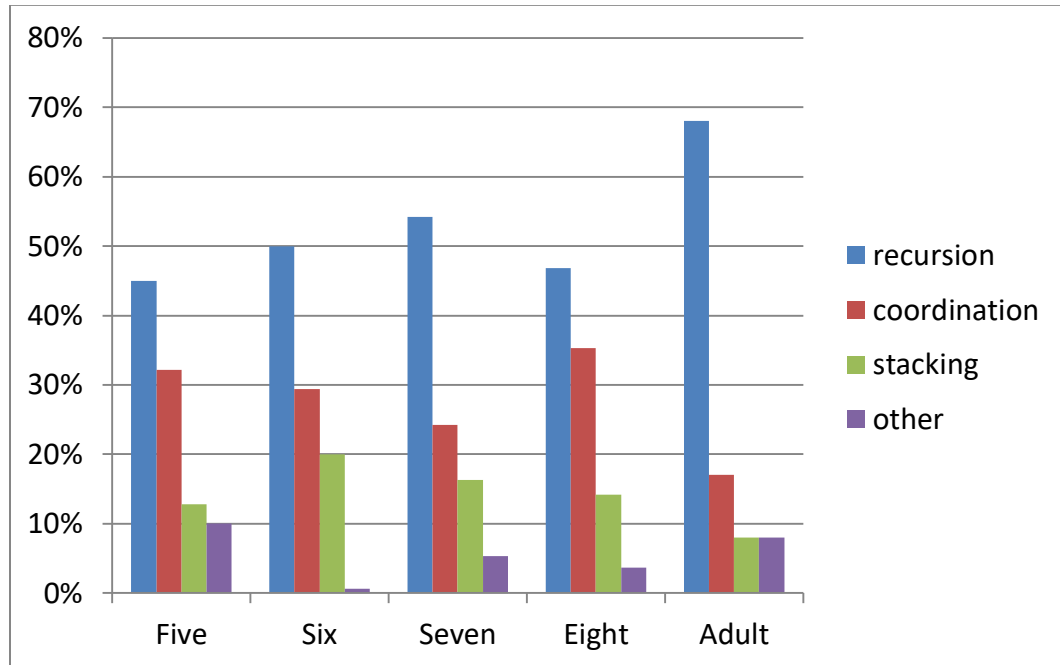
As in the previous experiment, three different methods were routinely used to test the data for significance; they are summarized here to avoid having to repeat them at each step of the presentation. The data were again non-parametric throughout, so the more powerful tests such as ANOVA were unavailable. Instead, for data comparing two variables, for example, recursion vs conjunction in a set of speakers, a paired sample Wilcoxon Rank Sum was used. Comparing two groups of speakers' preference for recursion, however, required an independent sample Wilcoxon Rank Sum test. If three or more groups, for instance 5s, 6s, 7s, 8s and adults are compared, then Kruskal-Wallis generates the p-value.

The statistics were obtained via Statistics Online Computational Resource (SOCR), an online service providing statistical computing applets.

7.2.2 A path to recursion?

Collective results of all PPs broadly suggest that recursive interpretations increase with age; adults have highest interpretations of all. Coordinate interpretations decrease with age; adults have lowest interpretations of all. Examining the results of the combined 19

items containing opportunities for performing a recursive operation across the five different age groups 5-8 and adults, the trend seems clear.



79. Overall recursion, conjunction and stacking

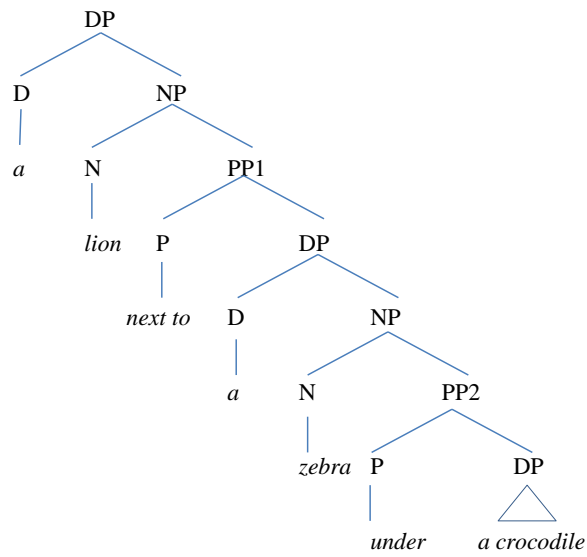
The data comparing recursion across the five groups come very near significance ($p = .078$, $t = 8.39$), and in fact significant differences obtain between the adults and the 5s, 6s, and 8s. The conjunctive differences are not as strong ($p = .410$, $t = 3.974$). Stacking registered a marked increase from age 5 to age 6 before steadily declining on through adults.

Comparing recursion and conjunction internally in each group, only the adults achieve an outright significant difference (68%:17%; $p = .008$, $z = 2.395$). The group of 7s difference was quite strong ($p = .057$, $z = 1.58$), yet this apparent tendency did not fulfill itself in the 8s, whose p-values were the same as the 5s and 6s ($p = .25$). This

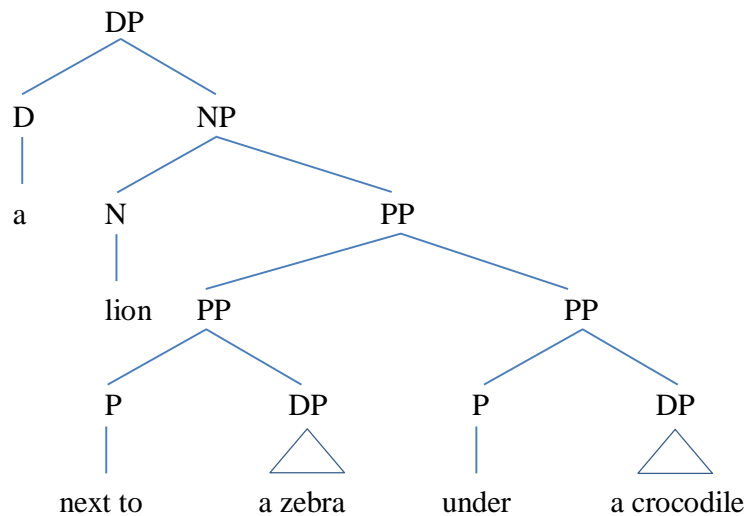
characteristic of the 8s to act somewhat as an outlier in the data is seen elsewhere in the results and is dealt with below.

7.2.2.1 Discussion

The preference for recursion over conjunction is apparent at all ages. The tendency to use operations seen in figure (80) grows with age while operations such as (81) diminish.



80. A lion next to a zebra under a crocodile (recursion)



81. A lion next to a zebra under a crocodile (conjunction)

The gap between the two is weak at age 5 (see figure (79)), suggesting that coordination and recursion are still competing as the chief operation performed in this scenario.

Nonetheless, recursion has, in fact, already begun to outpace coordination as the primary option. What is clearly underway at age 5 continues to strengthen with age and nearly reaches significance by age 7 ($p = .057$), before becoming unquestionably dominant in adults.

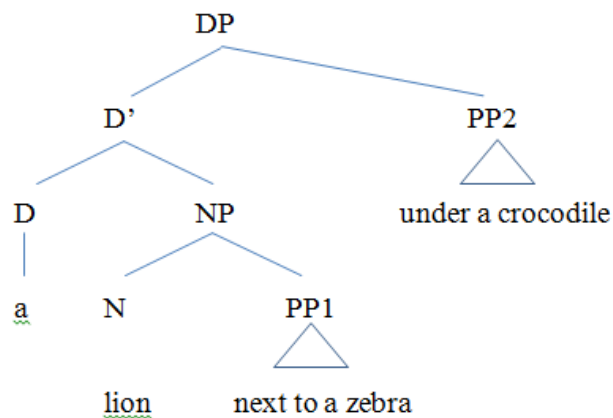
Just as apparent is the fact that conjunction remains a strong interpretation even with adults. While recursion clearly dominates, it has not stopped a conjunctive interpretation naturally arising from what are apparently default recursive structures.

The data suggest that significant maturational effects are at work on how multiple adjacent PPs are interpreted. The growth of recursion is apparent from 5s through to adults and, though at .078, this probability is not strong enough to qualify as significant,

trends are important and the relatively consistent one observed here is as well. Equally apparent is the trend of diminishing conjunction, which is interrupted again at one point (again, the 8s).

Also, the stacking interpretation appears in all age groups as well, peaking at a fifth of all interpretations at age 6 before starting a steady decline in tandem with coordination.

Thus, use of the structure seen in (82) apparently begins to take hold before tapering off, which suggests that it has a supporting role to play in the scenario.



82. A lion next to a zebra under a crocodile (stacking)

The stacking interpretation is dealt with more below, as it becomes chiefly relevant in the discussion concerning differing prepositions' unique properties which may serve to enable this operation. Nonetheless, the broader suggestion of an acquisition path wherein 'stacking' plays an important role, such as DUR→DSR→IR (Roeper & Oseki, to appear), clearly is on the right track. The precise contours of the path, however, in fact

may prove to be more nuanced than this as the effects of differing prepositions come to light.

This section has served as an overview of the notion of identifying an acquisition path to recursion (among locative PPs); each succeeding section will continue to touch on it as necessary to illustrate age effects.

7.2.3 Data by PP head

Three varieties of locative double PPs were accounted for, distinguished by the prepositions heading each PP.

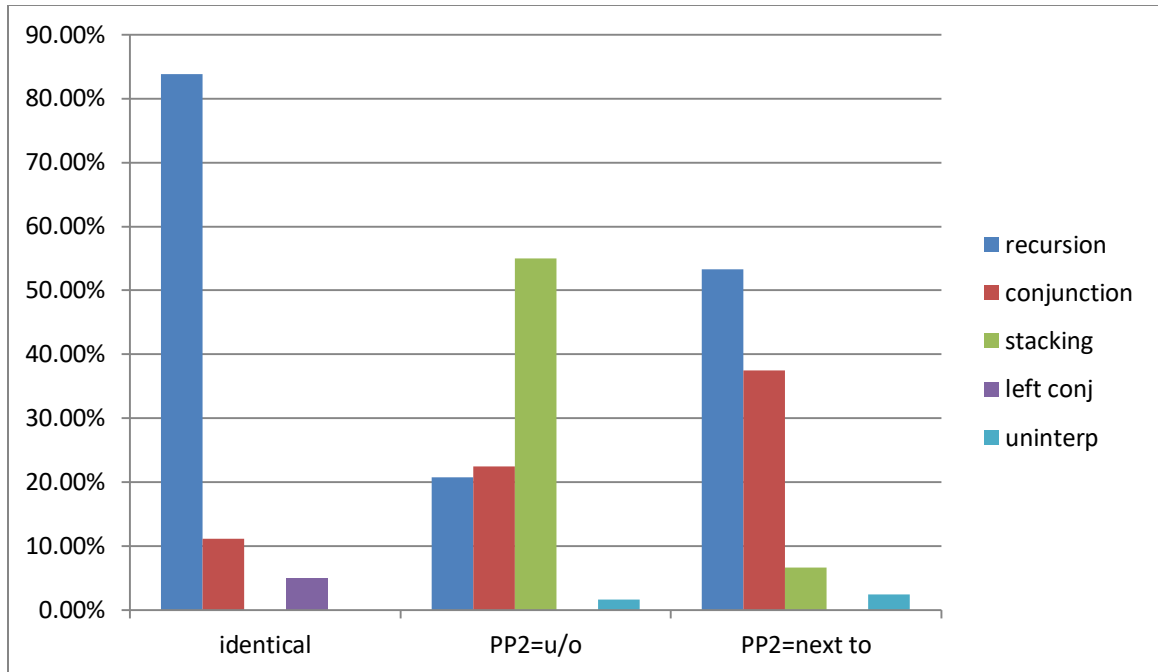
60. PP1 = over/under; PP2 = next to

61. PP1 = next to; PP2 = over/under

62. PP1 = over; PP2 = over or PP1 = under; PP2 = under

This is very closely in keeping with those used by Langendoen et al (1989).

Firstly, the full set of participants' data is analyzed irrespective of age; this provides an instant snapshot of the difference inherent in how subjects interpret these operations.



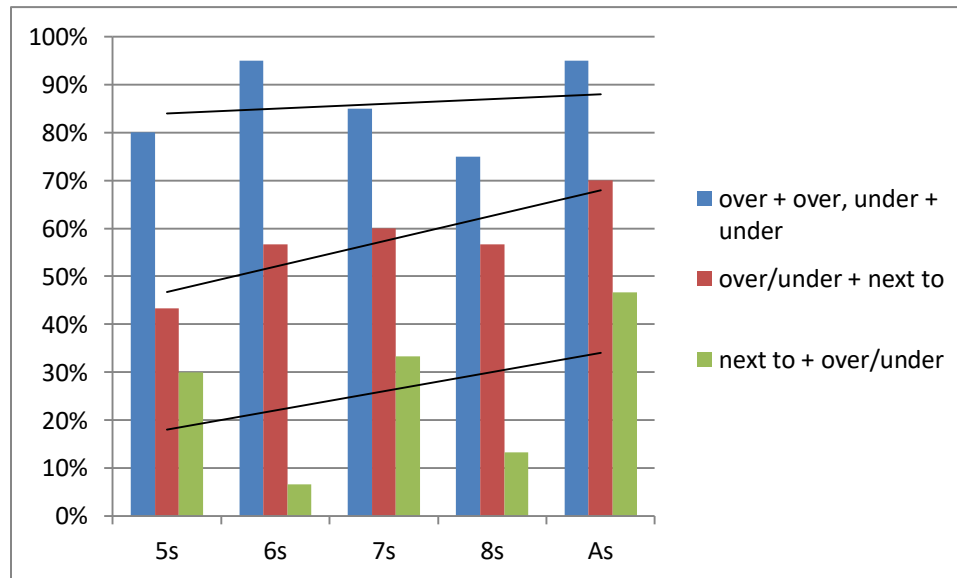
83. All subjects, PP heads compared

Looking first at recursion, there is a significant difference between all three sets. Two PPs identically headed by either *over* or *under* scored the highest rate, 83.8%. The differently-headed PPs, however, scored considerably lower. When PP1=*next to* and PP2=*over/under* accounted for the lowest rates of recursion, 21%, though when reversed, recursive interpretations were chosen 53% of the time ($p < .001$, $z = -3.98$). The difference in conjunctive rates between the latter two groups is also significant ($p = .006$, $z = -2.73$), as is that found in stacking ($p < .001$, $z = 5.232$)

Stacking in fact appears as a significant interpretation in only one of the two types in which it is possible, *next to* + *over/under*, where it is the chief interpretation at 55%; recursion and conjunction effectively split the difference at around 20% each. With

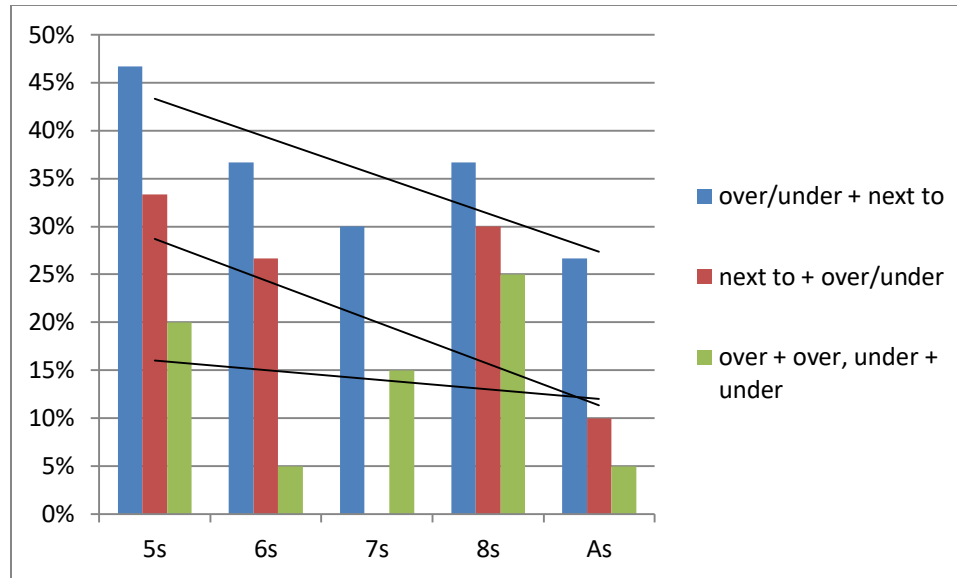
over/under + *next to*, stacking is only chosen 7% of the time, while recursion dominates again with over 50% to conjunction's 38%.

Breaking these data down by ages reveals other facets of the story as well.



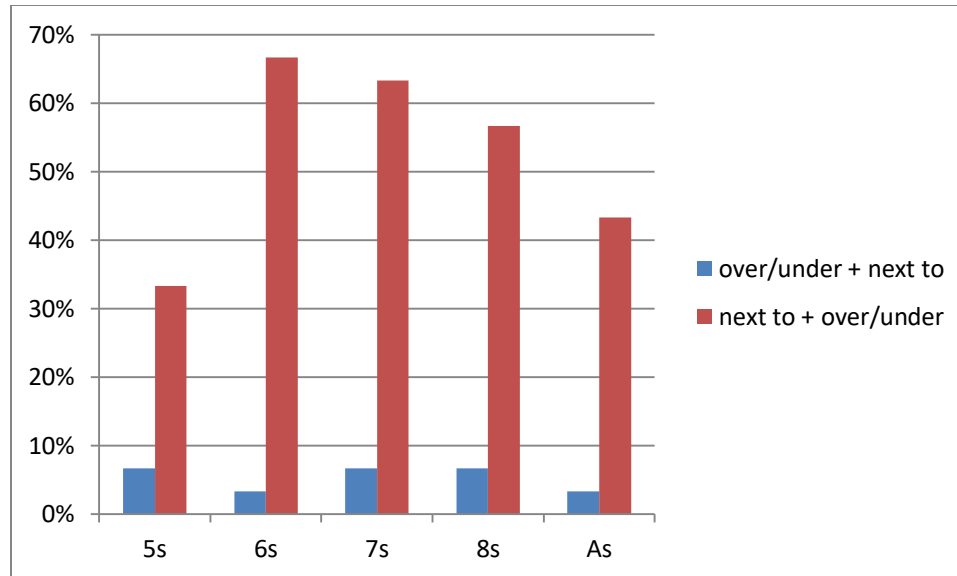
84. Recursion in two PPs, three types

Turning to just the differently-headed sets, the differences in recursive preference are clear at the onset with 5s and carry through to the adults, though only 6s and 8s had differences (from 40-50%) achieving significance ($p = .028$ and $.043$ respectively). The differences across ages in *over/under* + *next to* are not significant ($p = .391$, $t = 4.116$), though the trend is clear (despite the hiccup with the 8s). The differences across ages observed in *next to* + *over/under* is technically significant ($p = .046$, $t = 9.667$), but that is due to the low marks of groups 6 and 8 and not thanks to any discernible trend.



85. Conjunction in two PPs

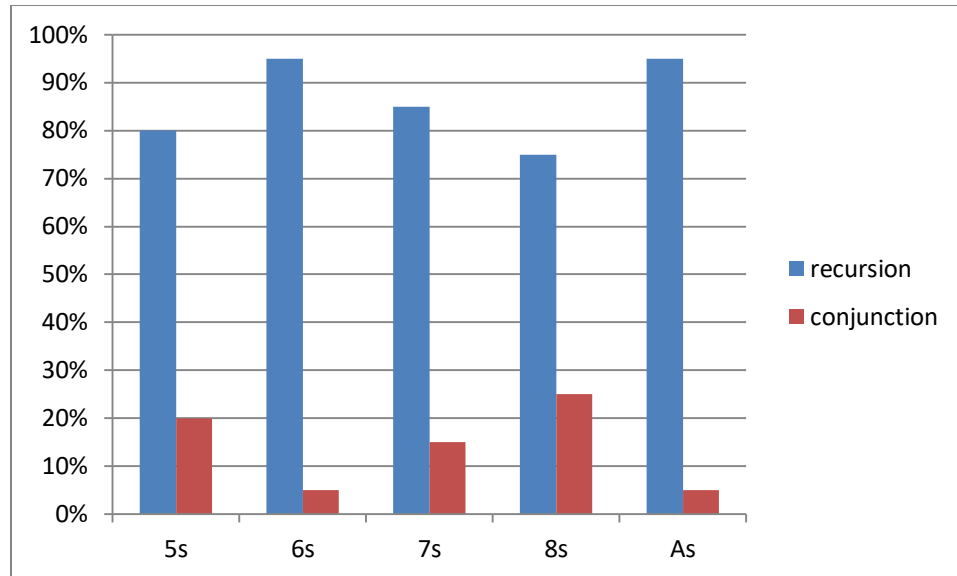
Differences in conjunction are apparent across ages as well, though significant differences in meaningful contexts are somewhat elusive. The declining trend in *over/under + next to* is apparent (excepting the 8s, of course) though not significant ($p = .782$, $t = 1.748$). The differences in *next to + over/under* are, however, significant, yet rooted in the fact that group 7 had no conjunctive answers. Nonetheless, a mitigating factor to this is that, on a group basis, significance still obtained between adults and 5s.



86. Stacking in two PPs

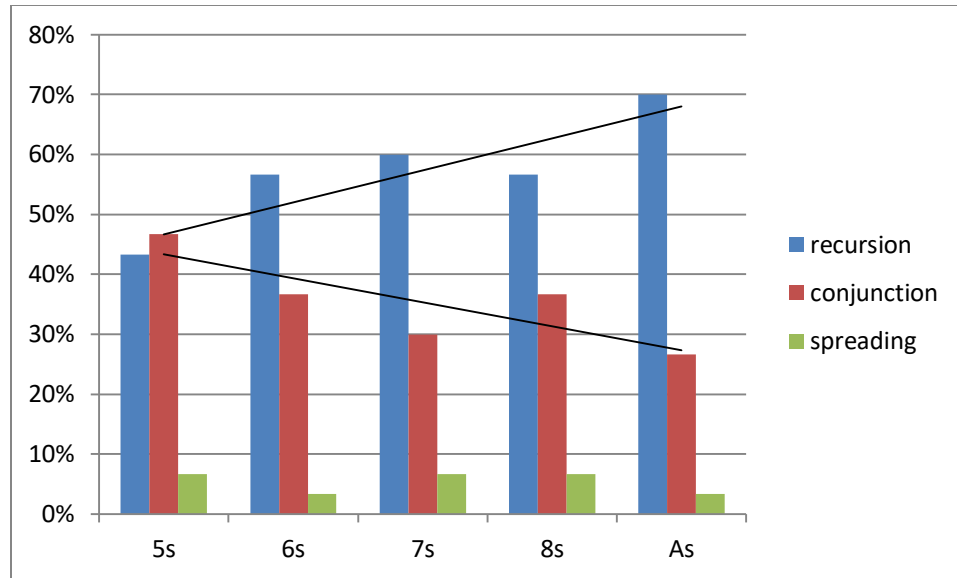
Stacking shows age variation where it dominates, in *next to + over/under*. Already strong by age 5 at over 33%, it doubles to 67% at age 6 where it peaks and thereafter declines steadily through adulthood ($p = .928$, $t = .875$). Yet stacking finds little variation over the ages in *over/under + next to*, here only found as an extreme minority response (3% to 7%) ($p = .222$, $t = 5.712$).

Analyzing preferences within age groups for each of the three types is revealing as well



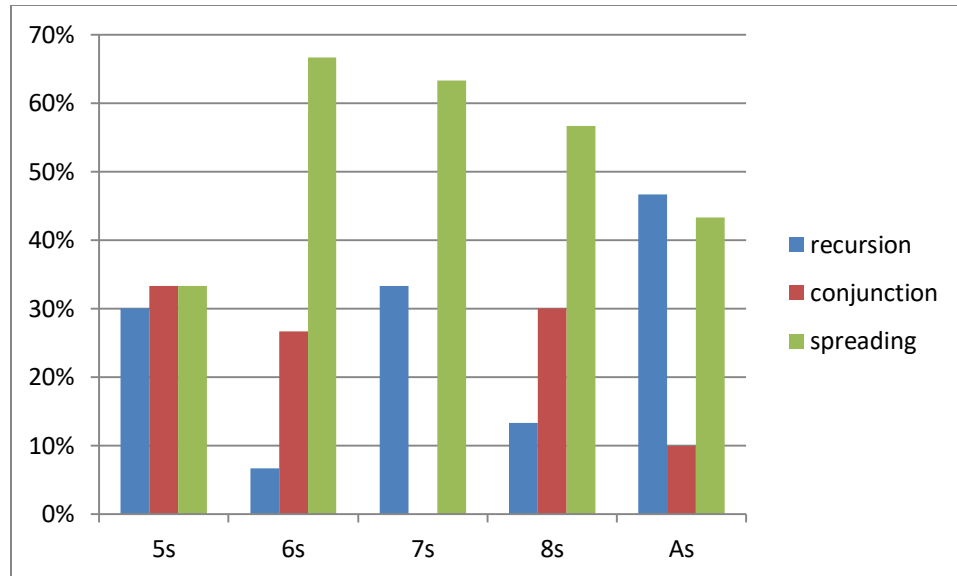
87. *under + under, over + over*

The first group, identically-headed PPs, triggered a strongly significant preference for recursion over conjunction in each of the five age groups ($p < .002$ in all cases except 8s with $p = .019$); it was unique among the three groups in this characteristic. Conjunction displays no significant trend, varying from 20% to 5% to 25% before settling back to 5% in adults.



88. *over/under + next to*

In *over/under + next to*, differences in three interpretations had p-values of at least .034 or better in four of the five groups; the exception were the 8s ($p = .081$, $t = 5.021$). The significance, however, was rooted in the difference between the stacking interpretation and the other two; stacking effectively neither grows nor diminishes, instead remaining a steady, though very minor, tertiary opinion. Not until age 7 does a significant difference emerge between recursion and conjunction. The adults are the only ones to register significant ($p < .001$) differences between all three interpretations.



89. *next to + over/under*

Finally, in *next to + over/under*, the preference was changed to stacking in all of the children's groups except 5s, who showed a nearly equal likelihood (c.30%) to choose any of the three interpretations. The 6s significantly preferred stacking over both others ($p = .004$, $t = 11.059$), as did the 7s ($p < .001$, $t = 16.722$) who were unique in obtaining significance between all three groups. The 8s obtained a significant ($p = .026$, $t = 7.266$) difference for stacking over recursion. With the adults, the significance is slightly weaker ($p = .044$, $t = 6.23$), however, this is due to the near extinction of the conjunctive interpretation; while recursion has returned as the dominant interpretation at 47%, it just barely edges out stacking at 43%. Effectively, recursion and stacking are equally likely interpretations for adults, as well as dominant, accounting for 90% of the answers between the two of them.

7.2.3.1 Discussion

The hypothesis concerning the effect of PP heads in interpretation was verified. Two identically-headed PPs trigger a far stronger recursive response than do differently-

headed PPs of either type. Differently-headed PPs are also quite clearly not a homogenous set, with pronounced differences apparent between *over/under + next to* and its mirror PP (see figure 83). What is more, a strong difference has already emerged by five years old, and, while varying in strength across the ages, is still clearly entrenched in adults (see figure 84). Together these data suggest that the effect that prepositions themselves have on which operations are performed is enormous and must be examined in detail.

Over + over and under + under trigger the highest recursion, a fact not only evident in the pooled data of all groups but also in each of the discrete ages. By age 5, recursion has already established an 80% preference rate, which reaches an adult-like 95% by age 6. Despite subsequent variations in specific levels, recursion has already emerged as the dominant operation with this set by age 5.

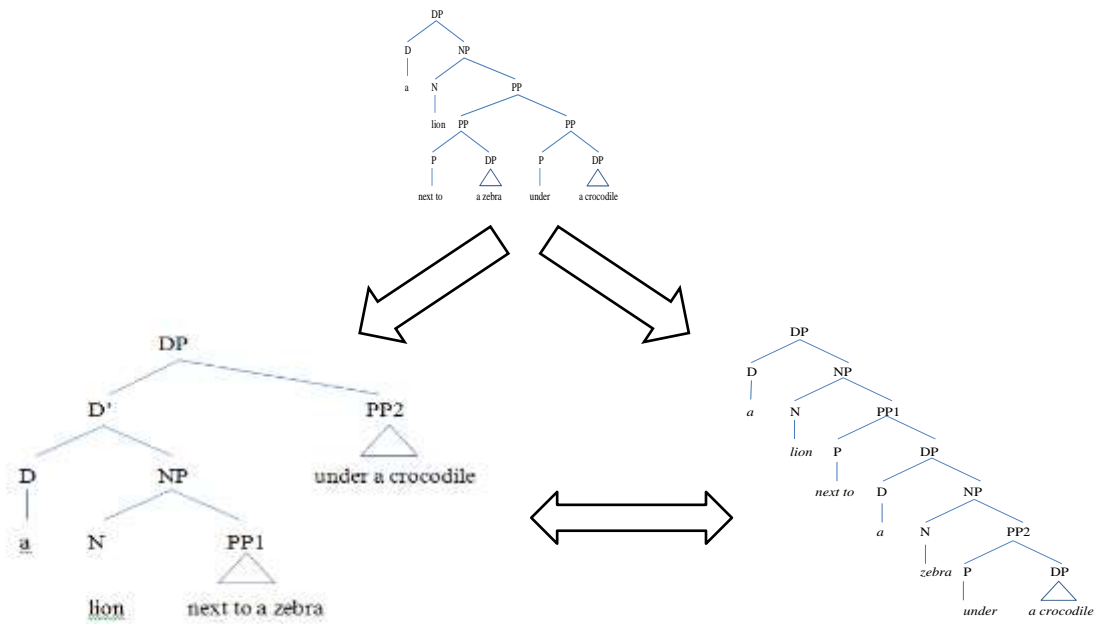
Nonetheless, the presence of *over* or *under* in PP2 does not seem to be a factor, as *next to + over/under* triggers the lowest recursion of all the groups; what is more, its growth from age 5 to adulthood is much more inconsistent, with what are proportionally much greater swings in interpretation, see-sawing up and down. Unlike with the identically-headed PPs above, not only have the 5s not settled on this as the preferred interpretation yet but apparently the adults have not either—their preference remains below 50%.

Over/under + next to triggers a higher recursive rate than its mirror discussed above (see figure 83). Furthermore, the growth of recursion with age in this type is much more consistent than in either of the two previous groups (see figure 84). This steadier progression and higher adult recursion (70%) than its mirror suggest that the

experimental data for this set may have more successfully captured a snapshot of the acquisition path than the data for the other two types.

The other side of the acquisition argument is whether any correspondent diminution in conjunction is observable. As with recursion, in *over + over* and *under + under*, the trend is virtually flat, as any extinction event with this type, if it exists, happens earlier than 5 (see figure 85). While both of the mixed types have distinct trends downward, the difference between them is much deeper than simply rate of conjunction. The five age groups in *over/under + next to* deviate little from the trend line, suggesting greater consistency and that a more coherent process may be in operation. In *next to + over/under*, however, the data points for conjunction are somewhat chaotic (as with recursion)—the 7s, at 0%, were far below the trend, while the 8s far above. Again, this suggests a potentially more unpredictable acquisition path for this type of item.

While the preceding discussion of recursion and conjunction might cover the essentials for two of the three items, in *next to + over/under*, stacking comes to the fore as the principal interpretation (see figure (83)). Non-existent in identically-headed PPs and barely registering as an option in *over/under + next to*, stacking is preferred two to one to the next most common interpretation (conjunction!), and recursion is knocked off its pedestal. While the strongest difference is rooted in the children—the 6s preferred stacking almost 10:1 over recursion—the ambiguity is still apparent in adults, whose answers were equally recursive and stacking (see figure 86). Thus, for this type of item, the acquisition path seems to be binary (see figure 90).



90. Next to + over/under acquisition path?

Exactly what this information may be telling us is unclear. One line of thought suggests that there is something inherent in the prepositions *over* and *under* that triggers a path wherein the previous input (DP + P(DP)) is spelled out to form an entity to which PP2 can attach. Another possibility is that the trigger lies in PP1, as when PP2 = *over/under*, PP1 is always *next to*. Perhaps *next to* acts as a trigger to form that entity, making a stacking attachment more likely. If this were the case, one might expect that effect to carry over into PP3; however, this effect was not observed. More likely is an effect related to the transitivity of the prepositions, considered in the following manner. If we have ‘the zebra over the bear next to the lion’ *over* possesses transitivity in the sense that the zebra could be over the bear and over the lion; with the prepositions reversed (the zebra *next to* the bear *over* the lion), *next to* does not have the same transitive characteristics, as the zebra may be next to the bear, but is unlikely to be perceived as also next to the lion—it is less ambiguous. This ambiguity resulting from transitivity may

act as a trigger facilitating the stacking interpretation; the intransitivity of *next to* pushes the execution of the recursive operation.

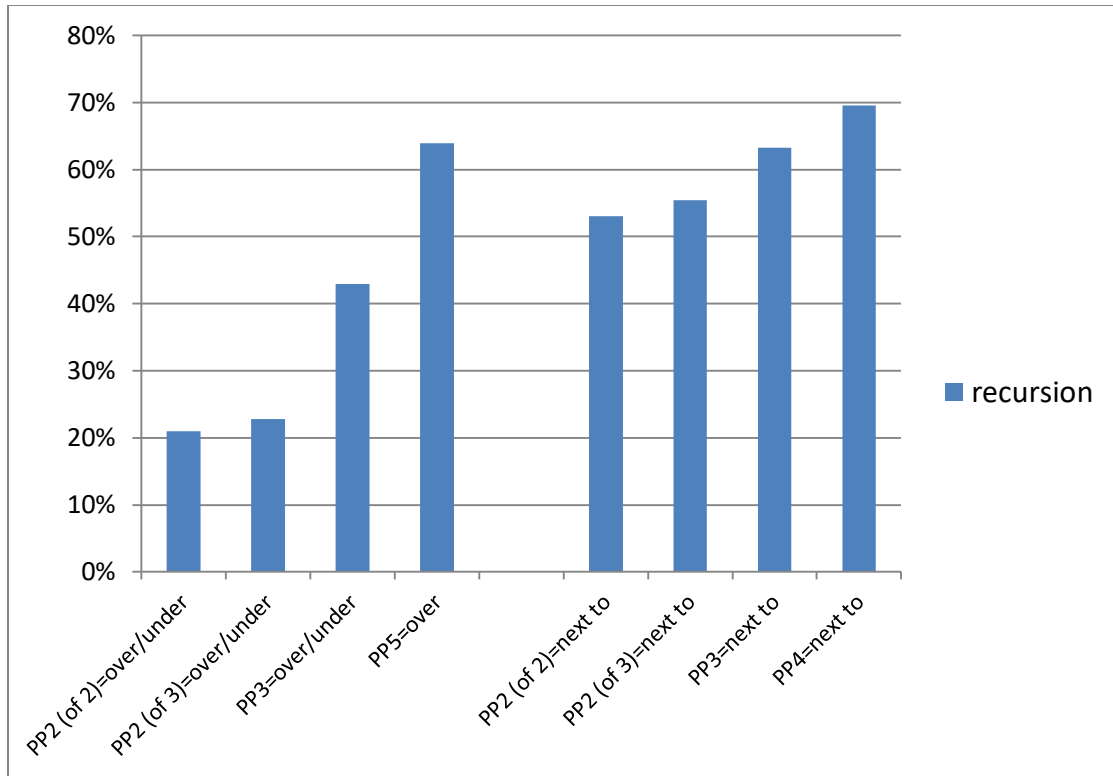
All of this suggests, then, that recursion within PPs may additionally be lexically- or semantically-based. Moreover, the apparent age of acquisition of each type of PP's operational tendencies—recursion, conjunction or stacking—differs for each type. *Over* + *over* and *under* + *under* are well-established in their recursive tendencies by age 5, *over/under* + *next to* is seen in progress along the path between 5 and adults, and *next to* + *over/under* undergoes considerably more flux, perhaps due to recursion's sharing of the 'destination' with stacking.

Roeper & Oseki's (to appear) proposal plays a role here as well; it must be refined, however, to reflect the data. Clearly, the appearance of DSR is at least lexically determined, not asserting itself with some items while dominating in others. Additionally, its purported role as an intermediary step between DUR and IR may be inaccurate, or perhaps insufficient. While it does appear and then diminish with *over/under*, it remains as a viable option through into adults, suggesting that it is more than simply an intermediate step on the road to recursion (IR), but perhaps a destination on the path unto itself. Nonetheless, as the data in (89) clearly suggest, DSR is triggered well before IR, which then grows steadily. Although DSR use declines steadily toward adulthood, it never disappears. This encourages a reassessment of what is meant by a path: DSR may open the door to IR, but it is never abandoned, as both are preferred in roughly equal measures by adult speakers.

Outside of this section of the data, however, DSR makes no significant appearance. It seems unlikely that *over/under + next to* ever had this option activated, even before 5 years old, as there is no observable decline in use with age nor any sort of ‘residual’ use in adults. Consequently, there remains a path to acquisition of simply DUR→IR, with DSR playing no role.

7.2.4 Number of adjacent PPs

Focusing on the raw number of PPs reveals variation as well. Nonetheless, given the clear variation among phrasal heads, the distinctions used in the previous section will continue to be observed below in tandem with the effects of number. The PP2 data used in the previous section (where PP2 is the final phrase heard) is kept apart from the PP2 data here, in which PP2 is only the penultimate phrase. Both of these are compared with recursion in PP3.

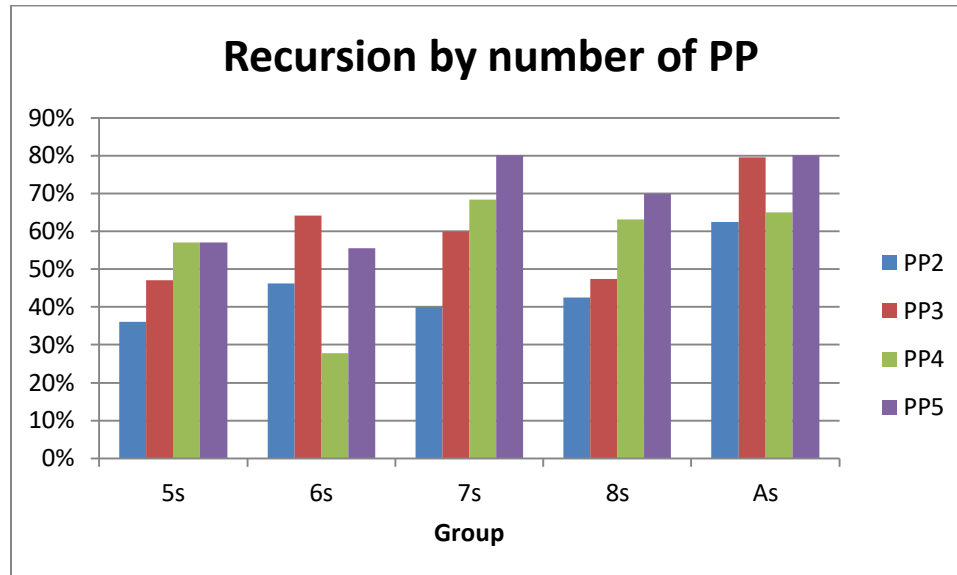


91. Recursion in PP2 and PP3, all ages

Before looking beyond PP2, the data shows a striking similarity in their operations whether they are the final or the penultimate phrase in the complex NP to which they belong. This is true regardless of the preposition; both types differ by only 2% between final and penultimate, an insignificant difference.

PP3 data suggest that the resistance to recursion in NPs using *over/under* in the final phrase could be overcome by length—recursive interpretations nearly double from the PP2 rate to 43%. This impression is bolstered by the fact that when *over* heads PP5 (*under* was not used, and neither headed a PP4), recursion rises noticeably yet again, this time to 64%).

Recursion with *next to* also benefits from lengthier chains of PPs, though not to the extent as in the previous set. The increase is steady, though, at 8% from PP2 to PP3 and a further 7% to PP4 where it reaches 70%.



92. Recursion in 2, 3 4 and 5 PPs by age

Attempts to observe any age effects are limited somewhat by the size of the data pool for larger numbers of PPs. Thus, no distinction is made in the preposition heading the PPs; all results are combined here undifferentiated. In the above chart, some caveats are useful. Firstly, the PP2s measured here were only those followed by a PP3; the complete data for PP2 is found above (figure 91). There were a total of 4 items containing PP2 + PP3; two of these items contained a PP4, and one of those contained a PP5. Of the initial four items, two PP2s used *next to* followed by PP3s using *under*; two used *over* and *under* followed by PP3s with *next to*. Both PP4s used *next to* (attaching to the PP3s using *under*) and the PP5 used *over*.

A steady progression is apparent in recursive interpretations in most groups. All groups increase from PP2 to PP3, and most (5s, 7s, 8s) also increase from PP3 to PP4. The final step from PP4 to PP5 found higher recursion in four (6s, 7s, 8s, As) while leveling out in the 5s. All groups also finish higher (on PP5) than they started on (on PP2).

7.2.4.1 Discussion

The data indicate that recursion is more likely in PP3 than it is in PP2 (see figure 91). The prepositions themselves continue to play a huge role, as recursion in *next to* ticks slowly and steadily upwards, while *over/under* undergo a major breakthrough in recursive interpretations beyond PP2. The huge leap in these operations from PP2 to PP3 and again from PP3 to PP5 suggests that any barriers to them created by the transitivity of *over/under* are worn down by complexity of NP.

Also, across all PP types, recursion grew from PP2 to PP3 within every age group (see figure 92). While there was more variation in PP4 and PP5 across groups, recursion only strengthened as the preference with each subsequent PP. As this preference was apparent from the 5s on up, this suggests that, if the syntactical complexity of NP increased side by side with corresponding recursive operations this aspect of the grammar was well on its way to becoming established before age five.

The take-away here is that the more complex an NP becomes (in terms of embedded PPs), the greater the tendency to create ever more hierarchical structures via recursive operations.

Answers involving medial interpretations, included as one of the chief options in the previous experiment, here came in quite the minority both for children and adults. Their

dispersed nature throughout the data makes it unlikely that anything useful can be gleaned from them; as such, their further analysis is not pursued here; nonetheless, see below for data on medial interpretations.

7.2.5 Operational continuity

In addition to comparing the results of PP2 and PP3 in isolation as above, trends may potentially be observed by noting what if any interpretation shift takes place as one moves from PP2 to PP3 within the same NP. To clarify, in the results above, a recursive answer in PP3 did not necessarily mean that it followed recursion in PP2—the results were recorded independently. Thus, the results from the four triple PP questions were compared to see if there were internal effects of recursion, i.e. does the interpretation of PP2 as recursive affect the likelihood of PP3 being recursive.

A total of 160 arrangements were created for the four triple PP questions. In the children together, 69 of these (43%) made use of a single interpretation—*conjunction* + *conjunction*, *recursion* + *recursion* or *stacking* + *stacking*—a number which rises to 65% in the adults. Over half (53%) of children's answers shifted their interpretation/operation from PP2 to PP3, while only a third of adults' answers had this characteristic. Breaking down the data into each type of operation chain reveals certain facets—the complete data are presented in the table below.

Table 4. Operations of PP2 + PP3

Shift type	child %	adult %	Langendoen et al
conjunction→conjunction	20%	10%	17%
recursion→recursion	19%	55%	44%
stacking →recursion	17%	3%	7%
conjunction→recursion	13%	20%	5%
stacking →conjunction	11%	0%	0%
uninterpretable	4%	3%	14% ⁹
stacking → stacking	4%	0%	1%
recursion→ stacking	3%	0%	1%
stacking →medial	3%	3%	na
recursion→medial	3%	3%	na
recursion→conjunction	1%	0%	0%
conjunction→ stacking	1%	3%	0%
conjunction→medial	1%	3%	na

The two most common chains, recursion + recursion and conjunction + conjunction, were consistently strongest in both children and adults. The tendency is clear as conjunction + conjunction decreases by half, from 20% in children to 10% in adults, while full recursion in both phrases nearly triples, from 19% to 55%, from children to adults.

Langendoen et al (1989) also found that the same two non-shifting interpretations (two recursive or two conjunctive) were the most common provided, with data points effectively located between those for children and adults in the present study. As Langendoen et al's subjects were in their mid-teens, this would represent an increase in non-shifting recursive interpretation across PP2 and PP3 corresponding to age from child to teen to adult. A non-shifting conjunctive interpretation, at 20% initially as strong as recursion in children, declines slightly to 17% in the mid-teens (Langendoen et al) before dropping to 10% in adults.

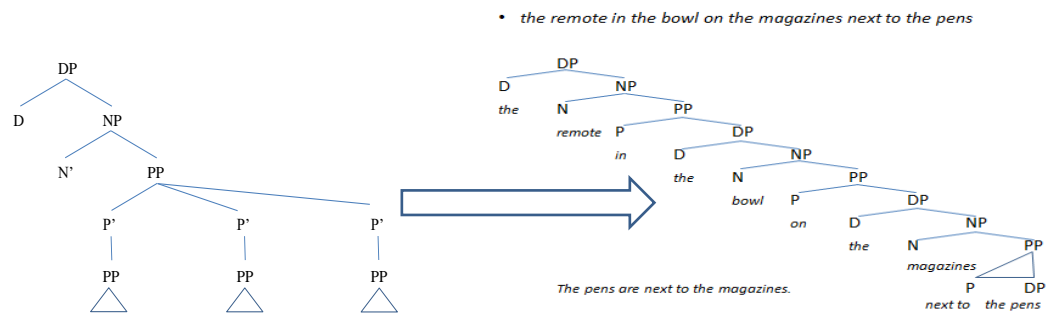
⁹ The disparity in uninterpretable results is likely due to my expansion of the coding to include medial interpretations.

Adults' second preference (20%) was a shift from conjunction to recursion; this combined with the above 2 were the only operation chains used in any significant amount by adults.

Of the remaining children's results, only 3 achieved a significant number of responses amounting to more than 10% of the pool; all switched to either recursion or conjunction in PP3. Children used conjunction to recursion less (13%) yet also used stacking to recursion (17%) and one that did not finish in recursion, stacking to conjunction (11%).

7.2.5.1 Discussion

Regarding shifting interpretations, these data provide some interesting insights. One is that, when confronted with an interpretation challenge consisting of compound phrases, adjoining them either both conjunctively or both recursively is preferred equally in children. The adult grammar, however, makes much greater use of entrenched recursive operations. There is a maturational shift in operations seen in representations below (repeated from earlier)

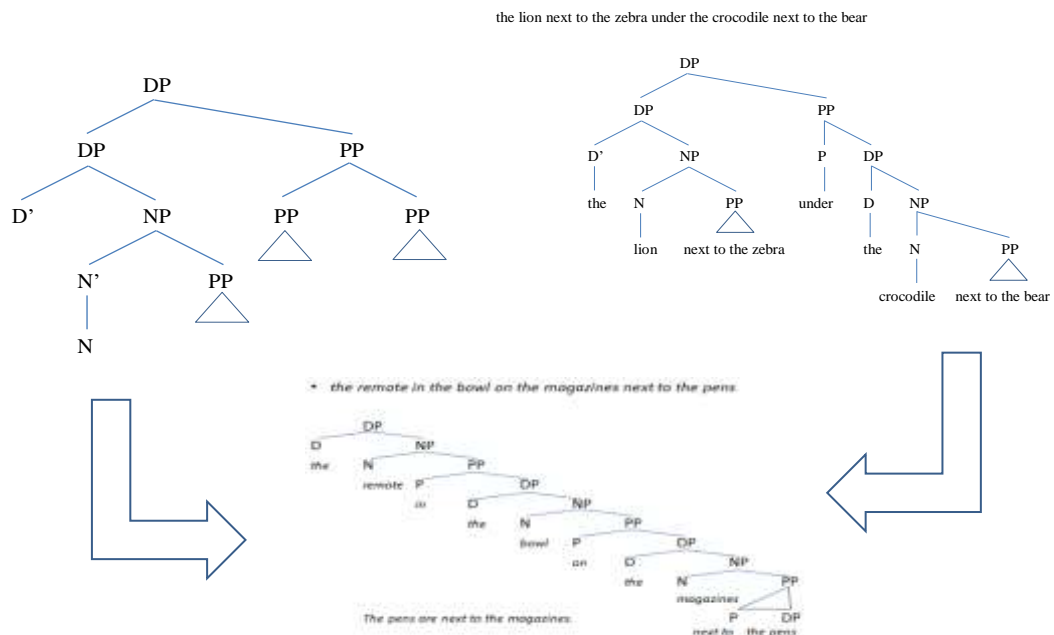


93. Three level conjunction vs recursion—the acquisition path

While children favor the operations in figure 93 equally, there is a profound reduction in the three-level conjunction seen on the left and a growth to dominance of recursion on the

right in adults; it could be credibly postulated that this represents some form of acquisition path for multi-level recursion.

Nonetheless, this path is not the only one. Two non-continuous interpretations, stacking + recursion and stacking + conjunction, used by children were virtually extinguished by adulthood, allowing other paths to be hypothesized.



94. Three PPs, additional paths to acquisition?

Yet even that does not illustrate the picture adequately as it does not account for the one significant adult interpretation involving a shift: conjunction to recursion. Present in children, it only strengthens in adults instead of weakening. This leaves a potentially much more complicated path, or pathes, than at first assumed.

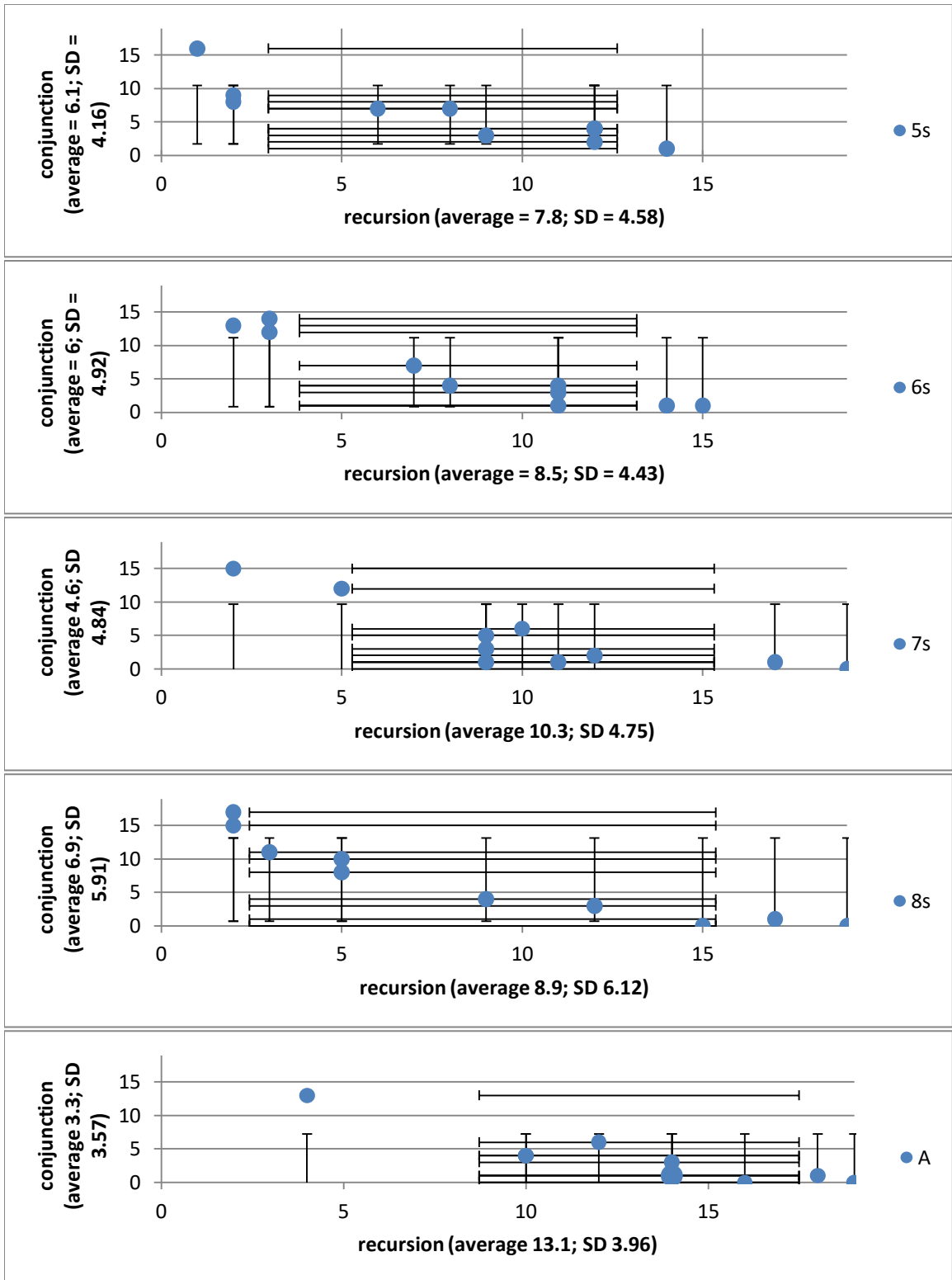
Another is that 30% of the time, speakers will shift from either stacking or conjunction to recursion, the most popular choice when a shift in interpretation is chosen. Indeed, when a shift occurred (84 samples), recursion was chosen 48 times (57% of the time) of the

four coded responses. Furthermore, of the 12 possible responses, all of those that used recursion in the final PP were in the top four responses given by children.

Again, this analysis suggests that, as the age of subjects increases, use of hierarchical structures increases as well. Here, the most hierarchical, recursion + recursion, increases most of all, but even paths which start out lacking hierarchy tend to move towards greater hierarchy the deeper into the NP they go.

7.2.6 Participant analysis

As with the previous experiment, closer examination of individual results may lend greater insight into the nature of the data. Moreover, as the 8s stand out for their non-conformity with the data trends, it is worthwhile to look at that data a bit more closely to see whether it is simply an anomaly or in fact enough to discredit any hypotheses of which it skews the data. Below (see 95) the distribution of individuals' answers is mapped across five charts, one for each age group. Each dot represents a data point defined by numbers of recursive and conjunctive answers given out of a maximum of 19. The error bars represent one standard deviation (SD) on either side of the average for the group (a total of two SD).



95. Individual results, recursion vs conjunction

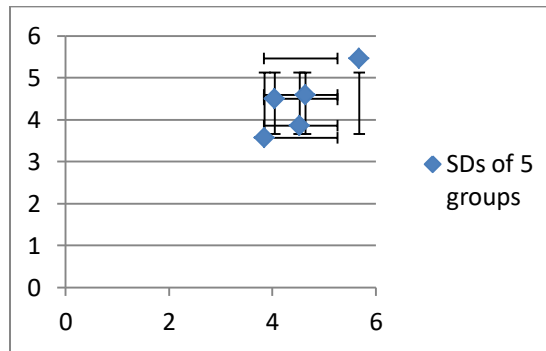
A number of observations can be made from these charts. Naturally, the trend of the groups downwards and to the right as we move from 5s to adults is what has been seen earlier in another format; this represents the shift from coordination to recursion. What is more, given the quite small sets of data involved in this pilot study (10 subjects per group), the potential for one or two outliers in the data to skew the data is considerable. Thus, not only are there outliers far to the left, representing minimal recursion, in the younger children's groups, but even the adult group contains one individual who apparently avoided recursion at all costs, relying almost exclusively on coordination, putting them far beyond SDs for both. What is more, outliers in the other direction are also strongest among the older groups; only the 7s, 8s and adults each contain one subject who used 'full' recursion (19 of 19). Nonetheless, again due to the extremely small number of subjects in the pilot study, the decision was made not to eliminate any of the data but to instead include it with this warning.

Also, the standard deviations of the 5s, 6s and 7s for both recursion (4.43-4.75) and conjunction (4.16-4.92) are quite similar; from this it can be inferred that their control of an operation was similar, regardless of age or whether it was recursion or conjunction. Adults have SDs below 4 for both operations, suggesting a greater control over them. The 8s, however, in addition to offering a lower recursive average and a higher conjunctive one than anticipated, also demonstrated notably more diffuse answers as demonstrated by their noticeably higher SDs: 6.12 for recursion and 5.91 for conjunction. This irregularity warrants a closer examination of the data. Comparing the SDs of the data more closely gives the following:

Table 5. Standard Deviations of L1 data

	recursion	conjunction
5s	4.521062	3.858756
6s	4.04475	4.495553
7s	4.635731	4.592385
8s	5.678028	5.4626
adults	3.848258	3.568804
Avg SD	4.545566	4.39562
SD of SD	0.636907	0.657114

Charting the Standard Deviations (the dots) and showing their own Standard Deviations (the lines in the chart of them (below), we see that the 8 group is indeed outside 1 Standard Deviation in both recursion and conjunction, while the other four ages are tightly grouped:



96. Standard Deviations graphed

Looking at the individual charts per group in the problem areas, -1 SD for recursion and +1 SD for conjunction, the explanation becomes apparent:

Table 6. Recursive and conjunctive SDs

Group	-1 SD recursion	+1 SD recursion	-1 SD conjunction	+1 SD conjunction
5	2.9	11.9	2	9.8
6	3.8	11.8	1.2	10.2
7	5.3	14.5	-0.5	8.7
8	2.7	14.1	0.9	11.9
adult	9.3	16.9	-0.3	6.9

Had the SDs of the 8s been more in line with those of the 5s, 6s and 7s, their performance would be much more difficult to explain. As it is, the lower average scores for recursion and higher ones for conjunction combined with the larger SDs in both means that the 8s SD range goes far lower for recursion and far higher for conjunction. This explains why the 8s ‘underperform’ the tendencies seen in the trend lines progressing from 5s to adult.

The data also suggest that conjunction may subside before recursion truly blossoms, as was seen in the previous experiment, though the evidence here is not as strong. If we define this as falling below the SD of recursion for adults more often than they fall above the SD of conjunction, several points appear.

7.2.7 Reversed Semantics or Postpositions?

The curiosity mentioned in the beginning of the chapter wherein prepositions were apparently ‘reversed’ on interpretation presents a dilemma in how to best analyze it. This is because there are at least two possible explanations for this phenomenon. One is that the listener has an ambiguous grasp of the semantics of the preposition, and *under* and *over* overlap on their semantic map. The representation produced correlates accurately with an identical phrase substituting ‘over’ for ‘under’ and vice versa. This would be considered ‘reversed semantics.’

An alternative explanation is to see this as a consequence of treating the prepositions as postpositions. In this scenario, ‘*a zebra under*’ in (63) would constitute an adpositional phrase headed by *under* with *a zebra* as its complement.

63. *Show me a zebra under a giraffe under a bear.*

This would also entail making the final noun of (63) the head of the entire NP, such that it would be translated to Standard English as (64).

64. *Show me a bear under a giraffe under a zebra.*

The third preposition, *next to*, was not affected by this phenomenon directly, as there is none of the available ambiguity in the two-dimensional space of the experiment (the screen): any two adjacent objects may accurately be described as next to. The significance of reciprocity is seen in (65) and (66).

65. The bear and the giraffe were next to each other.

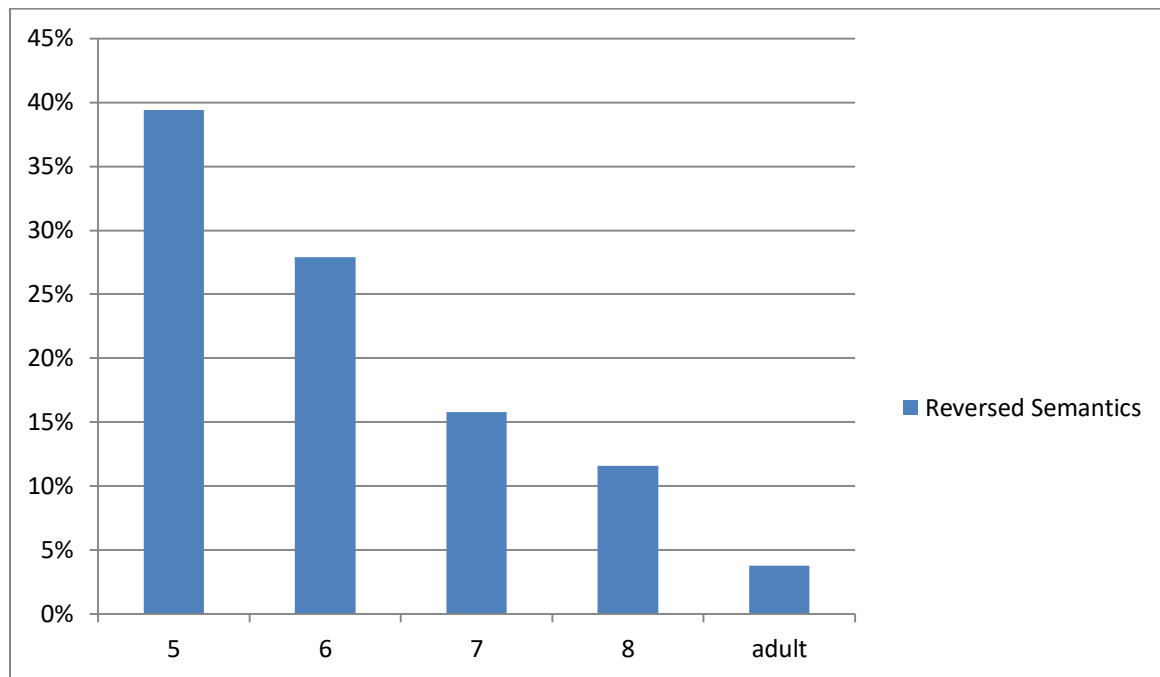
66. *The bear and the giraffe were under/over each other.

Nonetheless, *next to* was indirectly affected, as this often occurred in complex NPs containing *next to* and either of the other two prepositions.

67. *a lion next to a zebra under a crocodile*

Our first example in the chapter (repeated here as 67) would be shown with the crocodile under the zebra; the lion and the zebra are next to each other, so either one may be the complement of the preposition.

The salient question in regards to the experiment—whether the phrases are parsed conjunctively or recursively—allows for the same successful analysis of an answer whether or not this phenomenon has occurred. Thus, responses such as those described above are noted for their ‘non-traditional’ nature but coded along with the rest of the responses which used traditional interpretations.



97. Incidence rate of non-standard semantics or syntax

The percentages cited above are only of PPs which had the possibility for this to occur; PPs headed by *next to* were not included. Whichever analysis described above one chooses, the data that result from this ad hoc calculation indicate that it, too, is subject to maturational constraints. Surprisingly strong in five-year-olds at nearly 40%, its extinction proceeds more dependably and precipitously than that of conjunction and by

adulthood is virtually absent. It must be noted that, regarding the adult bar at 3.8%, this represented a total of five answers, all but one of which came from a single subject¹⁰.

My suspicion is that the broader semantics of *under* and *over* have been acquired along with *next to*; i.e. their ‘underness’ and ‘overness’ have been acquired along with the adjacency implications of *next to*. Similarly, then, they might also share an ambiguity as to what they syntactically take as complements: the preceding or the following NP. With *next to*, this produces no observable effect in performance, while with *over/under* the effect is clear.

Further evidence is found in the data from some of the distractor items used in ExL1. For instance, it was not uncommon in (68) to locate the zebra and hippo between the elephant and rhino.

68. I see an elephant and a rhino. They’re between a zebra and a hippo.

Nonetheless, a more thorough analysis of the data is required and a study targeted at this issue would certainly allow a better understanding of what may be involved.

7.3 Summary Discussion

The experiment provided valuable data regarding the operations performed on assorted PPs within complex NPs. Certain data confirmed hypotheses in predictable ways while other data disproved hypotheses, taking the analysis in unexpected directions.

There is indeed a discernible ‘path to acquisition’ of performing recursive operations on the relevant structures, as their use increases indisputably with age. What is more,

¹⁰ As the question is inevitable, it must be pointed out that this is not the same subject who fell far outside of the Standard Deviations for recursion and conjunction.

prepositions possess discrete characteristics which affect the likelihood of which operations are carried out. These characteristics also show that a binary description, recursion or coordination, may be inadequate to describe the options available; the presence of stacking (or 'DSR') indicates added nuance to the path. Complexity of NPs as described by number of PPs also facilitates greater recursion. Clearly, other factors are at play as well, as seen in the interpretations discussed in the previous sections.

To get a better understanding of what all of this may be saying, the results of experiment 2 must be reviewed in the context of experiment 1. The results of the two side by side will perhaps be the most thorough way to arrive at any broader conclusions.

CHAPTER 8

Synthesis

8.1 Introduction

Despite the valuable observations gleaned from each of the studies independently, a comparison of the data from both will allow for a richer and potentially further reaching discussion than was previously possible. While several conclusions from both experiments dovetail in their response to the broader research questions, others apparently contradict each other in unexpected ways. This comparison can then address the broader debate on the acquisition of recursion and how it may be situated in regards to UG and processing.

8.2 Overall recursion vs conjunction

Recursion is preferred to conjunction across the board, whether the subjects be children working in their L1 or adults in an L1 or L2. Although there are some important exceptions to this, explained below, the broader view that recursion would be the default operation is confirmed. By no means does conjunction shrink into insignificance, however; it remains a strong alternative to recursion throughout.

Due to considerable differences in methodology, there was no expectation that actual rates of recursion, as measured in percentage of answers, would be particularly similar—just the trends apparent would.

Simplification via PP dropping was used in ExL2 to offer an alternative to recursion and conjunction. This option naturally attracted some responses, though for the most part

remaining an extreme minority option. ExL1 indicated that subjects, in fact, never used this interpretation as a path to simplifying the challenge confronted with.

Other alternatives, as well as their various combinations, are dealt with in the relevant sections.

8.3 Age effects in child L1 and adult L2 similarity

Together the experiments certainly provide evidence that the L2 acquisition path could parallel that of child L1 for these structures, but only within certain conditions.

Differences arose, to be sure, regarding PP heads and length of PP chain, but those are dealt with below in their separate sections.

The children using L1 English clearly demonstrate characteristics indicative of a path being followed towards acquisition. With increasing age comes increasing input and operations default to recursion with ever-increasing frequency.

In L2 Spanish, although there are only two levels to observe, the clear difference in recursive rates suggest something akin to an acquisition path towards this operation. Advanced speakers are significantly more recursive in their operations, and in some scenarios indistinguishable from L1 Spanish speakers. The argument could certainly be made that recursive ability in L2 Spanish progresses and conjunction withers as input increases in much the same way that these operations change in the L1 of a child. What is more, we can see that an L2 speaker may potentially become indistinguishable from an L1 speaker in the comprehension of these structures as their exposure continues. Whereas exposure in one's L1 is constant, L2 exposure is often intermittent, with long gaps interrupting throughout. Strong recent exposure, measured in the raw number of

university courses taken, mimics adequately L1 input as far as (re-)activating recursive operations already available in a speaker's L1; what is more, this additional exposure is essential for this growth in recursion to take place. Of course, the exposure does not by any means need to be university language courses for this to happen; this only proved to be a convenient metric given the source of the data. Time abroad, speaking with Spanish speakers on a regular basis, or simply regular viewing of the extremely popular (and strangely addictive) Mexican telenovelas (soap operas) abundantly available on Univision would all likely serve as equally strong (if not stronger) input agents to trigger the same effect.

The data from the L2 English version of ExL2, however, indicates that a blanket statement in regards to the L2 path's similarity to that of L1 remains elusive. That data showed L2 speakers with significantly higher recursion than L1 speakers. It was suggested earlier that perhaps the productivity and distribution of right- and left-branching recursion in different languages held the key to explaining this apparent anomaly. If this were so, then the initial hypothesis would be overly simplistic in its description of the phenomenon. The mere existence of both Spanish and English productive PP recursion was, in fact, not sufficient to facilitate L2 paths in both languages similar to that of L1. The data suggested that not only was the Spanish language inherently more productive than English with this recursive operation, but also that L1 Spanish speakers could apparently take advantage of this parameter in L2 English. They were moving beyond 'native-like' and included an excess of recursion in their Interlanguage instead of a deficit.

This apparent abundance of recursion in Spanish PPs can very possibly be accounted for by one factor: possessives. Spanish possessives default to PPs in all scenarios, excepting the possessive determiners, *mi, tu*, etc. This vastly increases the breadth and frequency of PPs in general compared to English. While technically possible, the possessive PP in English is largely limited to the standard double genitive, e.g. *a friend of mine*, and even this may include the Saxon *s* (a friend of Tom's). Prenominally, of course, the Saxon *s* is the default possessive structure (Tom's friend) in English (again, except for determiners).

This information can be integrated into a more refined description of the path.

69. The L1 path to acquisition will demonstrate increasing appropriate recursive operations with age until that language's normal adult rate of recursion is reached.
70. The L2 path to acquisition of recursion will mirror that of L1 if the target adult grammar is *as* or *more* productive in its use of appropriate recursive operations than the L1 of the L2 speaker, provided that both languages share the specific operation.
71. The path will be truncated, eliminated or even bypassed if the reverse is true and the target adult grammar is *less* productive in its use of appropriate recursive operations than the L1 of the L2 speaker.

Adjusting the initial hypothesis in this manner would account for the data discrepancies between languages. It would also accommodate above-target recursion, as the L1 recursive operations carry over. Of course, there is insufficient data in the present study to confirm their validity; further studies would need to be carried out to specifically

address these issues. Moreover, these (69-71) yet need considerable refinement to achieve a more efficient descriptive adequacy.

8.4 PP heads and their effect on operations

Specific prepositions clearly produced very strong effects on which operations were likely to be performed for each PP, and any account of PP behavior in this regard must factor these into the equation or equations attempting to explain it. While the distinction created initially of identical and different prepositions in adjacent PPs was certainly useful and bore fruit, clearly limiting the structures to locative PPs was not enough to weed out extensive variation across prepositions in regards to their recursivity. The role of stacking/DSR arises as well and must be evaluated.

8.5 Identical PPs

Two locative PPs headed by identical prepositions triggered much stronger recursion than did other types of two PP items. This was true whether subjects were selecting from options (as in ExL2) or asked to create the spatial relationships themselves (ExL1). Nonetheless, while this was broadly true, closer inspection revealed broad variations in the different prepositions' dispensation towards recursion in ExL2. Fortunately, the specific combinations used in ExL1, *over/over* and *under/under*, were also used in ExL2, allowing a direct comparison. Less fortunately, the results of each preposition in ExL2 are quite different from each other.

In ExL1 *over/over* and *under/under* behaved quite similarly and thus were not separated for analysis; together they had over 80% recursion, far above the other combinations. In ExL2, in L1 English, *under/under* was similarly strong, while *over/over*, at just over

50%, was comparably quite reticent in performing the operation. To upset the horse cart more, these results were flipped in L1 Spanish, where their translated counterparts *debajo de/debajo de* and *sobre/sobre* were respectively weak and strong in recursion (given that the visual prompts and multiple-choice options were identical, this is at least very curious). This may, however, be the result of curious linguistic particularities in the design of ExL2—the stronger impression is that these types of PPs do facilitate recursive operations more than others.

The raw assumption at the start of the experiment was simply that sameness drives recursion. All prepositions used in the identical PP sets could be described as transitive, in the sense described in the previous chapter.

72. a over x over z

73. a under x under z

74. a in x in z

75. a behind x behind z

In examples 74 and 75, just as in 72 and 73, the first instance of *in* or *behind* could be applied transitively to the object of the second preposition, z—if a is behind x and x is behind z, then a is behind z.

This transitivity clouds the issue, then, because transitivity also translates into a form of conjunction: a is behind x and a is behind z. Thus what on the surface appears as recursion, and could use a recursive formal representation, may also be indicative of conjunction, and thereby carry a coordinate, flatter, representation. Earlier it was argued

that teasing the two apart is impossible within the present study; the recursive description, however, seems to most adequately describe what is observed.

Supporting the recursive angle is the fact that the comitative sets *with/with* and *con/con* also demonstrated higher recursion (although it could be argued that those are inherently less ambiguous than locatives) than other pairs, yet are not as likely to be found transitive and thereby conjunctive.

76. a with x with z

If *a* is with *x* and *x* is with *z*, *a* is not necessarily with *z*; what is more, *z* is barred from being with *x* and with *a* simultaneously, unlike the locative examples above.

77. the woman with the baby with the blue shirt

The blue shirt is either on the baby (recursion) or on the woman (conjunction), but not on both simultaneously.

Further studies would be needed to get at the core of this difference. *With* may be explored not only as a comitative but also as an instrumental; these results could be compared for a better understanding.

78. The child ate the soup with a spoon with help from his mother. (instr.+instr.)

79. The child ate the soup with tomatoes with a spoon. (com.+instr.)

The status of what was referred to as ‘alternate conjunction’ in ExL2 can be better assessed using the data from both experiments. In ExL2, it was added as a special fifth choice with this type of item, taking advantage, albeit unwittingly, of the prepositions’ transitive properties. As it used a hypothetically plausible interpretation that included

both PPs in the prompt, it unsurprisingly attracted numerous responses, from 15% in SL1 to 20% in EL1. Nonetheless, the response could be considered technically inappropriate given the PPs' apparent attachment points, much less appropriate than ordinary conjunction. This may explain why in ExL1, the combined total for all age groups was a much smaller 5%: a clearly nonproductive option. Therefore, it seems apparent that its inclusion as an option in ExL2 attracted a disproportionate attention relative to its likelihood as an interpretation in naturalistic production. As such, the relevant data from ExL1 would seem to be much more indicative of tendencies in true interpretation, and any suggestions that this might represent a viable form of 'alternative coordination' would probably be overstated.

8.6 Different PP heads and intransitivity

As described in the previous chapter, ExL1 compared only two of these, each the mirror of the other, while the items in ExL2 are both different from these and less tightly controlled, impeding easy comparison. Nonetheless, certain elements may be highlighted and possibly made sense of through comparative analysis.

Although identical PP chains were not available for comparison across experiments, individual PPs are. In ExL1 it was observed that *next to* heading PP2 led to stronger recursion, and this particular item leaps out of the data from ExL2 as being the most recursive item of all, regardless of language. Due to different formats in the different experiments the precise rates of recursion may vary, but no matter—the correlation is clear across methodologies. PPs headed by *next to*, whether in English or Spanish (*al lado de*), somehow trigger recursion more than do those headed by other locative prepositions when following PPs with different heads.

Speculation from the previous chapter suggested that the intransitivity of the preposition may have something to do with this interpretation. If so, evidence from other intransitive prepositions may help to assess the validity of this notion. ExL1 has no other PP chains to choose from, but three remain from this set in ExL2 to examine. One or more of these, in fact, could be said to possess intransitivity akin to *next to*.

The preposition *on top of* is intransitive in a sense very similar to *next to*. In (80), the corresponding target item from ExL2, this characteristic (and the options provided) makes it very clear that if the plates are on top of the tray, then the glasses are not.

80. *the glasses in front of the plates on top of the tray*

Similarly, in (81) the box is quite clearly next to the books, not the CDs, or the other way around.

81. *the CDs in the box next to the books*

Yet (80**Error! Reference source not found.**) and (81) inhabit opposite ends of the data raphs of both languages, with (80) at minimum recursion and maximum conjunction and (81) flipped, employing maximum recursion. If, in fact, these prepositions can be described as similar in their intransitivity, then it must be concluded that that is not what is driving the recursion.

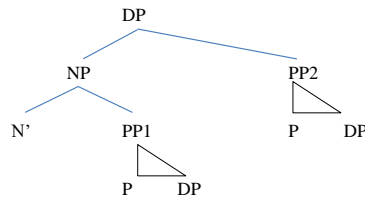
Perhaps it is nothing more complicated than the bi-directionality of *next to* which facilitates this recursion. As discussed earlier, if the box is next to the books, then they are next to each other. The same could not be said, of course, for (80), as the plates and the tray could not possibly be on top of each other.

Another potentially relevant factor which may affect recursivity is prepositional complexity in terms of how many words make up each preposition. As next to/al lado de was highly recursive in ExL2 yet on top of/encima de was minimally recursive in ExL2, at the surface, then, this might be dismissed as a factor; nonetheless, further studies would need to be carried out.

8.7 Stacking/DSR

No adequate parallels are available in the data across both experiments to make a broad observation here as the PP2=*over/under* paradigm from ExL1 is not present in ExL2, and of course stacking was not included as one of the options. Yet one characteristic of this structure which may comment on the design of ExL2 was the prevalence of stacking found in ExL1. The fact that this interpretation arose as a very significant alternative indicates that it may have been interesting to include this as an option in these types of questions. As there was such a strong distinction as to where this was licensed (when PP2=*over/under* but not when PP2=*next to*), very probably other discrete prepositions may also license this interpretation.

Exactly what about aspect of this type of complex NP promotes a representation such as that in (98) is unclear, however.



98. Stacking

It may serve as a form of ‘gateway’ representation into broader recursive syntax. As noted, the mini-complex NP begins to form ‘normally’ with PP1 attaching to the head noun before PP2 attaches high—higher, in fact, than conjunction. This aligns with Roeper & Oseki’s (2013) proposal of an intermediate step on the path.

82. DUR/conjunction → DSR/stacking → IR/recursion

Clearly, whether this step is taken is likely lexically-specific (e.g., driven by *over/under*) as well as potentially semantically-specific (e.g., driven by transitivity).

Another avenue worth exploring is whether a combinatorial effect exists among prepositions for this as well. As the data exclusively results from pairs wherein PP1=*next to* and PP2=*over/under*, a case could be made that this specific combination is triggering the stacking interpretation. This may be plausible due to the reciprocal nature of *next to*, as discussed earlier. If the reciprocal semantics is responsible for creating a stronger syntactic object which projects a distinct node to which a following PP can attach, that may help to explain how stacking arises in these scenarios.

Another interesting question is how and whether this might occur in Spanish, and whether the variation observed in ExL2 would also arise here. This might be a sign of an operation, like recursion and conjunction, affected by language variation, as observed with various items in ExL2, where recursion diverged cross-linguistically.

8.8 Multiple PPs

The data diverged in ExL2 and ExL1 regarding recursion in three PPs, seemingly suggesting opposite tendencies. In ExL2 a third PP did not encourage greater recursion; in fact, recursion declined in two of the groups. Group SL2B, whose grasp of recursion

was much weaker than the others to begin with, declined, yet so did EL2, the L1 Spanish speakers whose awareness of recursion showed itself to be higher than others in other parts of the data. This is contrasted with the data in ExL1, where recursion jumped from PP2 to PP3 in all 5 groups to varying degrees; what is more, further PPs triggered yet higher recursion.

The answer, most likely, lies in the design of ExL2. The options available in the three PP questions focused on recursion (recursion + recursion) and conjunction (recursion + conjunction), as before, but included recursion + medial, which seemed to be a third plausible (at the time of designing the experiment) interpretation. It avoided both a high coordinate attachment and a low recursive attachment by effectively splitting the difference. Its apparent plausibility made it a not uncommon choice for many, ranging from 13% to well over 20% in some groups. These choices seemed disproportionately to act as ‘spoilers’ for recursion, as the conjunctive data behave similarly, i.e. it declines from PP2 to PP3 in both experiments. In ExL1, recursion + medial choices were vanishingly rare in both children and adults. This interpretation, along with neighboring structures coordination + medial and stacking + medial, did not approach significance in any of the groups.

What is more, the recursively primed coordinate option in ExL2, recursion + conjunction, was equally absent from the responses in ExL1. The only significant responses involving an operational shift from PP2 to PP3 are those which start with something other than recursion in PP2 (coordination or stacking) and then shift into recursion for PP3.

In conclusion, it seems likely that fully two of the four options available in the three PP items from ExL2 were effectively red herrings, confusing and distracting the subjects from a 'truer' interpretation. A far better comparison would have been achieved by exploiting the difference between the maximum hierarchy of recursion + recursion and the minimum hierarchy of conjunction + conjunction, the two non-shifting operations, and the two significant ones described above that shift into recursion. With enough data across age groups, any development in how interpretations shift would be easily identified.

Thus, the difference in results should be put down to differences in experimental design; a medial option in ExL2 became a significant response due to appearing as an option containing all of the appropriate nouns in an ambiguous and potentially confusing prompt; the naturalistic production of ExL1 would suggest this is not a normal preference.

As a result, the data from ExL1 should be given greater prominence in assessing this particular question. The likelihood of recursion does increase with an additional adjacent PP; in fact, it seems safe to say that that likelihood increases with *each* additional adjacent PP. Greater complexity of the NP drives deeper hierarchy in its construction.

8.9 Expanding the results

Can these studies contribute to the bigger debate on recursion and whether or not recursion resides in UG as a core element of FLN? That depends on how the data are interpreted. Speakers from children through adults and in L1 or L2 prefer recursion to conjunction. As children age into adults and as L2 speakers gain experience this

preference for recursion is only strengthened. Yet earlier studies have shown that multiple-level recursion weakens acceptability (C and M 2009) trips up children more than adults (Terunuma and Nakato-Miyashita 2013) and increases the processing load (Maia et al 2013). All of this agrees with the principles of Minimal Attachment (Frazier) which would discourage ever-deepening levels of recursion. Despite this, recursion is the preferred interpretation, one whose attraction only increases along with age, input and exposure.

The data are inconclusive regarding whether “merge high”/conjunction is the default setting in child grammars, from which they would evolve toward recursion. While conjunction is much stronger the younger the subject, the data here do not support the strong version of this hypothesis (start at all conjunction), although it is possible that, as the data start with five-year-olds, perhaps the subjects have already set off down the path and are beyond the first step (merge high) already. It is also possible, however, that both options are available at an early age, and as exposure increases, the prevalence of recursion increases apace (depending on the particular recursive operation at hand). Alternatively, according to several of the theories here presented, the “algorithm” or “mechanism”, once activated, takes over and starts the push towards recursion. The evidence in the present study suggests that substantial access to recursion is available at an early age.

What is clear from the data is that the target adult grammar is definitely not 100% recursion. Coordination remains a viable alternative throughout, as does stacking in certain scenarios.

One possible explanation for this is placing recursion as an evolving core operator (see Roeper 2013) in UG. If, instead of striving for simpler expression and growing a grammar with increased conjunction, which would lighten the processing load, speakers become increasingly recursive, becoming technically less efficient (by allotting a greater share of their processing power than they have to) along the way. This would make sense if UG licensed an operator that permitted recursion, which, despite the increased processing load, would become the default after activation. Thus, ‘local scope’, or ‘late closure’, becomes the target grammar.

This increased processing load remains an uncomfortable truth for the theoretical goal of recursion. The evidence is clear that as hierarchy increases via continuing recursion, the processing cost does as well; flatter, coordinate structures cost considerably less, time-wise. Why, then, do subjects choose to impose these costs on themselves when given an open opportunity to choose? The answer likely lies in the semantic benefits of recursion.

This quandary may arise from the very possibly wrong assumption driven by the ignorance of the investigator that a tangible bridge may be crossed between competence and performance by correlating the recursive core of competence and the processing time of performance. Chapter 2 highlighted both of these issues, yet does not address the apparent disconnect that occurs. In an ultimate goal of developing a theory of UG, recursion is central due to its ability to simplify grammar enormously through infinite regress. This thereby makes a grammar more efficient. A grammar contains both operations available—one more efficient (recursion), the other less efficient (coordination). Extending the presumed benefit granted by this efficiency, the more efficient operation would be characterized by the ease with which it is processed. If

the efficiency is not found in the processing of these structures, then it must like in their semantic representations.

Of course, the obvious explanation for this disparity is that it is fundamentally misguided to attempt to draw a line between competence and performance in this fashion, a charge that it is difficult to avoid. But if, for the sake of exercise, one or two other options are explored, the waters may muddy. One possibility lies in characterizing the data differently. If, as HCF (2002) and others claim, recursive operations are the essence of UG, then we are driven to use them, regardless of cost. As the human brain has evolved to accommodate this, then the cost is factored in. The potential return in improved semantics on investment in time and energy is huge.

The data show that speakers prefer to perform recursive operations rather than coordinate ones¹¹, a tendency that age (in L1) and exposure (in L2) strengthen. The semantics of individual prepositions clearly affect recursive tendencies as well, although whether or not reciprocity is a factor or something else remains to be seen. Extending PP chains can also increase recursive interpretation, although staggering the input is certainly a factor. Spanish is significantly more recursive than English in PP interpretation. All of these results require confirmation and further study to learn exactly what is at the root of the differences.

8.10 Future work

There are some clear steps forward based on the results presented above. One of the key steps relies on some of the logical conclusions we may draw from the data. Whether

¹¹ in the scenarios described.

recursion is considered an inherent element of UG or a processing phenomenon or something else, clearly some norms can be observed in speakers' behavior.

Consequently, it can be claimed that for structure S and acquisition level L an individual should produce a recursive amount R, allowing for a certain variance; if an individual is significantly below target recursive output, an argument could be made for providing focused recursive input in order to help bridge the gap. For instance, overall recursive performance in group SL2B was about 6.9 (of 14) with a Standard Deviation of 2.9 (SD is only used as an illustration; the variance may be arrived at otherwise). Thus a recursive rate of 4 would be at the edge of accepted tolerances. Yet not only are there two individuals at 4, there are at least five outliers in the SL2B data whose rates are less than 4—two even have rates of zero! What can be the explanation?

One possibility, of course, is that they simply do not understand Spanish as an L2 at all. If this were so, then one would expect a similar pattern with conjunction. This group's conjunctive performance, however, was at or above average for the group, with only two appearing as outliers, and then for excessive coordinate interpretation. Also, in the L1 data, incomprehension is not an explanation. The outliers in the 5s, 6s and 7s have very high conjunction, with it virtually replacing recursion as an interpretation.

Thus the other option is that these speakers simply have not acquired or activated the relevant recursive algorithm discussed previously. As PP recursion plays a normal role in using English and Spanish regardless of the formal theoretical framework used to explain it, helping these speakers increase their rate of recursive interpretation through targeted input would seem to be a natural, and necessary, step. While tests would have to be

designed for the purposes both of diagnosis and treatment, if a method of input is found which activates the algorithm it may be invaluable.

Firstly, it would be essential to determine if applying a treatment to a set of input can boost recursive interpretations in individuals favoring coordination. To review, if recursive growth is assumed to happen in step with normal input/amount of exposure, then certain recursive baselines can be established for various structures, in this case PPs, and various ages or L2 levels. Nonetheless, individuals all perform differently, and while a majority perform in a similar fashion close to the average, some excel and seek out recursive interpretations at a much higher rate, while some clearly fail to produce the baseline recursive rate in their interpretations. For whatever reason, the input these individuals received was not sufficient to trigger target recursive readings of the prompts. Thus, if these individuals were provided with a form of targeted 'recursive instruction,' it seems likely that their recursive interpretations would increase.

To illustrate, simple adaptations can be made to either of the experiments presented here to make them more individual assessment tools and input devices rather than simple measurement instruments. Methodologically, it would have to proceed in three steps.

Firstly, the adapted experiment is conducted to assess individual recursive rates. With the iPad experiment, ExL1, the target items could be kept largely intact from the original design. The distractors could even be eliminated, as overt attention to Form would in fact be an asset. The results would be evaluated to determine which individuals were performing below the baseline for the structures at hand; it could even be adapted at this level to individual structures.

Secondly, these individuals could be given a version of the input containing a specific treatment wherein L1 or L2 speakers are shown the recursive alternates to coordination. The new recursive readings may be offered accompanied with the question, “Does this seem better or worse than before?” or some other manner of emphasizing the difference. Finally, a repeat assessment can be made to verify that preferences had shifted towards the baseline. If indeed they had, then the goal would have been achieved. If not, other explanations could be explored, including whether this could be categorized as a form of Specific Language Impairment.

As it is reckoned that ExL1 is more representative of speakers’ competence, an experiment of this nature would have to be expanded well beyond the confines of the current setup. This expansion would need to entail not simply other languages in L1 and L2 but also other structures.

The new test would of course have to examine Spanish in the same context as English, allowing similar interpretations (e.g. stacking/DSR) the opportunity to arise, and then observing where cross-linguistic differences might exist. Similarly, it would have to include both L1 and L2 speakers in both languages to confirm, or not, what was learned in ExL2 initially, especially concerning the recursive differences discovered between Spanish and English.

Other languages may help root out any recursive path related to right- or left-branching preferences inherent in those languages. For instance, while Japanese resists forming recursive adpositional operations, its status as a left-branching language may help clarify some generalizations based on barriers speculated to be imposed by these parameters.

When recursively structured, the Saxon genitive in English, for example, is notoriously difficult for L1 speakers of Romance languages to penetrate, presumably because its left-branching nature runs up against the right-branching parameter setting in Romance. L1 Japanese speakers, however, should not struggle with this (theoretically, at least) due to its branching characteristics. An appropriately-designed experiment should be able to show whether this line of thinking has any validity.

The very limited scope of the experiments described here (only locative PPs) means that a vast area of language remains to be explored in order to better understand the typology of recursion suggested by Roeper & Oseki (2013). Not only will lexical differences in recursion among individual prepositions have to be distinguished, but broader semantic categories (transitivity, reciprocity, etc.) must be investigated to learn their role in recursion. Beyond this, other structures, such as relative clauses, undoubtedly possess unique recursive characteristics, and the potential trigger effect of one or the other remain to be exposed, i.e., does the acquisition of recursive relative clauses enable productive recursion in PPs, or vice-versa?

Relative clauses have already demonstrated differences in preferred attachment points between Spanish and English (Gilboy, Sopena, Clifton, & Frazier, 1995); this can be explored further, examining the relationship between high or low attachment and coordination or recursion, respectively.

These are only some of the questions which remain; many more go unmentioned. As they are explored the recursive map will get filled in, providing a better understanding of its role in language and language acquisition.

APPENDICES

APPENDIX A

EXPERIMENT L2 QUESTION INDEX

This contains all the target items used in the L2 experiment. The items are given in both languages, with both the complex NP and the specific prepositions used in each highlighted at the beginning.

- **1-4—two matching prepositions:**
 - recursion
 - conjunction
 - alternative conjunction
 - simplify—dropping PP1
 - simplify—dropping PP2
- **5-8—two different prepositions—same as above but without alternative conjunction**
- **9-12—3 PPs, testing last PP attachment**
 - low attachment—recursion
 - medial attachment—not recursion, not conjunction
 - high attachment—conjunction
 - simplify—dropping PP3
- **13, 14—comitatives, two matching prepositions—same as 5-8.**

Also, the 21 distractor questions are included after the 14 target items.

1. in/in *the magazines in the bag in the box*

John wants to recycle some magazines. He's outside and tells his son Peter to bring them to him. Peter looks for them inside and sees that there are magazines all over. He asks his father which ones he wants. John tells him to bring him *the magazines in the bag in the box*. He's going to give the others to a friend.

Which magazines does John want?

en/en *las revistas en la bolsa en la caja*

Juan quiere reciclar algunas revistas. Está fuera de casa, y le dice a su hijo Oscar que se las lleve. Oscar las busca dentro, pero ve que hay revistas por todas partes. Le pregunta a su padre que cuáles quiere. Juan le dice que sólo le lleve las revistas en la bolsa en la caja, que va a darle las otras a un amigo.

¿Qué revistas quiere Juan?



99. The magazines in the bag in the box

2. under/under *the envelopes under the books under the pens*

The table is full of mail, and Louise wants to know if there are bills or anything else important. Her son Craig is visiting today and she asks him to open it. Craig sees that there are a lot of envelopes and asks his mother if he should open all of them. She tells him no, he needs to open *the envelopes under the books under the pens*, because they came a while ago.

Which envelopes should Craig open?

debajo de/debajo de *los sobres debajo de los libros debajo de los bolígrafos*

La mesa está llena de correo y Rosa quiere saber si hay facturas u otras cosas importantes. Su hijo Paco está de visita hoy, y ella le pide que lo abra. Paco ve que hay muchos sobres y le pregunta a su madre que si debe abrirlos todos. Ella le dice que no, que abra los sobres debajo de los libros debajo de los bolígrafos porque llegaron hace tiempo.

¿Qué sobres debe abrir Paco?



100. The envelopes under the books under the pens

3. over/over *the painting over the photo over the lamp*

Eric invites his friend Jill to his apartment to see his art. After Jill arrives, Eric goes into the kitchen to get them something to drink. Jill looks at the paintings around the living room and asks Eric which is his favorite. He says he loves all of them but he likes *the painting over the photo over the lamp* most. A good friend gave it to him a long time ago.

Which is his favorite painting?

sobre/sobre *el cuadro sobre la foto sobre la lámpara*

Pedro tiene muchos cuadros e invita a Marta a su apartamento para que los vea. Después de llegar Marta, Pedro busca algo de beber en la cocina. Marta mira los cuadros por la sala y le pregunta a Pedro que cuál es su favorito. Pedro dice que le encantan todos, pero le gusta más el cuadro sobre la foto sobre la lámpara. Un buen amigo se lo regaló hace mucho tiempo.

¿Cuál es su favorito?



101. The painting over the photo over the lamp

4. behind/behind *the plant behind the lamp behind the chair*

Jim goes on vacation, and waters all his plants before leaving. When he gets to where he's going, he realizes that he forgot to water one of the plants! Jim calls his neighbor, who has a key, and asks him to water it. The neighbor says sure, he'll water all of them. Jim says no, he should water *the one behind the lamp behind the chair*—he doesn't want the others to flood.

Which plant should the neighbor water?

detrás de/detrás de *la planta detrás de la lámpara detrás de la silla*

Luis se va de vacaciones, y riega todas sus plantas antes de irse. Al llegar a su destino, se da cuenta de que ¡se le olvidó regar una planta! Luis llama a su vecino, que tiene la llave, y le pide que la riegue. El vecino responde que sí, que regará todas. Luis dice que no, que riegue la planta detrás de la lámpara detrás de la silla. No quiere que las otras se inunden de agua.

¿Qué planta debe regar el vecino?



102. The plant behind the lamp behind the chair

5. **in/next to** *the CDs in the box next to the books*

Paul and Lisa want to take some CDs to listen to on a trip. There are several on the table, but Lisa is already in the car and tells Paul to get them. There are so many that he doesn't know which ones to take, and he asks Lisa. She tells him to get *the CDs in the box next to the books*—the others aren't for the trip.

Which CDs does Lisa want?

en/al lado de *los CDs en la caja al lado de los libros*

José y Ana quieren llevar unos CDs para escuchar durante un viaje. Hay varios encima de la mesa, y como Ana ya está en el coche y le dice a José que los coja. Hay tantos que él no sabe cuáles coger, y se lo pregunta a Ana. Ella le dice que coja los CDs en la caja al lado de los libros—los otros no son para el viaje.

¿Qué CDs quiere Ana?



103. *The CDs in the box next to the books*

6. in front of/on top of *the glasses in front of the plates on top of the tray*

Some friends are having a drink together. A few more arrive and they need more glasses, so Jason goes to the kitchen where Carl left some out. But there are a lot of glasses, and Jason asks Carl which to get. Carl tells him to get the glasses in front of the plates on top of the tray. If more people show up, he'll get out the others, too.

What glasses should Jason get?

delante de/encima de *los vasos delante de platos encima de la bandeja*

Unos amigos están tomando algo juntos. Llegan más amigos y necesitan más vasos, así que Javier va a la cocina donde Carlos ha dejado varios. Pero hay muchos vasos, y Javier le pregunta a Carlos cuáles coger. Carlos le dice que coja los vasos delante de los platos encima de la bandeja. Si llega más gente, entonces sacará los demás también.

¿Qué vasos quiere Carlos?



104. *The glasses in front of the plates on top of the tray*

7. under/on top of *the glasses under the photo on top of the shelf*

Monica has lots of glasses—glasses for reading, for the computer etc., and she always leaves them lying around the house. After getting into bed one night without them, she asks her husband if he could please bring her her glasses. He asks her which ones she wants and she tells him to get *the glasses under the photo on top of the shelf*. She wants to read her new novel.

Which glasses does Monica want?

debajo de/encima de *las gafas debajo de la foto encima de la balda*

Mónica tiene muchas gafas—las tiene para leer, para el ordenador, etc. Siempre se las deja por todas partes por toda la casa. Un día después de meterse en la cama, le pide a su marido que, por favor, le lleve las gafas. Él le pregunta que cuáles quiere y le responde que coja las gafas debajo de la foto encima del estante. Ella quiere empezar a leer su nueva novela.

¿Qué gafas quiere Mónica?



105. The glasses under the photo on top of the shelf

8. behind/on *the spoon behind the knife on the plate*

David and Theresa have invited some friends over for dinner. When he set the table David saw that there was a dirty spoon, but he forgot to change it. He's cooking so he asks Theresa to change it. They all look clean to her and she asks David which one it is. David tells her to change the spoon behind the knife on the plate, and she'd better hurry because it's late.

Which spoon should Theresa change?

detrás de/en *la cuchara detrás del cuchillo en el plato*

David y Teresa han invitado unos amigos para cenar. Cuando puso la mesa David vio que había una cuchara sucia, pero se le olvidó cambiarla. Está cocinando así que le dice a Teresa que la cambie. Todas parecen limpias para Teresa, y le pregunta a David cuál es. David le dice que cambie la cuchara detrás del cuchillo en el plato, y que se dé prisa, que ya es tarde.

¿Qué cuchara debe cambiar Teresa?



106. *The spoon behind the knife on the plate*

9. on/near/next to
the plant

the box on the table near the chair next to

Brian has to take some things to the garage and he's got them in some boxes in the living room. His son is going to help him and sees that there are several boxes. He asks his father which box to take. Brian tells him to get *the box on the table near the chair next to the plant*. Which one? the box on the table near the chair next to the plant—it's the lightest and the others are too heavy.

What box should the son get?

encima de/cerca de/al lado de
al lado de la planta

la caja encima de la mesa cerca de la silla

Carlos tiene que llevar muchas cosas al garaje, y las tiene en unas cajas en la sala. Su hijo le va a ayudar, y le pregunta a su padre que qué caja debe coger. Carlos le contesta que coja la caja encima de la mesa cerca de la silla al lado de la planta. ¿Cuál? la caja encima de la mesa cerca de la silla al lado de la planta—es la más ligera, y las otras pesan demasiado.

¿Qué caja debe coger el hijo?



107. The box on the table near the chair next to the plant

10. next to/near/in
corner

the basket next to the table near the plant in the

Betsy wants to take some shoes to the repair shop and she has them in a basket in her room. Her hands are full so she asks her daughter to get them. When her daughter goes into the room she sees several baskets with shoes and asks which to get. Betsy says that she wants *the basket next to the table near the plant in the corner*. Which one? The basket next to the table near the plant in the corner. The other shoes are fine.

Which basket does Betsy want?

al lado de/cerca de/en
esquina

la cesta al lado de la mesa cerca de la planta en la

María quiere llevar unos zapatos al zapatero, y los tiene en una cesta. Ya tiene las manos llenas, así que pide a su hija que los coja. Su hija ve varias cestas con zapatos, y pregunta cuál debe coger. María quiere la cesta al lado de la mesa cerca de la planta en la esquina. ¿Cuál? La cesta al lado de la mesa cerca de la planta en la esquina. Los demás zapatos están perfectamente.

¿Qué cesta quiere María?



108. The basket next to the table near the plant in the corner

11. in/on/next to
pens

the remote in the bowl on the magazines next to the

Two friends are watching a movie on TV. Karen gets up and tells Beth to pause the movie. Beth sees that there are 4 or 5 remotes and she doesn't which to use. Claudia says that it's the remote in the bowl on top of the magazines next to the pens. *Which one?* The remote in the bowl on top of the magazines next to the pens. She always gets confused too about which one to use.

Which remote does Beth need?

en/encima de/al lado de *el mando en el bol encima de las revistas al lado de los bolígrafos*

Dos amigas ven una película. Claudia se levanta, y le dice a Verónica que pause la peli. Verónica ve que hay 4 ó 5 mandos, y no sabe cuál usar. Claudia le dice que es el mando en el bol encima de las revistas al lado de los bolígrafos. ¿Cuál? El mando en el bol encima de las revistas al lado de los bolígrafos. Claudia también se confunde siempre sobre cuál coger.

¿Qué mando necesita Verónica?



109. The remote in the bowl on the magazines next to the pens

12. next to/in/behind *the flashlight next to the candles in the drawer behind the book*

Anne wants to go in the basement but the light bulb there burned out. She asks her husband Bob where there's a flashlight that works. Bob says that there are a few but she should use the flashlight next to the candles in the drawer behind the book. *Which* one? The flashlight next to the candles in the drawer behind the book, because the others don't have batteries.

Which flashlight should Anne use?

al lado de/en/detrás de *la linterna al lado de las velas en el cajón detrás del libro*

Ana quiere ir al sótano pero se ha fundido la bombilla allí. Le pregunta a su marido Borja dónde hay una linterna que funcione. Borja le dice que hay varias pero que utilice la linterna al lado de las velas en el cajón detrás del libro. –¿Cuál? La linterna al lado de las velas en el cajón detrás del libro porque las otras linternas no tienen pilas.

¿Qué linterna debe utilizar Ana?



110. *The flashlight next to the candles in the drawer behind the book*

13. with/with *the toy with the cushions with the flowers*

Joe visits Bianca in the afternoon. Bianca has to work a little more, so Joe tries to play with Bianca's dog a while, but the dog isn't interested in playing. There are thousands of dog toys, and Joe asks Bianca which one he likes most. She says that his favorite is the toy with the cushions with the flowers—he's already bored with the others.

Which one is the dog's favorite toy?

con/con *el juguete con los cojines con las flores*

José visita a Anabel por la tarde. Anabel tiene que trabajar un poco más, así que José intenta jugar con el perro de Anabel un rato, pero el perro no tiene interés en jugar. Hay miles de juguetes de perro, y José le pregunta a Anabel cuál le gusta más. Él le dice que su favorito es el juguete con los cojines con las flores—ya está aburrida de los otros.

¿Cuál es el juguete favorito del perro?



111. *The toy with the cushions with the flowers*

14. with/with *the woman with the baby with the blue shirt*

Mary and Rob are looking at some friends' photos in Facebook. A friend had a party the other day and there are lots of photos of it. Suddenly Rob says that he knows one of the women. Who? Since he can't reach the screen, he says that it's the woman with the baby with the blue shirt—she was his neighbor a few years ago.

Who does Rob know?

con/con *la mujer con el bebé con la camisa azul*

María y Rodrigo están mirando las fotos de unos amigos en Facebook. Un amigo hizo una fiesta el otro día y hay miles de fotos de ella. De repente, Rodrigo dice que conoce a una de las mujeres. ¿A cuál? Como no llega a tocar la pantalla, él dice que es la mujer con el bebé con la camisa azul—que era su vecina hace varios años.

¿A quién conoce Rodrigo?



112. The woman with the baby with the blue shirt

15. Distractor 1

Bruce needs some pens for drawing. He's in the living room and he asks his roommate Bill to get them for him from his room. Bill goes in Bruce's room but he sees the woman with the baby with the blue shirt a lot of pens on the desk and he asks Bruce which ones he wants. Bruce tells him not to get all of them; he wants red pens, black pens and a pencil, too.

What does Bruce want?

Bruce necesita unos bolígrafos para dibujar. Él está en el salón y le pide a su compañero que se los lleve desde su cuarto. Su compañero entra en su cuarto pero ve muchos bolígrafos en su escritorio y le pregunta a Bruce cuáles quiere. Bruce le dice que no coja todos; quiere los bolígrafos rojos, negros, y también un lápiz.

¿Cuáles quiere Bruce?



16. Distractor 2

Tim's mother needs to pack some shirts in his suitcase for his trip, but she can't find them. She asks Tim where they are, and he says they're in the other room. She goes there, but there are a lot of shirts and she asks which ones he wants. Tim says he doesn't want the ones that are on the hangers but instead he wants the folded and ironed shirts with buttons.

Which shirts does Tim want?

La madre de Tim necesita meter unas camisas en su maleta para su viaje, pero no las encuentra. La madre le pregunta a Tim dónde están, y él le dice que están en el otro cuarto. Ella va allí, pero hay muchas camisas, y le pregunta a Tim cuáles quiere. Tim no quiere las que están en las perchas sino que quiere las camisas dobladas, planchadas y que tienen botones.

¿Qué camisas quiere Tim?



17. Distractor 3

Carmen has a couple of hours until her flight and decides to buy a magazine to pass the time. In the store in the terminal she finds magazines about the economy which don't interest her. Instead of that, she buys a good one about fashion, although she doesn't like it that much. As she's leaving the store, she sees a good one about cycling that's her favorite and she buys it too. She's still got a lot of time left for her flight.

What does Carmen buy?

A Carmen le quedan dos horas para su vuelo y decide comprar una revista para pasar el tiempo. En la tienda de la terminal encuentra revistas de economía, que no le interesan. En lugar de eso, compra una buena de moda, aunque no le gusta muchísimo. Al salir de la tienda, ve una de ciclismo que es su favorita y también la compra. Todavía, le queda mucho tiempo para su vuelo.

¿Qué compra Carmen?



18. Distractor 4

Russ and Sue want to watch a movie together and are looking over what there is on Netflix. Russ says that he wants to watch a crime movie, but Sue doesn't like those. She says that she wants to watch a horror movie. But finally, they watch a documentary about the jungle—they talk about watching a new comedy, but it doesn't look very interesting.

What movie do Russ and Sue choose?

Russ y Sue quieren ver una película juntos, y están mirando las películas que hay en Netflix. Russ dice que quiere ver una policiaca, pero a Sue no le gustan esas películas. Ella dice que le gustaría ver una de terror. Pero al final, ven un documental de la selva—hablan de ver una nueva comedia, pero no les parece muy interesante.

¿Qué película eligen Russ y Sue?



19. Distractor 5

Tom is setting the table with his daughter Erin for coffee with guests. Tom is in the dining room and asks Erin to get the cups/mugs and plates in the kitchen. Erin sees that her father has already taken out all the cups/mugs and plates, and she doesn't know which ones to take. Tom tells her to get the white plates and cups/mugs. Which ones? says Erin. The white plates and cups—he doesn't like the others.

What does Tom want?

Tomás está poniendo la mesa con su hija Cova para café con invitados. Tomás está en el comedor y manda que Cova coja las tazas y los platos en la cocina. Cova ve que su padre ya ha sacado todos los platos y tazas, y no sabe cuáles coger. Tomás le dice que coja las tazas y platos blancos. ¿Qué? dice Cova. Las tazas y platos blancos dice—a él no le gustan los demás.

¿Qué quiere Tomás?



20. Distractor 6

Ethan is getting ready to go to school. Like always he's late, and his father is helping him pack his backpack. There are some books and folders on the table and his father asks Ethan which ones to pack. Ethan tells him to pack the red books and folders. What? says his father. The red books and folders. He doesn't need the others for school.

What does Ethan need?

José se está preparando para ir al colegio. Como siempre llega tarde, y su padre le está ayudando a hacer la mochila. Hay unas carpetas y libros en la mesa, y el padre le pregunta a José cuáles meter. José le dice que meta las carpetas y los libros rojos. ¿Qué? dice el padre. Las carpetas, y los libros rojos. No necesita los otros para el cole.

¿Qué necesita José?



21. Distractor 7

Jesse is going to spend the night in a hotel, and his mother is packing his suitcase. Jesse doesn't like hotel soaps, so he brings his own things for washing. His mother asks him which ones he wants to take, and he says that he always takes soap and shampoo. The towels too? his mother asks. He says no, he likes the ones in the hotel—they're always soft.

What is Jesse going to take?

Fernando va a pasar la noche en un hotel, y su madre le está haciendo la maleta. A Fernando no le gustan los jabones del hotel, así que llevará sus propias cosas para bañarse. Su madre le pregunta cuáles quiere llevar, y él le contesta que siempre lleva jabón y champú. ¿Las toallas también? pregunta su madre. Dice que no, que le gustan las del hotel—siempre están suaves.

¿Qué va a llevar Fernando?



22. Distractor 8

Mike is making dinner, and his friend Jen is cutting vegetables for him. As Mike knows the recipe by heart, Jen asks him if he wants to use all the vegetables there are, and he says yes. Jen says that she doesn't like onions, but he answers that without them, the recipe won't come out right. Jen protests, and Mike agrees not to use much onion.

Which vegetables should Jen cut?

Ramiro está haciendo la cena, y su mujer Eva le está cortando las verduras. Como él tiene la receta memorizada, Eva le pregunta que si quiere utilizar todas las verduras que hay y Ramiro contesta que sí. Eva dice que no le gusta la cebolla, pero él dice que sin ella, la receta no saldrá bien. Eva protesta, y Ramiro consiente en utilizar poca cebolla.

¿Qué verduras debe cortar Eva?



23. Distractor 9

Rachel is going on a trip and her sister Natalie is helping her pack. She's taken several things out of the closet to choose from, but she can't take all of them. Natalie asks which ones she wants to take and Rachel says the striped jacket and shirt. What? asks Natalie. The striped jacket and shirt—the others wouldn't be right.

What clothes will Rachel take?

Lucia va de viaje y su hermana Susana le está ayudando hacer la maleta. Ha sacado varias prendas del armario para elegir, pero no puede llevárselas todas. Susana le pregunta cuáles quiere llevar y Lucia le dice que la camisa y la chaqueta de rayas. ¿Qué? pregunta Susana. La camisa, y la chaqueta de rayas—las otras prendas no serán adecuadas.

¿Qué ropa llevará Lucia?



24. Distractor 10

Emily is going shopping and whenever she can she uses the bags she's already got. She tells her son Will to get them from the other room, but Will doesn't know which ones to take. Emily tells him that she wants the paper ones as well as the plastic ones. Will says that the plastic ones look torn, and Emily tells to take them anyway—she can recycle them.

What bags are they going to use for the shopping?

Julia va a hacer la compra y siempre que puede, utiliza las bolsas que ya tiene. Le dice a su hijo Rubén que las coja del otro cuarto, pero Rubén no sabe cuáles coger. Julia le dice que quiere las de papel y también las de plástico. Rubén dice que las de plástico parecen rotas, y Julia le dice que las coja también, que así ella las puede reciclar.

¿Qué bolsas van a utilizar para la compra?



25. Distractor 11

Tania and Brian are preparing a party for their son Ben. Brian is looking for some balloons in the kitchen, and he asks Tania which ones to get. Tania tells him to get the pink and yellow balloons. Brian inflates them, and also some blue ones that he finds there.

Which balloons does Tania say that they'll use?

María y Juan están preparando una fiesta para su hijo Manolito. Juan está buscando unos globos en la cocina, y le pregunta a María cuáles coger. María dice que coja los globos rosas y amarillos. Juan los infla y también algunos azules que encuentra por allí.

¿Qué globos dirá María que se utilicen?



26. Distractor 12

Ben is fixing up the house for a dinner. His wife Patricia is looking for some candles for him to light, and she asks Ben which ones he wants. Ben says he wants the tall new ones in lots of colors. Which ones?—The different colored ones that are tall and new. Patricia gets the tallest ones she finds, and also some that have already been used.

Which candles does Ben want?

Javier está arreglando la casa para una cena. Su mujer Irene le está buscando unas velas para encender, y le pregunta a Javi cuáles quiere. Javi dice que quiere las velas altas, nuevas y de varios colores. ¿Cuáles? –Las de varios colores que son altas y nuevas. Irene coge las más altas que encuentra, y también unas que ya se han utilizado antes.

¿Qué velas quiere Javier?



27. Distractor 13

Steve and Nicole are playing Scrabble. Nicole usually wins but this time Steve has made some words with lots of points. In her tiles Nicole has lots of consonants but no vowels. Nicole doesn't know it, but Steve has cheated and has hidden the vowels under a magazine. But at least he has some vowels.

Which are Nicole's tiles?

Alberto y Emma están jugando al Scrabble. Emma normalmente gana pero esta vez Alberto ha hecho unas palabras con muchos puntos. Entre sus fichas Emma tiene muchas consonantes pero ninguna vocal. Emma no lo sabe, pero Alberto ha hecho trampas y ha escondido las vocales debajo de una revista. Pero por lo menos él tiene algunas vocales.

¿Cuáles son las fichas de Emma?



28. Distractor 14

Jack is setting the table for dinner. He's not sure which cups and glasses to take so he asks Sophie. She has thought of some special ones, and tells him to get the tall cups and glasses. Jack doesn't find the tall ones, and instead he sets the table with the glasses and with some others. Later Sophie has to change them.

What does Sophie want Jack to get?

Agustín está poniendo la mesa para una cena. No está seguro de qué vasos y copas coger así que le pregunta a Sofía. Ella tiene pensado unos especiales, y le dice que coja las copas y los vasos altos. Agustín no encuentra los altos, y pone la mesa con las copas y con otros. Luego Sofía tiene que cambiarlos.

¿Qué quiere Sofía que coja Agustín?



29. Distractor 15

Amy is serving dinner at the table, but she's forgotten the silverware. She asks Tina to go and get them from the kitchen. Tina sees so many that she doesn't know which ones to get, and she asks Amy. Amy tells her to bring her the long spoon and knife, and a fork. She also has to carve the roast. Tina brings her the longest ones.

What does Amy want?

Paula está sirviendo la cena en la mesa, pero se le han olvidado los cubiertos. Le pide a Amanda que los vaya a buscar a la cocina. Amanda ve tantos que no sabe cuáles coger, y se lo pregunta a Paula. Paula le dice que le traiga la cuchara y el cuchillo largo, y un tenedor. Es que también tiene que cortar el asado. Amanda le lleva los más largos.

¿Qué quiere Paula?



30. Distractor 16

It's snowing a lot today and George has to put on snow boots to go out, so he has to take with him other shoes to change into. Since he has to work and afterwards do some sports, he decides to take some brown shoes and sneakers. However, he doesn't find them, and instead takes some black shoes and sneakers—after all, black goes with everything.

What shoes does George want to take with him?

Está nevando mucho hoy y Jorge tiene que ponerse botas de nieve. Así que tiene llevar consigo otro calzado para llevar. Como tiene que trabajar y luego hacer deporte, decide coger unas zapatillas y unos zapatos marrones. Sin embargo, no los encuentra y coge unas zapatillas y zapatos negros, porque al final el negro va con todo.

¿Qué zapatos quiere llevar Jorge?



31. Distractor 17

It's cold and Derek has to put on warm clothes before going out. He can't find his gloves and cap close to the door and asks his sister Tiffany if she's seen them in the living room. There, Tiffany doesn't know which ones to get, and Derek tells her to get the black cap and gloves. They'll be best for the weather. Tiffany gets what seems right for the cold today.

Which ones does Derek want?

Hace frío e Iván debe abrigarse antes de salir. No encuentra sus guantes y gorro cerca de la puerta y le pregunta a su hermana Blanca si los ha visto en la sala. Allí Blanca no sabe cuáles coger. Iván le dice que le coja los guantes y el gorro negro. Serán los más adecuados para el clima. Blanca coge lo que le parece para el frío de hoy.

¿Qué quiere Iván?



32. Distractor 18

Chris has a lot of computers and has to sell one. He's got some laptops, a desktop for the office, and also a new iPad that he loves. He wants to keep the one in the office, and decides to sell the one that's the most difficult to carry, because after all, how many like that does he need?

Which computer is Chris going to sell?

Emilio tiene muchos ordenadores y tiene que vender uno. Tiene unos portátiles, uno de la oficina y también un nuevo iPad que le gusta mucho. Quiere quedarse con el de la oficina y decide vender el que es más difícil de llevar, porque al final, ¿cuántos así necesita?

¿Qué ordenador va a vender Emilio?



33. Distractor 19

Tom wants to listen to music in the living room without any interruptions. He's looking for some headphones so that he's not bothered by other sounds. He finds some good ones, but he doesn't want any with a microphone. Finally he finds some that cover his ears and that are wireless. The little ones hurt his ears.

Which headphones does Tom use?

Martín quiere escuchar música en la sala sin interrupciones. Busca unos auriculares para que no le molesten otros sonidos. Encuentra unos buenos pero no quiere que tengan micrófono. Por fin encuentra unos que le cubren las orejas y que son inalámbricos. Los pequeños le hacen daño en los oídos.

¿Qué auriculares utiliza Martín?



34. Distractor 20

Katy is getting dressed for a party. She can't make up her mind between necklaces even though she tries on several combinations. She asks her husband Paul which ones look best to him. Paul says that he likes the silver ones and the stone ones, but not so much the gold ones. In the end, Katy decides to put on one with big stones.

Which ones does Paul like?

Martina se está vistiendo para una fiesta. No puede elegir entre varios collares aunque prueba varias combinaciones. Le pregunta a su marido Pablo que qué collares le parecen los más adecuados. Pablo dice que le gustan los de plata y de piedras pero no tanto los de oro. Al final, Martina se pone uno de los de las piedras grandes.

¿Cuáles le gustan a Pablo?



35. Distractor 21

Andrew and Jasmine are going to the cinema tonight. It's cold and they'll have to put on warm coats. Each one is choosing their coat, and Jasmine tells Andrew to put on the black coat, and he tells her to put on her blue coat. Neither one agrees with the other, but in the end they put on the black and blue coats and leave.

Which coats do Andrew and Jasmine like?

Julia y Esteban van al cine esta noche. Hace frío y tendrán que abrigarse. Cada uno está eligiendo su abrigo, y Julia le dice a Esteban que se ponga el abrigo negro, y él le dice a ella que se ponga el abrigo azul. Ninguno está de acuerdo con el otro, pero al final se ponen los abrigos negros y azules y se van.

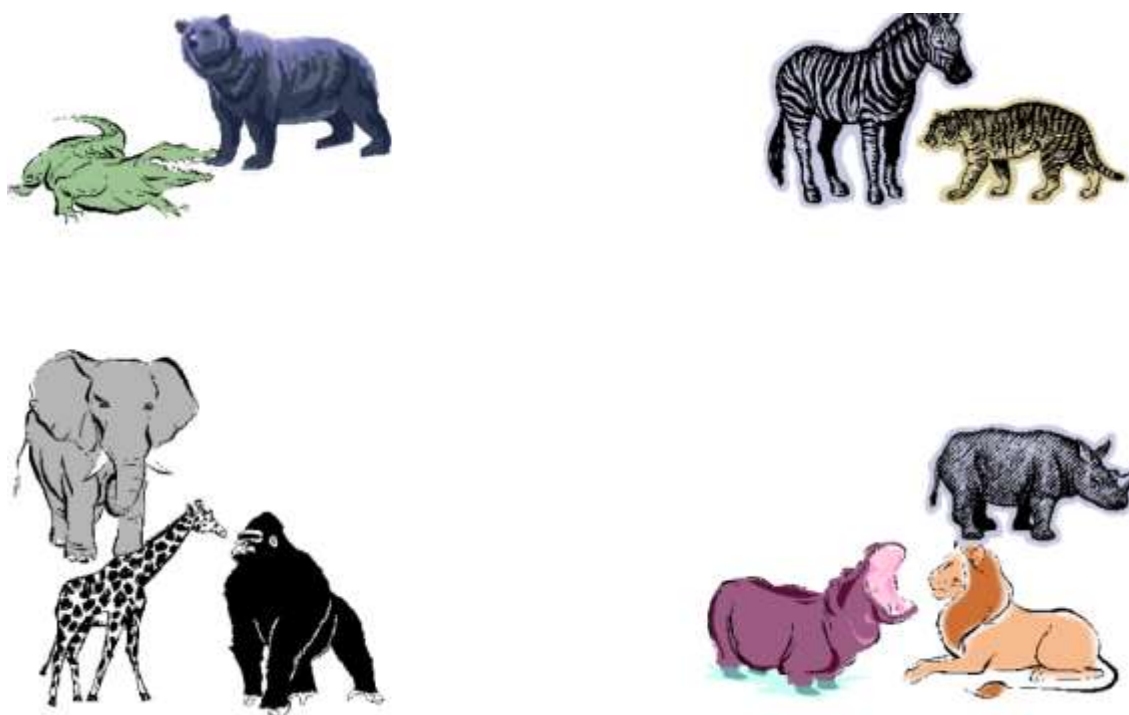
¿Qué abrigos les gustan a Julia y Esteban?



APPENDIX B

EXPERIMENT MATERIALS, L1 CHILD ACQUISITION

EXPERIMENT



113. ExL1: the initial layout for all subjects and items

Full script, Experiment L1

Do you see the pictures on the screen here? This is a lion.

What's this? (bear)

And this? (repeat until all identified)

Now watch this. I can move them around with my fingers. (demonstrate) Then I put them back like this (click undo). Now you try it!

OK, now I'm going to ask you to move things around on the screen for me. Like, I see a hippo under an elephant. (demonstrate)

Now, I see a tiger. You show me a tiger next to a bear. (moves things) Good!

OK, let's do some more. If you want me to repeat anything, just ask. **I see a lion. (1) Show me a lion next to a zebra under a crocodile.** Ok.

I see a giraffe and a rhino. Show me a giraffe and a rhino over a hippo.

I see a zebra. (2) Show me a zebra under a giraffe under a bear.

I see a lion and a tiger. Show me a lion and a tiger with an elephant.

I see a hippo. (3) Show me a hippo next to a giraffe under a rhino.

I see an elephant. (4) Show me an elephant next to a lion over a crocodile next to a giraffe.

I see an elephant and a rhino. They're between a zebra and a hippo.

I see a bear. (5) Show me a bear under a tiger next to a crocodile.

I see a tiger. Show me a tiger and a hippo with a bear.

I see a giraffe. (6) Show me a giraffe next to a bear under a lion.

I see a zebra. Show me a zebra between an elephant and a giraffe and a rhino.

I see a gorilla. (7) Show me a gorilla over a rhino next to a crocodile (7b) under a tiger. (pause) (7c) next to a lion.

I see a giraffe. Show me a giraffe over a tiger.

I see a tiger. (8) Show me a tiger over a bear over a hippo.

I see a hippo. Show me a hippo between an elephant and a zebra.

I see a rhino. (9) Show me a rhino next to a lion under an elephant (9b) next to a zebra.

I see a zebra. (10) Show me a zebra under a crocodile next to a gorilla.

I see a gorilla. Show me a gorilla and a zebra with a rhino and a hippo.

I see a crocodile. (11) Show me a crocodile over a tiger next to a giraffe.

I see an elephant. (12) Show me an elephant over a crocodile next to a hippo (12b) under a gorilla. (pause) (12c) next to a tiger. (pause) (12d) over a bear.

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