

# **The Syntax-prosody Interface of Jordanian Arabic (Irbid Dialect)**

By

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## ABSTRACT

This dissertation studies the prosodic structure of the variety of Jordanian Arabic that is spoken in the rural areas of the Governorate of Irbid (IA) by investigating the role of syntactic structure in the formation of prosodic domains. It empirically explores the word-level, phrase-level and clause-level prosody of IA and attempts to account for these empirical results in a framework based on the standard syntactic-prosodic interface principles developed in Match Theory (Selkirk 2011) and formulated as OT constraints (Prince & Smolensky 1993). The basic hypotheses in this dissertation are that the prosodic word ( $\omega$ ), phonological phrase ( $\Phi$ ) and intonational phrase ( $\iota$ ) are present in IA, and that they are anchored in syntactic constituents. Relying on hypotheses derived from the MATCH constraints (Selkirk 2011) that ensure the syntactic-prosodic correspondence,  $\omega$ ,  $\Phi$  and  $\iota$  should respectively match the grammatical word, syntactic phrase and clause and should recursively match embedded syntactic constituents.

A series of experiments was designed to test the hypotheses. Twenty native speakers (ten males and ten females) of Jordanian Arabic living in Irbid participated in the tasks. Each pair of participants performed several tasks in one session. Two game-based tasks were designed to explore intonational and temporal cues to  $\Phi$  and  $\iota$  boundaries and examine their relation to XPs and clauses, respectively. Two additional reading tasks were designed to determine the application domain of post-lexical segmental processes in IA (the coarticulation of pharyngealization and vowel hiatus resolution). The collected tokens were submitted to acoustic and statistical analyses.

Based on the results of these experiments, the existence of the  $\omega$ ,  $\Phi$  and  $\iota$  is confirmed and our understanding of their segmental and suprasegmental cues is refined.  $\omega$ 's match grammatical words and are the domain of stress, realization of the feminine -t suffix and coarticulation of pharyngealization.  $\Phi$ 's match syntactic phrases and are cued suprasegmentally: their right boundaries are marked by low phrase accents (L-) and pre-boundary syllable lengthening. As for  $\iota$ 's, they match clauses and are cued by additional final lengthening, boundary tones (H% or L%) and resistance to vowel reduction.

There is also ample evidence that syntactic nesting motivates prosodic recursion. At the  $\omega$  level, the primary/secondary status of genitive constructs of stress mirrors syntactic nesting. At the  $\Phi$  level, recursion is evidenced by gradient pre-boundary syllable lengthening, which is greater at the right boundaries of higher prosodic subcategories that match larger syntactic domains. As for recursion at the  $\iota$  level, it is not only cued by gradient pre-boundary syllable lengthening, but also by boundary tones: continuative H% are used at sentence-internal  $\iota$  boundaries, but L% tones are cues to boundaries of larger  $\iota$ 's. However, prosodic recursion is not unconstrained in IA: prosodic domains can only consist of two subcategories, i.e. a minimal and maximal layers. In this way, prosodic recursion is neither prohibited as proposed in the early version of Strict Layer Hypothesis (Nespor & Vogel 1986, Selkirk 1986), nor free to perfectly mirror syntactic nesting.

As in most previous case studies, it is proposed that the one-to-one correspondence constraints of Match Theory (Selkirk 2011) account for the prosodic patterns in IA, but have

to be complemented with language-specific markedness constraints on phonological weight, exhaustivity and recursion. It is also shown that these explanatory principles can, with minor reorganization, account for the prosodic patterns described in other Arabic dialects.



## **ACKNOWLEDGMENTS**

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## §1 Introduction

In this dissertation, the prosodic structure of the variety of Jordanian Arabic that is spoken in the rural areas of the Governorate of Irbid (IA) will be studied by investigating the role of syntactic structure in the formation of prosodic domains. Original models of the Prosodic Hierarchy proposed three prosodic domains interfacing between syntax and phonology, i.e. the prosodic word ( $\omega$ ), phonological phrase ( $\Phi$ ) and intonation phrase ( $\iota$ ). These domains were claimed to be hierarchically ordered and universally found in the prosodic structures of languages (Selkirk 1984, 1996, Nespor & Vogel 1986). Moreover, following the Strict Layer Hypothesis, none of these levels could be skipped or repeated. This parsimonious model has been further developed in the past 35 years, and this dissertation will be framed in its most recent offshoot, Match Theory (Selkirk 2009, 2011). In this theory, the prosodic domains are syntactically grounded:  $\iota$ ,  $\Phi$  and  $\omega$  match the clause, the syntactic phrase and the grammatical word, respectively. Furthermore, contrary to early models, Match Theory allows recursive prosodic domains: for instance, the minor and major  $\Phi$ 's have been posited to account for the effect of prosodic weight/size on the prosodic hierarchy (Itô & Mester 2012, 2013).

In the past few years, researchers have argued that the  $\iota$ ,  $\Phi$  and  $\omega$  may not be universal as they can be skipped in some languages (e.g. Schiering et al 2010, Brunelle 2017) and as some languages may have additional levels (Hildebrandt 2007, Bickel et al. 2009). In this dissertation, I aim to determine whether these three prosodic levels are necessary to account for the prosodic facts of IA, and if positing more prosodic domains and/or recursion in the prosodic structure of this dialect is required.

A prosodic level in a language can be diagnosed by exploring the (non-)application of segmental processes, such as sandhis and syllable duration, and suprasegmental cues, such as F0 contour variation at the potential positions of prosodic boundaries. A segmental process or a suprasegmental cue can be categorical or gradient. Categorical processes include the intrusive-*r* inserted at  $\omega$ -final position in the Eastern Massachusetts dialect (Selkirk 1996) and a pitch accent aligned to each  $\omega$  in Egyptian Arabic (Hellmuth 2006). Gradient segmental and suprasegmental phenomena cue prosodic boundaries of different strengths. An example is vowel reduction, a strategy to resolve post-lexical vowel hiatuses in Greek (Baltazani 2006): vowels normally resist reduction at  $\iota$ 's, but rarely at  $\Phi$ 's boundaries in this language. Another example is the greater phrase-final lengthening in syllables that are followed by a strong prosodic boundary in English (Wagner 2005, 2010) and Arabic (Yasin 2012) among other languages. In this dissertation, I aim to find out segmental processes and suprasegmental cues to  $\omega$ ,  $\Phi$  and  $\iota$  and their boundaries in IA, and to determine if they are categorical or gradient and if they suggest prosodic recursion.

I will attempt to analyze IA prosodic patterns in a framework based on the violable syntactic-prosodic correspondence constraints proposed in Match Theory (Selkirk 2011). In addition, these patterns will be discussed in relation to early version of the Strict Layer Hypothesis (Selkirk 1984, 1996, Nespor & Vogel 1986) in which level skipping and recursion are not possible. I will also compare the formation of the  $\Phi$ ,  $\iota$  and  $\omega$  in IA and in previously studied Arabic dialects: Egyptian Arabic (EA), Lebanese Arabic (LA) and Amman Arabic (AA). I will determine whether the prosodic differences among these dialects can be captured only by constraints re-rankings and minor changes to existing constraint templates. If this goal is attainable, this would suggest that a Match Theory account of IA prosody has some typological validity. On the

contrary, if dramatically different formal tools are needed, this would suggest that the current analysis is language-specific and possibly too ad hoc.

The research questions of my dissertation are:

- a. Are  $\omega$ ,  $\Phi$  and  $\iota$  present in the prosodic structure of IA?
- b. What are the segmental, temporal and intonational cues to  $\omega$ ,  $\Phi$  and  $\iota$  boundaries?
- c. Are these prosodic domains recursive? Is there a need to propose prosodic level repetition?
- d. What are the cues of prosodic recursion?
- e. Can the prosodic patterns in IA be accounted for in a framework derived from Match Theory (Selkirk 2011)?
- f. Can the typological differences between IA and other studied Arabic varieties be correctly captured with minimal constraint rerankings or addition of constraints?

In the following section, I introduce the Prosodic Hierarchy (Nespor & Vogel 1986, Selkirk 1986) and briefly discuss the basic principles of the Strict Layer Hypothesis (Selkirk 1984, 1996, Nespor & Vogel 1986) and the syntactic-prosodic constraints of Match Theory (Selkirk 2011).

## **§ 1.1 An overview of the Prosodic Hierarchy**

In the original model of the Prosodic Hierarchy developed in the early 1980s (Nespor & Vogel 1986, Selkirk 1984, 1986), the prosodic hierarchy in (1) was stipulated:



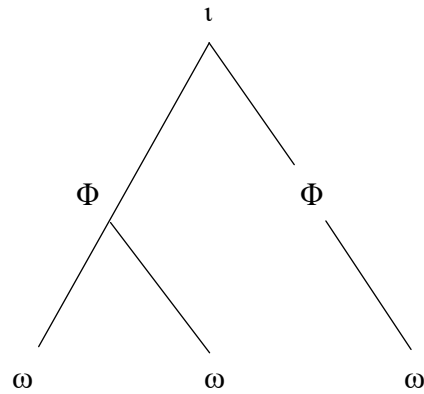
(1) Utterance (U) > Intonational phrase (ι) > Phonological phrase (Φ) > Prosodic word (ω) > Foot (Ft) > Syllable (σ)

A level called the Clitic Group was posited between the ω and Φ level in the original framework of the Prosodic Hierarchy to account for word cliticization. It has since been suggested that clitics do not require a separate prosodic level, but may enforce ω- and/or Φ-recursion (Selkirk 1996, Peperkamp 1997 among others).

The hierarchy in (1) was partly autonomous from the syntactic structure. Although the parsing of prosodic domains referred to edges of syntactic constituents, no one-to-one mapping of prosodic domains and syntactic constituents was postulated because the prosodic hierarchy was treated as a separate layer of representation: this captured the fact that ω's, Φ's and ι's tend to match grammatical words, phrases and clauses respectively, but that mismatches are frequent.

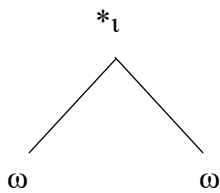
In the original model, prosodic categories obeyed a layering principle called the Strict Layer Hypothesis (Selkirk 1984, 1996, Nespor & Vogel 1986) consisting in several conditions. First, a constituent of a category that belonged to level  $n$  in the Prosodic Hierarchy had to immediately dominate at least one constituent of a category  $n-1$  as shown in (2):

(2)



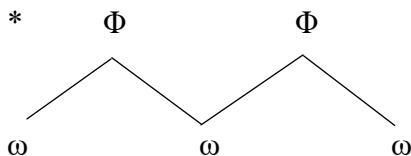
In addition to immediate dominance, level skipping was not possible under the Strict Layer Hypothesis (Selkirk 1984, 1996, Nespor & Vogel 1986). This is illustrated with  $\Phi$ -level skipping in (3):

(3)

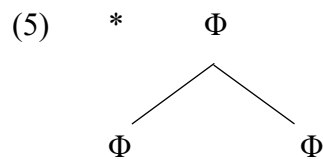


Multiple domination was another violation of the Strict Layer Hypothesis. In (4), for instance, the second  $\omega$  is dominated by more than one  $\Phi$ , which was not allowed.

(4)



Overall, the Strict Layer Hypothesis required the Prosodic Hierarchy to be non-recursive and therefore ruled out the prosodic pattern in (5) in which an upper level  $\Phi$  dominates a lower level  $\Phi$ .



The Strict Layer Hypothesis entails a universal Prosodic Hierarchy: languages are not expected to skip any of the levels suggested in (1) or to have any additional ones. However, the universality of the Hierarchy has recently been challenged. Brunelle (2017) and Schiering et al. (2010) could not find evidence for the  $\omega$  level or its prominence in the prosodic structure of Vietnamese, and Hildebrandt (2007) and Bickel et al. (2009) provide evidence for a large number of prosodic domains in Tibeto-Burman languages. Another claim of the Strict Layer Hypothesis is that prosodic levels are non-recursive. Recently, some empirical and theoretical studies have suggested that prosodic recursion is possible and can be a reflection of syntactic embedding (Féry and Truckenbrodt 2005, Wagner 2005, 2010, Selkirk 2009, 2011, Itô & Mester, 2012, 2013, Elfner 2012 among others). In addition, there is plenty of evidence that immediate dominance is not always satisfied. For example, the syllables or feet of monomoraic grammatical words can link directly to  $\Phi$ 's rather than be parsed in  $\omega$ 's.

Some authors (e.g. Cooper & Paccia-Cooper 1980, Kaisse 1985, Wagner 2005 and Pak 2008, among others), have gone even further, arguing against the existence of the prosodic structure and proposing that domain-sensitive phonological processes make direct reference to syntactic

structure. These proposals are still tentative, but have forced more mainstream models to adopt tools that more closely align syntactic and prosodic constituents.

The most recent instantiation of the Prosodic Hierarchy, Match Theory, fully integrates the notion of recursion (Selkirk 2009, 2011). In this approach, prosodic recursion caused by syntactic nesting is neither prohibited nor exceptional. Direct syntactic-prosodic mappings are stipulated in the form of two sets of violable Match constraints that require one-to-one correspondence between syntactic and prosodic constituents. These constraints keep the syntactic structure and the prosodic structure faithful to each other:  $\omega$ 's,  $\Phi$ 's and  $\iota$ 's respectively match grammatical words, syntactic phrases and clauses (and vice-versa) under the pressure of the faithfulness constraints summarized in (6):

(6) a. Input-output constraints: *MATCHWORD*, *MATCHPHRASE*, *MATCHCLAUSE*.

A word, phrase and clause in the syntactic structure respectively must be matched by a corresponding  $\omega$ ,  $\Phi$  and  $\iota$  in the prosodic representation.

b. Output-input constraints: *MATCH $\omega$* , *MATCH $\Phi$* , *MATCH $\iota$* .

A  $\omega$ ,  $\Phi$  and  $\iota$  in the prosodic representation respectively must be matched by a corresponding word, phrase and clause in the syntactic structure.

The first set of constraints summarized in (6a) is violated when one of the relevant syntactic constituents is not matched by a corresponding prosodic domain. The second set of constraints shortened (6b) is violated when a prosodic domain does not match the corresponding syntactic constituent (Selkirk 2011). When unchecked by other constraints, the faithfulness constraints in (6) predict a kind of prosodic recursion that perfectly mirrors the syntax, as in (7):

$$(7) \text{NP1} [ \text{N} [ \quad ] \text{NP2} [ \dots ] ]$$

$$(\quad (\quad)_{\omega} (\dots)_{\Phi})_{\Phi}$$

Obviously, few languages allow this perfect match between syntax and prosody. In Match Theory, this is attributed to markedness constraints that ban certain types of structures, be them minimal weight requirements (BINMIN) or constraints explicitly banning recursion (NOREC). BINMIN $\Phi$ , for example, overrides the anchoring of  $\Phi$  boundaries to XPs edges in some languages that have restrictions on  $\Phi$  minimal weight. In Egyptian Arabic, for instance, it forces  $\Phi$ 's to minimally consist of three  $\omega$ 's (Hellmuth 2011).

My starting assumption in this dissertation will be that  $\omega$ 's,  $\Phi$ 's and  $\iota$ 's in IA closely match grammatical words, syntactic phrases and clauses and that IA allows prosodic recursion as long as it mirrors syntactic nesting. As the distribution of each IA prosodic domain is explored, I will look for patterns that deviate from this simple starting point and determine if they can be accounted for by simple markedness constraints.

In the following section, I give more details about the  $\omega$ ,  $\Phi$  and  $\iota$  and present some of their segmental and autosegmental correlates across languages.

## § 1.2 Interface prosodic domains and their diagnostics

$\omega$ 's are normally formed with reference to morphological structures such as a stem and its affixes. They can be the domain of metrical, intonational and segmental phenomena, the most frequent being stress assignment (Peperkamp 1997). In (8), for example, *Minnesota* forms two feet. Each foot receives a star in the metrical grid, and then *sota* projects in the next line (i.e.  $\omega$  level). It becomes the head of the  $\omega$  and receives stress.

(8)    (            \*    )         $\omega$   
           ( \*    ) ( \*    )        Ft  
           ,minə    'soutə

‘Minnesota’.

$\omega$ 's are not only formed around lexical/content words, but can sometimes be formed around function words as well. For example, the object pronoun ('them) $_{\omega}$  in English projects a  $\omega$  and receives stress when it is under information or contrastive focus (Selkirk 1996).

The  $\omega$  can be the domain of cliticization (e.g. a function word can be cliticized to the  $\omega$  of an adjacent content word). Evidence for cliticization comes from phonological phenomena such as stress assignment: clitics enter the domain of stress assignment rules if they are  $\omega$ -internal. One example of  $\omega$ -internal clitics that impact stress placement comes from Turkish (Kabak & Vogel 2001). In this language, stress goes to the final syllable of a  $\omega$ . In (9a), stress falls on the stem-final syllable, but in (9b) it always lands on the last suffix. The suffixes in (9b) are therefore cliticized to the  $\omega$  of *se.pet*.

(9) a. (se'pet) $\omega$

'Basket'

b. (sepet-'ler) $\omega$     (sepet-ler-'im) $\omega$     (sepet-ler-im-'den) $\omega$

Basket-PL    Basket-PL-POSS.    Basket-PL-POSS-from

'Baskets'    'My baskets'    'From my baskets'.

(Kabak & Vogel 2001: 324)

Compounds are also claimed to be parsed in a single  $\omega$ . In Hebrew<sup>1</sup> (Siloni 2002) and Japanese (Itô & Mester 2007), the words that make up a compound are grouped in a single  $\omega$  and receive only one stress.

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<sup>1</sup> I am referring to the construct state, which is a type of compounding in Hebrew.

Besides stress, the  $\omega$  can also be defined as the application domain of segmental processes. For example, the intrusive- $r^2$  is inserted in  $\omega$ -final position in the Eastern Massachusetts dialect (Selkirk 1996) as exemplified in (10):

(10) (schwa-[r]) $_{\omega}$  (epenthesis) $_{\omega}$

(Selkirk 1996: 28)

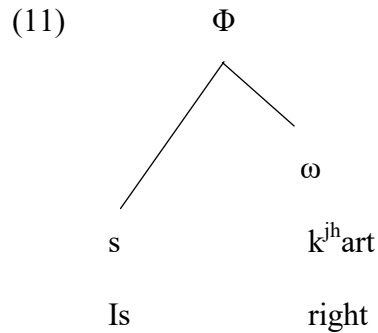
The  $\Phi$  can be defined by referring to syntactic constituency. In early work on the Prosodic Hierarchy (Nespor & Vogel 1986, Selkirk 1984) and in later developments in edge based-approaches (Selkirk & Tateishi 1988, Selkirk & Shen 1990, Truckenbrodt 1995), the boundaries of the  $\Phi$  had to be anchored to the left or right edge of an XP. In Match Theory, both edges of an XP simultaneously match boundaries of a  $\Phi$  (Selkirk 2009, 2011).

The interface between  $\Phi$  and  $\omega$  is instrumental in capturing the prosodic behavior of some function words. A  $\Phi$ , following the Strict Layer Hypothesis (Selkirk 1984, 1996, Nespor & Vogel 1986), must dominate at least one  $\omega$ . However, in more recent studies it has been proposed that a  $\Phi$  can directly dominate lower domains. When  $\Phi$  dominates a  $\omega$ -external foot or syllable, we obtain a structure called a free clitic (Selkirk 1996). The free clitic analysis is typically used to explain marked phonological patterns. For instance, Green (2008) suggested that the Irish cluster  $sk^h$  is not possible at the left edge of a  $\omega$  in Irish, but is allowed when it arises from the combination of a prosodic word and a free clitic, as in (11).

---

<sup>2</sup>The other condition to intrusive - $r$  is that the first word ends with a low vowel and the second word starts with any vowel.





‘(It) is right.’

The example in (1) illustrates a segmental process that is bound by  $\Phi$ . The  $\Phi$  can also be the domain of intonational and temporal processes. For example, each  $\Phi$  receives a pitch-accent in English (Adger 2006, Kratzer & Selkirk 2007). Moreover,  $\Phi$ 's are normally marked by high or low right boundary tones. Other intonational and temporal diagnostics to  $\Phi$  boundaries are F0 partial reset (Truckenbrodt 2007) and final lengthening (Wagner 2005).

$\iota$ 's normally match syntactic projections that are larger than XPs (i.e. clauses) or categories that are external to clauses (Potts 2003, Selkirk 2011). The  $\iota$  level is linked to the illocutionary clause that is introduced by a functional syntactic head  $\text{Comp}^0$  at the top of the syntactic representation of a sentence. This clause can be either non-integrated (e.g. parentheticals) or embedded in a host sentence such as non-restrictive relative clauses (Nespor and Vogel 1986, Truckendrodt 1995, Potts 2003, Selkirk 2006, Dehé 2009, Selkirk 2011 among others).

Across languages,  $\iota$ 's are linked to intonational phenomena: an  $\iota$  is normally marked by a right boundary tone, such as a continuative high boundary tone or sentence-final low boundary tone (Selkirk 2011). Full F0 reset, blockage of downstepping and final lengthening are also

diagnostics to  $\iota$  boundaries in several languages (Féry and Truckenbrodt 2005). In addition to intonational phenomena, several segmental processes were presented as diagnostics to  $\iota$  boundaries or defined as  $\iota$ -domain processes in the literature, such as consonantal lengthening in  $\iota$ -initial position in the Tuscan variety of Italian spoken in Florence (Nespor & Vogel, 1986).

As mentioned at the beginning of this chapter, a main goal of this dissertation is to isolate phonological processes that cue  $\omega$ ,  $\Phi$  and  $\iota$  boundaries in IA and to see if they provide any evidence for prosodic recursion. In the following section, I define prosodic recursion and review case studies that have substantiated it.

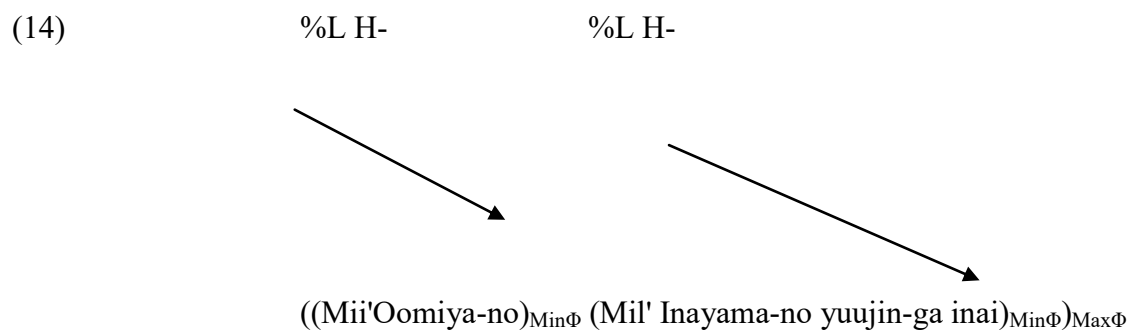
### **§ 1.3 Prosodic recursion and its diagnostics**

It is now relatively uncontroversial that the Strict Layer Hypothesis has to be relaxed and that prosodic recursion is attested in some languages (e.g. Truckenbrodt 1999, Wagner 2005, 2010, Elfner 2012, Itô & Mester 2012, 2013). In Match Theory, recursive prosodic domains that reflect syntactic embedding are optimal and universal as long as the Match constraints are not violated by markedness constraints that hinder recursion (Selkirk 2009, 2011). However, it still remains to be determined if prosodic recursion is exceptional, common or universal.

Prosodic recursion involves repetition in the prosodic structure without the creation of a new category, as exemplified in (12):



$\Phi$ -recursion was recently proposed as well (e.g. Itô & Mester 2010, Elfner 2012). Itô and Mester (2012) suggested  $\Phi$ -recursion in Japanese prosodic structure to account for two intonational phenomena: the minimal  $\Phi$  is the domain of the initial rise (%L-H) as indicated by the arrow in (14), and the maximal  $\Phi$  is the domain of downstep. If one associates downstep and the initial rise to a single  $\Phi$  constituent, one obtains a simple account in which there is no fundamental qualitative difference between minor and major  $\Phi$ 's: all  $\Phi$ 's, regardless of their level of recursion, start with a rise and are the domain of downstep.

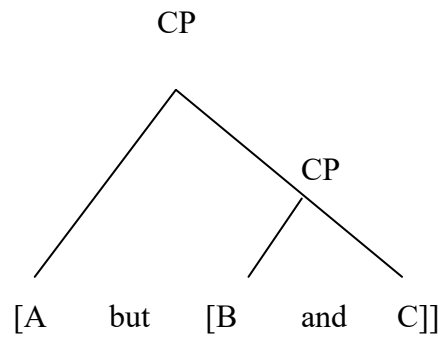


'Mr. Inayamas friend from Oomiya isn't there. '

(Itô and Mester 2012: 285)

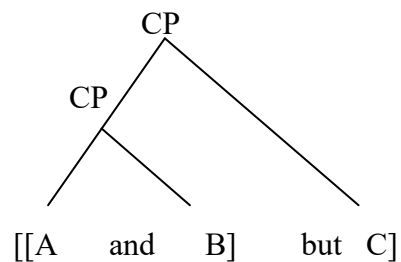
Ladd (1988, 1996) also presented evidence of recursion at the  $\iota$  level, where F0 rest and downstep not only mark the left edges of clauses, but do so in a phonetically gradient manner, reflecting  $\iota$ -recursion. The coordinate clauses that were under examination have the following recursive representations:

(15) a. The clauses B and C are nested into a higher syntactic node (a complex CP) that has an iterative relation with A:



Warren is a stronger campaigner, [but Ryan has a lot more money, and Allen has more popular policies]

b. The clauses A and B are nested into a higher syntactic node that has an iterative relation with C:



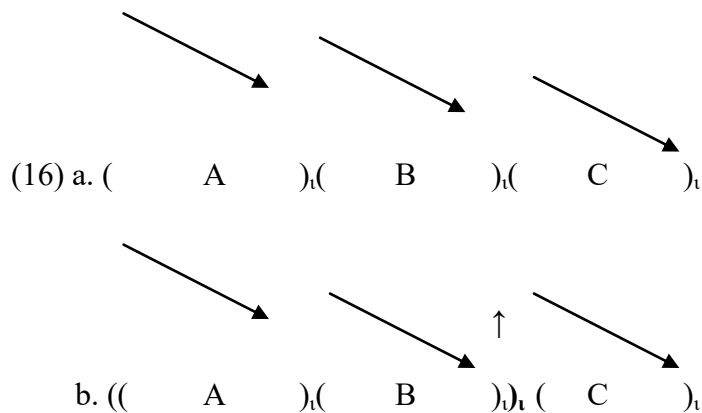
[Allen is a stronger campaigner, and Ryan has more popular policies], but Warren has a lot more money.

(Ladd 1996: 242)

Ladd (1988) predicted that the boundary before *but* in both structures should be stronger than the

boundary before *and*, since *but*, unlike *and*, conjoins two clauses that are immediately dominated by the maximal CP.

The results showed that sentences that have the structure in (15a) have the non-recursive prosodic parsing in (16a), as suggested by pitch accent downstep<sup>3</sup> across clauses: the high pitch accent at the left of B in (16a) is downstepped relative to the first pitch accent in A and the first accent of C is relatively lower than the first one in B. This systematic downstepping indicates that the prosodic boundary between A and B is not stronger than the one between B and C.



On the contrary, the initial peak of clause C in (16b), which is a syntactic constituent on its own, is downstepped relative to A but not B. Therefore, the initial peak of C in (16b) is either higher than B or at least not much lower than B, as indicated by the upwards arrow. Ladd treats this as a diagnostic to prosodic recursion: the maximal  $\iota$  boundary in bold at the right edge of (B), causes a partial F0 reset or prevents downstep at the left of C. This prosodic recursion mirrors syntactic nesting: A and B in (16b) form  $\iota$ 's that are dominated by a larger  $\iota$ , while C is in another  $\iota$ .

<sup>3</sup> Pitch accent downstep refers to the gradual lowering of a number of accents.

This leads us to the question of gradient cues to prosodic recursion: boundaries of different strengths could have quantitatively different effects on a specific phonetic property (be it intonational, durational or segmental). An example of the effect of boundaries of different prosodic categories is F0 reset that was reported by Féry and Truckenbrodt (2005) and Truckenbrodt (2007). In these studies, Féry and Truckenbrodt showed that F0 reset can be full or partial: full F0 reset normally occurs at  $\tau$  boundaries and partial F0 reset occurs at  $\Phi$  boundaries. An example of the effect of boundaries of different recursive layers is the pre-boundary syllable lengthening that was reported in Wagner (2005, 2010) as an additive temporal cue to minimal and maximal  $\Phi$ 's in English coordinate structures. Along these lines, a gradient correlate to prosodic boundaries may support prosodic recursion.

I have now introduced the main theoretical concepts that will be discussed in this dissertation: prosodic domains, the syntax-prosody interface, segmental and suprasegmental correlates to prosodic domains, recursion and gradience. In the next two sections, I present a brief review to the limited literature on the prosodic structures in Arabic vernaculars and present the research questions addressed in this dissertation.

#### **§ 1.4. Prosodic domains in Arabic**

A few studies experimentally investigated aspects of prosody in some Arabic varieties. Below, I will review studies that tackled the construction of  $\omega$ ,  $\Phi$  and  $\tau$  and their correlates in Egyptian Arabic (EA) (Hellmuth, 2004, 2007, 2011, 2015, Chahal and Hellmuth 2014), Lebanese Arabic

(LA) (Chahal 2001, Chahal and Hellmuth 2014) and Jordanian Arabic as spoken in Amman (AA) (Yasin 2012, Hellmuth 2015).

The  $\omega$  is the domain of stress assignment in EA (Hellmuth 2006), LA (Chahal 2001, Chahal and Hellmuth 2014) and AA (Yasin 2012). It is the domain of pitch accent distribution in EA (Hellmuth 2006): a lexical word projects a  $\omega$ , bears primary stress and receives a pitch accent in this dialect. Function words can also project  $\omega$ 's if they are polymoraic and/or inflected.

As far as I know, no segmental processes applying to  $\omega$  have previously been reported in the literature on Arabic prosody. However, a form of vowel shortening seems to play that role in Jordanian Arabic. This process is also found in neighboring dialects (e.g. Syrian and Palestinian Arabic) and should also apply inside the  $\omega$ -domain in these vernaculars. For example, the word *?a.xu:* ends with a long vowel in (17). Its long vowel is shortened when this vowel appears in  $\omega$ -final position, as in (17a), but it remains long in  $\omega$ -internal position, as in (17b) because the cliticization of the mono-consonantal suffix *-k* prevents vowel shortening<sup>4</sup>.

(17) a. (?a.xu) <sub>$\omega$</sub>  (sami) <sub>$\omega$</sub>

Brother Sami

‘Sami’s brother’.

b. (?a.xu:-k) <sub>$\omega$</sub>

brother-2SM.POSS

‘Your father’.

---

<sup>4</sup> McCarthy (2005) and Abu-Salim (1982) consider this process a long vowel shortening process at word-final position. Broselow (1976) and Watson (2002) see it as a short vowel lengthening in word-non-final position.



The relationship between  $\Phi$ 's and XPs has been studied in EA (Hellmuth 2004, 2007 and 2015) and LA (Chahal 2001, Chahal and Hellmuth 2014). In EA, Hellmuth found that  $\Phi$ 's are mapped from maximal XPs if they are heavy. Although there is some variation in the datasets collected starting from 2004, it seems that generally-speaking, a  $\Phi$  should dominate at least three  $\omega$ 's.

In AA, a pilot study conducted by Hellmuth (2015) and Yasin's (2012) dissertation both suggested that  $\Phi$ 's are formed around maximal XPs, regardless of their prosodic weight.

The suprasegmental cues associated to  $\Phi$  in these studies are final lengthening, L- phrase accents and F0 pitch accent reset. Furthermore, Yasin (2012) reported that in AA, the feminine suffix *-t* is realized across  $\omega$ 's that are in the same  $\Phi$ , but gets deleted or is produced as *h* in  $\Phi$ -final position.

There has been some research on  $\iota$  in Arabic dialects, even if less than on the  $\Phi$ . There is a consensus that  $\iota$ 's match clauses in EA (Hellmuth and Chahal 2014), LA (Chahal 2001) and AA (Yasin 2012), and similar acoustic cues to  $\iota$  are found in all dialects (Hellmuth and Chahal 2014, Yasin 2012). The  $\iota$  appears to be the domain of pitch-accent downstepping in AA (Yasin 2012) and in EA, where  $\iota$ -boundaries cause a full F0 reset (Chahal & Hellmuth 2014). In all studied dialects, pre-boundary lengthening marks  $\Phi$ 's and  $\iota$ 's boundaries but is stronger in syllables that appear before  $\iota$  boundaries.  $\iota$ 's are also normally followed by boundary tones. Finally, a process of *i*-epenthesis to avoid a complex consonant cluster at the contact point of two words was reported to be blocked at  $\iota$ -boundaries in EA (Hellmuth 2004, Yasin 2012).

As far as I know, no study has empirically examined prosodic recursion in any Arabic variety yet. However, there is circumstantial evidence that  $\omega$ ,  $\Phi$  and  $\iota$  are non-recursive in these dialects. Based on Abdul-Karim's (1980) proposal that there is no secondary stress in LA, Chahal and Hellmuth (2014) suggested that the  $\omega$  in this dialect is a non-recursive domain. That said, Al-Ani (1992), based on empirical results, reported two types of stress that differ in prominence in a specific Arabic construction (i.e. the genitive construct), which could support the existence of a recursive  $\omega$  in Arabic. Finally,  $\Phi$ 's normally match maximal XPs in AA, EA and LA, suggesting that there is no recursion at this level in Arabic.

## § 1.5 Dissertation outline

In Chapters 3, 4 and 5, I will define the formation of  $\omega$ ,  $\Phi$  and  $\iota$  and explore the correspondence between syntactic and prosodic domains in IA. The remainder of this dissertation is organized as follows: In Chapter 2, I introduce IA in relation to *Al-'arabiyya Al-Fusha*<sup>5</sup> and other Jordanian varieties and briefly discuss the phonology of this dialect. In Chapter 3, the  $\omega$  formation in IA will be explored. I will discuss the prosodic status of function words, which seems to violate layeredness, and the prosodic representation of genitive constructs, which provide evidence for recursivity. Suprasegmental and segmental evidence for  $\omega$  will also be reviewed.

In Chapter 4, the construction of  $\Phi$  will be investigated. The direct correspondence between XPs and  $\Phi$ 's will be under examination. An important question in this chapter is: do nested XPs motivate recursive  $\Phi$ 's? In an experiment on  $\Phi$  construction, complex XPs of different types will

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<sup>5</sup>Al-'arabiyya Al-Fusha is the eloquent form of Arabic which has rich inflectional and derivational systems and can also be called Classical Arabic or Standard Arabic

be acoustically and statistically analyzed to determine if the cues expected to be associated with right XPs edges, phrase-final lengthening and L- phrasal tones, provide any evidence for  $\Phi$  recursion.

The construction of  $\iota$  and the correspondence between  $\iota$ 's and nested relative clauses will be explored in Chapter 5. Sentences with complex relative, parenthetical and conditional clauses will be analyzed to see if they provide any evidence for  $\iota$ -recursion. This will be done not only by looking at phrase-final lengthening and boundary tones (i.e. cues to prosodic boundaries at the right edges of clauses), but also by examining the conditions that motivate the failure of vowel reduction, hiatus resolution process that occur at word edges.

In Chapter 4 and 5, I will only investigate potential cues to prosodic boundaries at the right edges of syntactic XPs and clauses. I do not explore possible cues at the left edges of syntactic constituents (e.g. F0 reset and suspension of F0 downstepping) because in the limit amount of previous work on the prosody of Jordanian Arabic makes it difficult to make predictions about these processes. It was much easier to make reasonable preliminary working hypotheses for right edges because their phonetic cues (final lengthening, boundary tones) are much more salient and therefore more easily accessible to native speaker intuitions. I did try to find left boundary cues (in a post-hoc manner) in the data collected in chapters 4 and 5, but this was difficult for several reasons. First, IA speakers who participated in the experiments did not seem to consistently use the same cues to mark left edge boundaries. Second, although there is evidence for downstep, it seems subtle, speaker-specific (or even optional) and its domain of application ( $\iota$  or  $\phi$ ) appears

variable. This variability among speakers in using cues to prosodic boundaries at the left edges of syntactic constituents should of course be accounted for in further researcher in order to explore the domain of F0 downstepping in IA and to answer the following question: do full F0 reset, partial F0 reset or suspension of F0 downstepping are used by IA speakers to mark left prosodic boundaries of different strengths (e.g.  $\Phi$  and  $\iota$  boundaries). However, this will require tightly controlled experiments that are beyond the scope of this dissertation.

Finally, I will analyze the formation of these three prosodic domains in a framework that is based on the correspondence constraints of Match Theory (Selkirk, 2009, 2011) in Chapter 6. In the same chapter, I will attempt to account for the prosodic difference between IA and other studied Arabic varieties by minimal reorganization of the formal tools developed for IA.

## § 2 Overview: Jordanian Arabic as spoken in Irbid

The goal of this chapter is to introduce IA and its phonology. In the following section, I will situate IA with respect to *Al-‘arabiyya Al-Fusha*<sup>6</sup> and other varieties spoken in Jordan.

### § 2.1 The situation of Irbid Arabic

Arabic is a Semitic language that was originally spoken in Arabia by nomadic tribes. Its current geographical extension is due to the expansion of Islam in the 7<sup>th</sup> century. The early form of the language is characterized by its elaborated inflectional and derivational systems. This variety is often called Classical Arabic, but Arabs, in general, do not make distinctions between the language of Quran and the poetry of the pre-Islamic and early-Islamic period and the form of Arabic that is currently used in news broadcasting, and call it *Al-‘arabiyya Al-Fusha*. One of the features of Modern Standard Arabic that distinguish it from Classical Arabic is the fact that spoken forms of the former reduce the inflectional morphology of *Al-‘arabiyya Al-Fusha*. For example, the singular nominative marker *-u* in *mu.dar.ris-u* ‘teacher-NOM’ can be dropped. Note however that some morphological markers remain compulsory: for instance, the plural nominative marker *-u:n* in *mu.dar.ris-u:n* ‘teacher-NOM.PL.M’ cannot be dropped.

There is a debate about whether vernaculars co-existed with the language of poetry and the Quran in 7<sup>th</sup> century in Arabia and whether these vernaculars were similar to *Al-‘arabiyya Al-Fusha*. Fück (1955), cited in Holes (2004), hypothesized that there were vernaculars that were

similar to *Al-‘arabiyya Al-Fusha* since people could understand poetry composed in *Al-‘arabiyya Al-Fusha*.

The establishment of the Islamic empire at the end of the 7<sup>th</sup> century resulted in the spread of Arabic in North Africa and the Levant (current day Syria, Lebanon, Palestine and Jordan) where Aramaic was spoken. However, some Arabic tribes already lived in the southern Levant, like the Nabateans and the Ghassanids, a group of Arabian tribes who migrated to Jordan during the third century. Many of them were Christians or converted to Christianity when they mingled with the people in Jordan. Vesteeagh (1984), cited in Holes (2004), indicated that the contact between people from Arabia and the conquered people in Levant resulted in the creation of a pidgin that turned into a creole that had some resemblances to *Al-‘arabiyya Al-Fusha*. The dialects in Levant nowadays could be connected to this creole.

Jordanian Arabic is a cover term including a number of social and regional varieties. Social varieties can be described as *Madani* ‘urban’, *Badawi* ‘bedouin’ and *Fallahi* ‘rural’. *Madani* Arabic in Jordan is spoken in the cities (Amman, Al-Zarqa, Al-Salt, Irbid and Aqaba). *Fallahi* Arabic is spoken in the villages surrounding these cities. *Badawi* is spoken by Jordanian clans originally from the Arabian Peninsula. They are nomadic tribes who traveled to Jordan at different points in time. Many *Badawi* varieties<sup>7</sup> have been studied in Jordan, but the best-known is the Bani Hassan Tribal dialect spoken in the north of Jordan. *Badawi* Arabic is spoken in Al-Mafraq, Al-Karak, Madaba, Maan and Al-Tafela (Figure 1).

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<sup>7</sup>There are many other Badawi dialects in Jordan including the dialects of the following clans: Huwaytat, Audwan, Sarhan and Bani Atiyya.

Another important dialect in Jordan is that of the descendants of Palestinian immigrants who started to settle in Jordan around the middle of the 20<sup>th</sup> century and live in the cities next to people who are originally Jordanians. Most of them speak their own mother regional dialects of Nablus, Khalil, Jaffa and Haifa. Recent immigrants from Syria and Iraq also speak their home dialects.

In the governorate of Irbid, *Fallahi* Arabic is spoken in villages, while town dwellers speak *Madani* and Palestinian Arabic. This can be generalized to a great part of Ajloun and Jerash (Figure 1). The focus of this dissertation is the variety spoken in Irbid villages. It belongs to the *Fallahi* dialect that is spoken in the north of Jordan and the south of Syria. This area, now divided by the political border between Jordan and Syria, is called Sahel Hauran ‘Hauran Plains’. It ranges from areas near Damascus to Ajloun in the north of Jordan. Irbid, Al-Ramtha, Ajloun and Jerash constitute the Jordanian part Sahel Hauran. The circle in the map in Figure 1.1 shows the locations where the *Fallahi* variety of Sahel Hauran is spoken in Jordan. Al-Ramtha is included as a part of Irbid.

**Figure 1** Map showing the location of the *Fallahi* Arabic variety studied in this dissertation.



The three varieties of Jordanian Arabic introduced above are the spoken varieties that Jordanian speakers acquire as their mother tongue. These varieties of Jordanian Arabic are used in everyday conversations and TV series, but are not written. During formal education, speakers start to learn the grammar and the writing system of *Al-'arabiyya Al-Fusha*. *Al-'arabiyya Al-Fusha* or its modern form is used for news broadcasts, religious and political speeches and administration. As a result of the spread of education and media, *Al-'arabiyya Al-Fusha* lexical items, phrases and various structures are increasingly used, especially in class, but also in less formal speech and everyday conversations between educated people. Speakers may switch back and forth between the colloquial Arabic and *Al-'arabiyya Al-Fusha* to signal their educational



status. The effect of this contact between the two varieties needs to be studied experimentally. This is beyond the scope of this dissertation, but convergence between the two varieties will be mentioned when relevant.

One of the components that makes *Fallahi* Arabic different from *Al-‘arabiyya Al-Fusha* is its syllable structure. Complex onsets are avoided in *Al-‘arabiyya Al-Fusha* but are prevalent in *Fallahi* Arabic. Also, the complex codas of *Al-‘arabiyya Al-Fusha* are only possible in *Fallahi* Arabic when they do not violate the Sonority Sequencing Principle. As for morphology and syntax, the morpho-syntactic markers of *al-Fusha*, such as the case markers, are either subject to paradigm leveling or dropping. For example, *-i:n*, the accusative and genitive masculine plural case in *Al-‘arabiyya Al-Fusha*, is generalized to the nominative in *Fallahi* Arabic. There are also important differences in the default word order, which are one of the reasons to hypothesize that Jordanian Arabic and other Arabic varieties may (not) be derived directly from *Al-‘arabiyya Al-Fusha* or that it was strongly influenced by neighboring or substrate languages, such as Aramaic, as suggested by Vesteeh (1984), cited in Holes (2004).

One of the most common and salient features that makes *Fallahi* Arabic different from *Madani* Arabic is that *Fallahi* has a recurring discontinuous negation marker, as shown in (18).

(18) Discontinuous negation marker (it is more frequent in *Fallahi* than *Madani*):

Madani : ma: ga:l

Fallahi : ma: ga:l-ɨf

NEG say.3SMPST.

NEG say.3SMPST.-NEG

‘He did not say that.’

Pharyngealization is another feature that is found in *Fallahi* more than in *Madani*. The plain word *ga:l* and *ma:lu* in (19) in *Madani*, for example, have pharyngealized counterparts in *Fallahi*:

(19) Pharyngealization:

Madani:

Fallahi:

a. ga:l

g<sup>ʕ</sup>a:l<sup>ʕ</sup>

say.3SMPST

‘He said’.

b. ma:l-u

m<sup>ʕ</sup>a:l<sup>ʕ</sup>-u<sup>ʕ</sup>

what-3SGM

‘What is his problem?’

Another distinctive feature of *Fallahi* is the presence of the alveo-palatal affricate in place of the standard  $k^{\delta}$ , as in  $k[\widehat{tj}]ammal$  ‘finish.3SM.PST’. Moreover, while *Fallahi* has  $g$ ,  $g$  is produced as a glottal stop in *Madani*. As for *Badawi* Arabic, it has *tanween* ‘nunation’, the word-final indefinite marker. It also has a number of words, phrases, and structures that are not found in other Jordanian dialects.

Contact between *Fallahi* Arabic and other dialects affect daily speech to some extent. For instance, women from rural areas often mix prestigious *Madani* features with their dialect. They tend to use a glottal stop instead of  $g$  and avoid using the alveo-palatal variant of  $k$ . With the increasing number of Syrian refugees in the north of Jordan and the growing popularity of Syrian-dubbed Turkish series and movies, some females have also started mixing Syrian words with their dialect.

In the following section, I introduce the phonemic inventory and stress rules in IA.

## § 2.2 The phonology of Jordanian Arabic as spoken in Irbid

### § 2.2.1 Phonemes: consonants & vowels

In the following table, the consonants of the *Fallahi* variety as spoken in Irbid are listed.

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<sup>8</sup> The realization of  $k$  as  $\widehat{tj}$  in Jordanian Arabic should be studied since the contexts in which  $k$  fronting is not straightforward. For example,  $k$  is fronted in  $[\widehat{tj}]ammal$  ‘finish.3SMPST’, but not in  $[k]allam$  ‘talk.3SGMPST’.

**Table 1: Consonants in Irbid Arabic.**

	Plosive		Nasal	Tap	Fricative		Affricate	Approximant	Lateral	
<b>Labial</b>	b		m		f			w		
<b>Interdental</b>					θ	ð				
						ð <sup>ʕ</sup>				
<b>(Post)alveolar</b>	t	t <sup>ʕ</sup>	d	n	r	s	s <sup>ʕ</sup>	z	ʤ	l
					ʃ					
<b>Palatal</b>								j		
<b>Velar</b>	k		g							
<b>Uvular</b>					x	ɣ				
<b>Pharyngeal</b>					ħ	ʕ				
<b>Glottal</b>	ʔ				h					

The Classical Arabic *q* has the velar counterpart *g* in the rural dialect and *k* has the alveo-palatal variant *tʃ*. As for vowels, they are listed in the following table.

**Table 2: Vowels in Irbid Arabic.**

	Front		Central		Back	
	Short	Long	Short	Long	Short	Long
High	i	i:			u	u:
Mid		e:				o:
Low			a	a:		

In general, diphthongs are not found in Jordanian Arabic. For instance, *sajf* ‘sword’ in *Al-arabiyya Al-Fusha* is produced as *se:f* in Jordanian Arabic.

### § 2.2.2 Lexical stress assignment in IA and its suprasegmental correlates

Syllables in IA are grouped into three classes as illustrated below:

**Table 3: Syllable types in IA**

		Example
<b>Light:</b>	CV	ra.ma ‘throw.SG3M.PST’
<b>Heavy:</b>	CVC	mak.tab ‘office’
	CVV	saa.xin ‘hot’
<b>Superheavy:</b>	CVVC	raaḥ ‘go. SG3M.PST’
	CVCC	laff ‘turn back.SG3M.PST’
	CVVCC	saarr ‘happy’

Complex onsets are possible in IA when they are followed by long vowels, as exemplified in (20):

(20) kta:b	sba:.ḥa	dra:.se	wla:d
CCV:C	CCV:.CV	CCV:.CV	CCV:C
‘Book’	‘swimming’	‘learning’	‘children’

As shown in these examples, complex onset clusters cannot incur a strong violation of the Sonority Sequence Principle. Sonority may fall from a glide to *l*, as in *wla:d*, but not from a glide to a stop.

Although almost all Arabic dialects employ stress<sup>9</sup>, stress assignment varies from dialect to dialect. In a word domain, syllable weight and its position relative to the other syllables normally

<sup>9</sup> Mass (2013) and Burdin et al (2014) convincingly argue that Moroccan Arabic does not have a lexical stress.

determine stress distribution. The rules of stress assignment in IA are listed in (21):

(21) a. Stress the final syllable if it is super-heavy:

taḥ. 'siin

‘Developing’.

b. Otherwise, stress falls on a heavy penult:

is. 'taf.sar

Ask.SG3M PST

‘He asked about’.

c. If the penult is light, stress falls on the antepenultimate:

'iḥ.ta.ra

buy. SG3M PST

‘He bought’.

It is worth mentioning here that IA morphology affects stress assignment. For example, stress lands on *mak* of '*mak.ta.beh* in (22) in the absence of a superheavy ultimate syllable and a heavy penult. However, after the affixation of *-hum*, stress lands on the heavy penult *bet*.

(22) 'mak.ta.be-[h] → mak.ta.'be-[t]-hum

'Library.F'      library-F-PL3M.REF

'Their library'.

As for the acoustic correlates of stress, Al-Ani (1992), Jong & Zawaydeh (1999) and Zuraïq (2005) found that stressed syllables are lengthened in Jordanian Arabic. Al-Ani (1992) also showed that stressed syllables have a strong intensity boost and a modest increase in F0.

In the following section, I introduce coarticulation of pharyngealization. This process is important in this dissertation as it will be used in Chapter 3 as a diagnostic for  $\omega$  formation. For this reason, it deserves its own section, even if it is by no means limited to IA.

### § 2.3 Coarticulation of pharyngealization

Pharyngealization<sup>10</sup> is a secondary articulation of consonants that is common in Semitic languages. From a production viewpoint, pharyngealization involves a constriction of the pharynx during the production of plain segments. It can be defined as the spreading of the pharyngeal feature of the contrastively pharyngealized coronals /d<sup>ʕ</sup><sup>11</sup>, t<sup>ʕ</sup>, s<sup>ʕ</sup> ð<sup>ʕ</sup>/ to neighboring segments. In IA, the pharyngeal feature spreads regressively as in (23a) and progressively in (23b):

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<sup>10</sup>Arabic linguists refer to pharyngealization as emphasis.

<sup>11</sup>d<sup>ʕ</sup> is rare among speakers of IA. It can be used by females.



(23) a. Regressive coarticulation:

/ta. fa.s<sup>ʕ</sup>i:l/ → [t<sup>ʕ</sup>a.ʕ.f<sup>ʕ</sup>a.ʕ.s<sup>ʕ</sup>i:l]

detail.PL

‘Details’.

b. Progressive coarticulation:

/t<sup>ʕ</sup>a:w.l-a:t/ → [t<sup>ʕ</sup>a:ʕ.w<sup>ʕ</sup>.l<sup>ʕ</sup>-a<sup>ʕ</sup>:t<sup>ʕ12</sup>]

table-PL.F

‘Tables’.

From an acoustic viewpoint, pharyngealization lowers the F2 of vowels (Zawaydeh 1999, Jongman et al. 2007). Jongman et al (2007) also found that the F1 and F3 of a pharyngealized vowel undergo raising in Jordanian Madani dialects.

Spreading of the pharyngeal feature is common in Arabic varieties; however, it applies under different conditions. For example, it is unidirectional in Saudi Arabic as spoken in Abha (Davis

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<sup>12</sup> The directionality and the distance from the pharyngeal consonant play a role in pharyngealization coarticulation. In this example, the pharyngeal feature of t<sup>ʕ</sup> at the onset of the word could have lesser impact towards the right of the feminine plural morpheme -a:t.

1995), but bidirectional in Jordanian Arabic. It was reported in a number of studies that its spreading can be blocked by a specific set of segments. For instance, Davis (1995) reported that in two Palestinian dialects, progressive spreading is blocked by an adjacent high non-back vowel. This was also found in Jordanian Arabic. In (24a&b), progressive and regressive coarticulation of pharyngealization are blocked by an intervening *j* and *i* respectively.

(24) a. blockage of progressive coarticulation:

/t<sup>ʕ</sup>aj.b-a:t/ → [t<sup>ʕ</sup>a<sup>ʕ</sup>j.b-a:t]

Delicious-PL.F

‘They are delicious.’

b. Blockage of regressive coarticulation:

/la.gi.t<sup>ʕ</sup>-a:t/ → [la.gi.t<sup>ʕ</sup>-a<sup>ʕ</sup>:t<sup>ʕ</sup>]

foundling-PL.F

‘Foundlings’.

The prosodic domain of application of coarticulation has not been devoted much attention yet.

Zawaydeh (1999) and Card (1983) have argued that the domain of coarticulation of pharyngealization is the word in Amman and Jerusalem Arabic, but in Qatari Arabic coarticulation can apply regressively from a word-initial pharyngealized segment to the

preceding word (Bukshaisha 1985 cited in Watson 1999). This Qatari study can be taken as the first attempt to show that the application domain of pharyngeal feature spreading is larger than the lexical word and can be a prosodic domain.

In (25), the pharyngeal feature of  $t^{\text{f}}$  in  $t^{\text{f}}u:l$  spreads progressively towards the end of the entire genitive construct in IA.

(25) Progressive coarticulation across word boundaries within a genitive construct:

$t^{\text{f}}u:l$      $\text{ʔabu:-ha}$  →     $t^{\text{f}}u:.\text{f}^{\text{f}}\text{-a}^{\text{f}}$      $b^{\text{f}}u:.\text{h}^{\text{f}}\text{a}^{\text{f}}$

length father-SG3F

‘The height of her father’.

Since spreading is not blocked at the right edge of  $t^{\text{f}}u:l$ , the domain of coarticulation of pharyngealization is not necessarily the lexical word, but can be larger. In Chapter 3, I will hypothesize that  $\omega$  is the domain of pharyngealization coarticulation in IA.

In the following section, I introduce the genitive construct in Arabic. The importance of this construction in this dissertation stems from the fact that it is a type of compounding, and compounds normally form  $\omega$ 's.

## 2.4 Genitive construct (construct state)

Genitive constructs are a common form of compounding in Semitic languages. The genitive construct is a possessive construction. It is a DP/NP that dominates a head N followed by an inner NP, as exemplified in (26):

(26)

a.  $NP_1[N[kita:b \quad NP_2[al-ʃiʃir]]]$   
book DEF-poetry

‘The book of poetry’.

The *Al-'arabiyya Al-Fusha* genitive construct has a number of grammatical markers. The genitive case marker *-i* and the indefinite marker *-n* appear to the right of the inner NP (NP2), as shown in (26b). N also has a case suffix specified by its syntactic position: it is marked by the nominative *-u* in subject position, by the accusative *-a* in object position and by the genitive *-i* after prepositions. It is important to highlight that these grammatical markers are not present in IA genitive constructs.

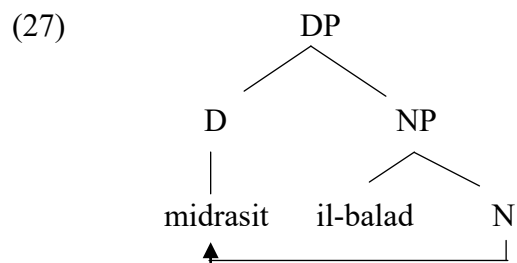
b.  $DP_1[N[kita:bu \quad NP_2[ʃiʃirin]]]$   
book-Nom poetry-GEN-INDEF.

‘A book of poetry’.

The inner NP of a genitive construct can be definite or indefinite in both IA and *Al-'arabiyya Al-Fusha*, as shown in (26a&c). In both varieties, the definiteness of the entire genitive construct is determined by the definiteness of the internal NP.

c. DP<sub>1</sub>[N[kita:b NP<sub>2</sub>[[iʕir]]]  
           book      poetry  
 ‘A book of poetry’.

Most analyses of genitive constructs involve the movement of the bare noun (i.e. the head of genitive construct) to the head of a DP as specified in (27) in order to account for its properties, such as definiteness spreading and immediate adjacency (Borer 1999, Fehri 1991 & 1993, Ritter 1988, Siloni 1991).



madrasi-t    il-balad  
 school-F.    DEF-country  
 ‘The school that is in a village’.

To my knowledge, the prosodic representation of genitive constructs has only been discussed in Jordanian Arabic as spoken in Amman. Yasin (2012) proposed that the elements of this construct are mapped to flat  $\omega$ 's, and then to a  $\Phi$  in this dialect. I will propose that this construction is mapped to a recursive  $\omega$  in IA in Chapter 3.

Before exploring the domains of IA prosodic structure, it is worth noting that many aspects of intonational phonology in Jordanian Arabic, similar to several other Arabic dialects, needs to be explored. As far as I know, Kalalkeh (2009) has run an experiment on the timing of peak alignment of pitch accents in Jordanian Arabic and Standard Arabic and found that peaks of nuclear pitch accents are aligned early. Furthermore, the intonation of Jordanian Arabic is one of the targets of IVAr<sup>13</sup> (the Intonation Variation in Arabic) project (in progress) which is basically to create a database of speech data and investigate intonational, metrical and rhythmic variations across some Arabic dialects including Jordanian Arabic.

Now that crucial background information about IA has been laid out, we can turn to the study of prosodic domains proper. Chapter 3 deals with  $\omega$ .

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<sup>13</sup>This project is hosted by the Department of Language and Linguistic Science at the University of York. It is the result of collaboration between six researchers: Hellmuth, Al-Mbarak, Kalalkeh, Bouchhioua, Gargett and Louriz.

### **§3 The Prosodic word in Irbid Arabic**

In early versions of the Prosodic Hierarchy (Nespor & Vogel 1986, Selkirk 1986), the  $\omega$  level was universal and non-recursive. More recently, some studies have cast doubt on the existence of  $\omega$  level in all languages. For example, the existence of  $\omega$  in Vietnamese has been questioned and many more levels of prosodic domains have been proposed in some Tibeto-Burman languages (Hildebrandt 2007, Bickel et al. 2009, Schiering et al. 2010, Brunelle 2017). Furthermore, the general relaxation of the Strict Layer Hypothesis now allows  $\omega$  recursion. In this chapter, I will assert the necessity of the  $\omega$  in IA by looking for phonological evidence for this domain. I will explore its syntactic grounding and assess its recursive nature by looking at function words and compounds.

#### **§3.1 Prosodic word: evidence, syntactic grounding and recursion**

In the standard theory of the Prosodic Hierarchy (Selkirk 1984, Nespor & Vogel 1986), the  $\omega$  can be defined based on phonological evidence. For instance, it is normally the domain of stress assignment in lexical words and some function words (Selkirk 1996, Peperkamp 1999, Kabak & Vogel 2001, Hellmuth 2006, Itô & Mester 2007). In § 3.2, I go over the prosodic status of function words in AI and show, following Selkirk (1996)'s typology, that they project their own  $\omega$ 's and receive stress if they meet some weight-minimality requirements.

$\omega$  is not only the domain of stress assignment in lexical and some function words, but also the domain of primary stress assignment in special grammatical structures (i.e. compounds). A compound can project a recursive  $\omega$ . For example, in an English compound, one stress is

promoted to primary status and any other stress undergoes demotion to secondary status when the maximal  $\omega$  of the compound is formed (Itô & Mester 2007), as exemplified in (28):

$$(28) \quad \left( \begin{array}{c} * \\ \text{language} \end{array} \right)_{\omega_{\max}} \left( \begin{array}{c} * \\ \text{instructor} \end{array} \right)_{\omega_{\min}}$$

A compound can also form a non-recursive  $\omega$  as in Hebrew (Siloni 2002): one stress remains and all other stressed words are de-stressed. Along similar lines, Abdul-Karim (1980) cited in Chahal and Hellmuth (2014) suggested that a secondary stress should not be posited in Lebanese Arabic. On the contrary, Al-Ani (1992) indicated, based on empirical results, that some constructions (i.e. the genitive constructs<sup>14</sup>) have secondary stress in Arabic: the two elements of a genitive construct, which is a type of compounds, have stress, but the first is more prominent. In Hellmuth's (2006) dissertation, it has been reported that both elements of a genitive construct in Egyptian Arabic are accented, and therefore they must be stressed first. However, this, I assume, should not be taken as evidence that this construction has an even metrical structure bearing in mind that in a few tokens Hellmuth has found that the first element is unaccented. In § 3.3, I argue that it is necessary to posit a recursive  $\omega$  in IA to account for the metrical structure of

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<sup>14</sup> The genitive construct, which is called the construct state by Arab linguists, is a possessive construction that is found in Semitic languages. It is a complex noun phrase that contains a head-initial noun/the possessor and a following noun phrase/the possessed.



Arabic genitive constructs, contra Yasin (2012) who analyzed these constructions as  $\Phi$ 's. In addition to their metrical structure, the realization of the feminine suffix *-t* in genitive construct-internal position supports mapping these constructions to recursive  $\omega$ 's.

As far as I know, no  $\omega$ -domain segmental processes have been reported in the literature on Arabic prosody. In § 3.4, I hypothesize that the  $\omega$  is the domain of pharyngealization of coarticulation, based on earlier claims that the application domain of this process is either the lexical word or the grammatical word in Arabic varieties (Card 1983, Zawaydeh 1999, Watson 1999, Jongman et al 2007). My hypothesis is empirically examined. The results of the experiment show that the initial hypothesis is over-simplistic, and that while coarticulation of pharyngealization can apply outside the scope of a  $\omega$ , it is blocked by  $\omega$  configuration.

### **§3.2 Function words**

As just mentioned above, primary stress is assumed to be the main realization of prosodic wordhood. As such, lexical words, which all bear primary stress, form their own  $\omega$ 's. The status of function words is more complicated. A function word projects its own  $\omega$  and receives a stress if it is at least bimoraic, after the exclusion of the rightmost mora due to extrametricality.

Following this proposal, the function words containing superheavy syllables in (29) are  $\omega$ 's.

(29) a. Monosyllabic superheavy function words:

(ˈfu:g)<sub>ω</sub> (ˈgba:l)<sub>ω</sub> (ˈtiħt)<sub>ω</sub> (ˈbaʕd)<sub>ω</sub> (ˈdʒanb)<sub>ω</sub>

‘up’ ‘before’ ‘below’ ‘after’ ‘beside’

b. Disyllabic function words containing a superheavy syllable:

(mi.ˈʃa:n)<sub>ω</sub> ‘in order to’ (gid.ˈda:m)<sub>ω</sub> ‘in front of’.

A disyllabic function word must have, at least, a heavy syllable to project ω’s, as exemplified in

(30):

(30) Disyllabic function words containing a heavy syllable:

(ˈbar.ra)<sub>ω</sub> (ˈdʒuw.wa)<sub>ω</sub> (ˈlam.ma)<sub>ω</sub>

‘outside’ ‘inside’ ‘when’

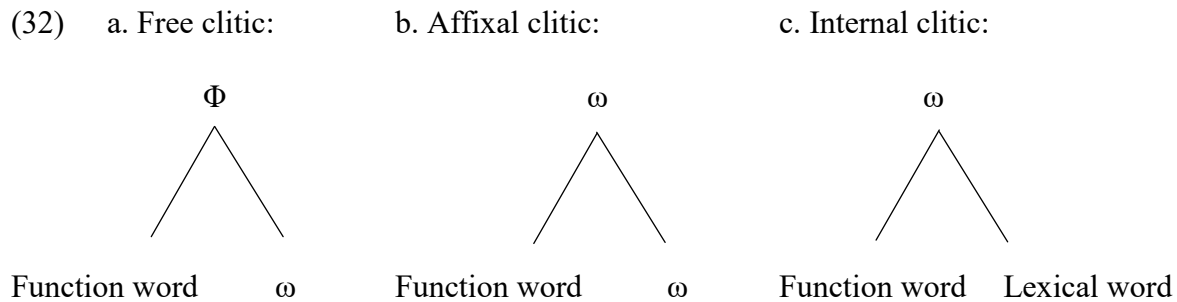
Function words that do not meet the minimality requirements can take the shapes listed in (31):

(31) (CVC): ʔaw ‘or’ (VC): il ‘DEF.’ (CV):fi ‘in’ bi ‘in’ (CV:): ma: ‘not’ (CV.CV): ʕa.la ‘on’

ʔi.ða ‘if’

These function words neither project ω’s, nor receive stress. Moreover, they are not affecting the stress of neighboring words.

According to Selkirk (1996), a function word that does not project a  $\omega$  can directly link to a  $\Phi$  (free clitic), to a non-minimal  $\omega$  (affixal clitic) or to a minimal  $\omega$  (internal clitic), as illustrated in (32):



I propose that function words that do not meet the minimality requirement in IA are free clitics. Evidence for the free clitic analysis comes from the metrical representation of function word-lexical word sequences. If a function word is affixed to a recursive  $\omega$  or becomes a part of a flat  $\omega$ , as illustrated in (32b&c), it should somehow affect the stress of the adjacent lexical word. Recall that stress assignment rules in IA are: (i) Stress the ultimate superheavy syllable. (ii) If it is not superheavy, stress the heavy penult. (iii) Otherwise, stress the antepenult.

In (33a), for example, stress falls on the initial syllable of the lexical word *ga.lib* ‘heart’ because its final syllable is not superheavy. If we assume an affixal analysis, the light function word *fi* ‘in’ should form a large  $\omega$  with *ga.lib* in (33b), and as such, should receive antepenultimate stress. A similar prediction applies if *fi* is an internal clitic. Contrary to this prediction, stress stays on the initial syllable of the lexical word in the right variant in (33c). This means that *fi* is a free clitic: it is outside the  $\omega$  containing *galib*.



reduced when it is not in sentence-final position, as shown in (35a&b). If the reduced form of the auxiliary *ka:n* was an affixal or internal clitic, it should receive stress, as shown in (35c&d).

However, it does not suggest that the proper analysis is the free clitic analysis in (35b).

- |   |  |
|---|--|
| (35) a. (( <i>'ka:n</i> ) <sub>ω</sub> ( <i>'si.miŋ</i> ) <sub>ω</sub> ) <sub>Φ</sub><br><br>Be.3SGM.PST hear.3SGM.PST<br><br>'He should have heard.' | b. ( <i>kan ('si.miŋ)</i> ) <sub>ω</sub> ) <sub>Φ</sub><br><br>c. *( <i>'kan ('si.miŋ)</i> ) <sub>ω</sub> ) <sub>ω</sub><br><br>d. *( <i>'kansi.miŋ</i> ) <sub>ω</sub> |
|---|--|

Finally, function words that do not normally meet the minimality requirement and fail to project their own ω's and receive stress can meet the minimality requirement by concatenating with other light function words. For example, *fi* 'in' and *bi* 'in' are normally light. But they become heavy penults (i.e. they undergo vowel lengthening) when they are attached to pronouns in (36b) allowing them to form ω's.

- |  |   |
|--|---|
| (36) a. Non-inflected <i>fi</i> and <i>bi</i> :<br><br>( <u><i>f</i></u> <i>i</i> ('be:t-na) <sub>ω</sub> ) <sub>Φ</sub><br><br>in house-3SGM.REF<br><br>'In our house'. | b. Inflected <i>fi</i> and <i>bi</i> :<br><br>( <u><i>f</i></u> <i>i</i> : <i>-ha</i> ) <sub>ω</sub><br><br>in-3SGM.REF<br><br>'In it'. |
| <br><br>( <u><i>b</i></u> <i>i</i> ('be:t-na) <sub>ω</sub> ) <sub>Φ</sub><br><br>in house-3SGMREF<br><br>'In our house'.   | <br><br>( <u><i>b</i></u> <i>i</i> : <i>-ha</i> ) <sub>ω</sub><br><br>in-3SGMREF<br><br>'In it'.  |

To sum up,  $\omega$ 's in IA are not only projected by lexical words, but also by function words meeting minimality requirements. All other function words are free clitics. They neither receive stress nor affect stress assignment of adjacent words. So far, we have seen that  $\omega$  has a perfectly flat structure and admits neither recursion nor prosodic word cliticization in IA. However, in the following section, I show that genitive constructs provide evidence for  $\omega$ -recursion.

### **§3.3 Genitive constructs**

In this section, I show that the assignment of primary stress and the demotion of any other stress to a secondary status in genitive constructs is evidence that these constructions project recursive  $\omega$ 's. In addition to the metrical structure of the genitive constructs, the realization of the feminine suffix *-t* within these constructions provides segmental evidence of their mapping to  $\omega$ 's.

Genitive constructs are a common form of compounding in Semitic languages. Compounds are often analyzed as recursive  $\omega$ 's (Selkirk 1996, Peperkamp 1997, Itô & Mester 2009), but their prosodic status actually varies across languages. In English, both members of a compound receive stress, but only the first member has a primary stress, while Japanese compounds only have one accent (Itô & Mester 2007).

Yasin (2012) has proposed that the elements of a genitive construct in Jordanian Arabic project flat  $\omega$ 's that are dominated by a  $\Phi$ , as shown in (37).

(37) ((            )<sub>ω</sub> (            )<sub>ω</sub>)<sub>Φ</sub>

NP1[N[bina:je-t]] NP2[il-ħuku:ma]]

Building-F DEF-government

'The government building'.

I will rather argue that the genitive constructs project recursive  $\omega$ 's. The metrical structure of the genitive constructs indeed appears recursive: according to Al-Ani (1992), each element in a genitive construct receives a stress, but the stress of the first one is more prominent. For example, N and NP2 in the genitive construct in (38) project  $\omega$ 's and receive stress but the status of NP2 stress is secondary.

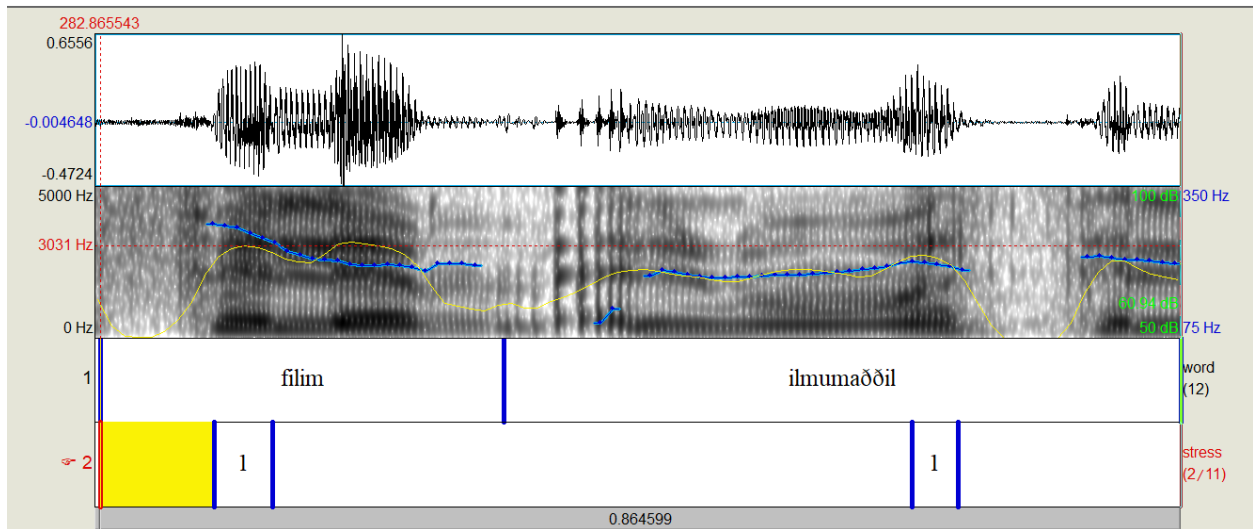
(38) NP1[N['fi.lim]] NP2[il-mu,maððil]]

Film DEF-actor

'The actor's movie'.

The secondary status of *il-mu,maððil* can be deduced from the intensity and F0 of the stressed syllable *mað*. This syllable has lower F0 peak and intensity than *fi* in *filim*. It is worth mentioning that this genitive construct was extracted from a complex sentence: it occupies a sentence-medial position. This way, the effect of sentence-initial strengthening and sentence-final lowering are avoided.

**Figure 2** The stressed syllable of *'fi.lim* has higher F0 peak and intensity than the stressed syllable of *il-mu, maððil* in *'fi.lim il-mu, maððil* 'The actor's movie'.



The secondary status of NP2 stress indicates that there should be a new prosodic layer in which the highest star in the metrical grid of the compound is assigned to N. This layer should be the maximal  $\omega$ , as shown in (39).

$$(39) \quad (* \quad \quad \quad )_{\omega}$$

$$(* \quad )_{\omega} \quad ( \quad * \quad )_{\omega}$$

$$NP1[N[ 'fi.lim ] \quad NP2[il-mu, mað.ðil]]$$

In addition to the metrical structure of the genitive constructs, the application of *t*-liaison within these structures supports the proposal that a genitive construct projects a recursive  $\omega$ . For example, the feminine suffix *-t* is realized in  $\omega$ -internal position in (40b), but is produced as [h]



in  $\omega$ -final position in (40a).

(40) a. (bi.na:.je-h) $\omega$

Building

‘Building’

b. (bi.na:j-t-u) $\omega$

building-F-3SM.POSS.

‘His building.’

The realization of the feminine suffix *-t* in genitive construct-internal position in (37) above indicates that the entire construct is contained in a recursive  $\omega$ : the feminine suffix is realized in *bina:je-t*, suggesting that this suffix is not treated as  $\omega$ -final.

To sum up, facts about the metrical structure of the genitive constructs and the application of *t*-liaison within these constructions are strongly in favor of  $\omega$ -recursion in IA. In the following section, I investigate the coarticulation of pharyngealization in IA speech to see if it provides further evidence for the  $\omega$  formation rules provided above. I hypothesize that its domain of application is the  $\omega$ .

### §3.4 Coarticulation of pharyngealization

It is well-established that pharyngealization can spread in one or both directions within “words” in the loose sense in Arabic. However, the directionality of this process, its blockers and its exact domain of application vary among Arabic dialects. In this section, I focus on its domain of application in IA.

Previous studies have found that coarticulation of pharyngealization tends to be bound by lexical word boundaries in Arabic dialects (Card 1983, Zawaydeh 1999, Jongman et al 2007), but it was reported that coarticulation of pharyngealization can override word boundaries as in Qatari Arabic (Bukshaisha 1985 cited in Watson 1999). Recently, Youssef (2013) also showed that the  $\omega$  should be the domain of coarticulation of pharyngealization in Cairene Arabic. He presented instances in which the pharyngeal feature spreads on suffixes and prefixes.

In this section, I present an experiment on coarticulation of pharyngealization in IA. This experiment which contains a reading task is mainly designed to test if this process reflects the  $\omega$  formation principles proposed in the previous sections. The structures under examination are genitive constructs and reduced function word-lexical word sequences. The goal of this study is not to define the correlates of pharyngealization in IA, but it is rather to present coarticulation of pharyngealization as a diagnostic for  $\omega$  and its boundaries.

### **§3.4.1 Hypotheses**

My initial hypothesis is that the application domain of coarticulation of pharyngealization is the  $\omega$ . I expect that this process will not be blocked at word edges within genitive constructs, which are proposed to map to recursive  $\omega$ 's in the previous section, as shown in (41a&b). On the contrary, it is expected to be blocked at the contact point between a reduced function word and the following lexical word in (42) because these words do not belong to a single  $\omega$ .

(41) a. Expected regressive coarticulation of pharyngealization in genitive constructs:

NP1[N[aħla] NP2[t<sup>ʕ</sup>a.gum]] → ((a<sup>ʕ</sup>ħl<sup>ʕ</sup>a<sup>ʕ</sup>)<sub>ω</sub> (t<sup>ʕ</sup>a<sup>ʕ</sup>g<sup>ʕ</sup>.u<sup>ʕ</sup>m)<sub>ω</sub>)<sub>ω</sub>

Most-beautiful set

‘The most beautiful set’.

b. Expected progressive coarticulation of pharyngealization in genitive constructs:

NP1[N[ar.xas<sup>ʕ</sup>] NP2[nu:ʕ]] → ((a<sup>ʕ</sup>r<sup>ʕ</sup>.xa<sup>ʕ</sup>s<sup>ʕ</sup>)<sub>ω</sub> (n<sup>ʕ</sup>u:<sup>ʕ</sup>ʕ)<sub>ω</sub>)<sub>ω</sub>

Cheapest type

‘The cheapest brand’.

(42) Expected blocking of progressive coarticulation of pharyngealization in function word-lexical word sequences:

ka:n d<sup>ʕ</sup>all → (kan (d<sup>ʕ</sup>a<sup>ʕ</sup>l<sup>ʕ</sup>l<sup>ʕ</sup>)<sub>ω</sub>)<sub>ϕ</sub>

Be.3SM.PST stay.3SM.PST

‘He should have stayed.’

### §3.4.2 Wordlists and procedures

To test the hypotheses that were just laid out, sentences including genitive constructs and sequences of a reduced function word and a lexical word were recorded. In each genitive construct or function word-lexical word sequence, there is a word that has a pharyngeal consonant (source) and another that only has plain segments (target). In the genitive construct

in (43) for instance, the pharyngeal feature should spread progressively from the first word that has a pharyngeal segment *nus<sup>ʕ</sup>* to the second plain word *sa:ʕah*.

(43) *nus<sup>ʕ</sup> sa:ʕah*

Half hour

‘Half an hour’.

There are 6 genitive constructs in the wordlist. They are divided into 3 cases of progressive and 3 cases of regressive coarticulation of pharyngealization. With regard to function word-lexical word sequences, there are 8 phrases, which are all regressive. This means that the direction of coarticulation can only be measured within genitive constructs, but it was impossible to do otherwise as the language does not have pharyngealized enclitics. All target words contain the target vowel /a/ either as their first vowel (in the case of progressive coarticulation, as in (43)) or as their last vowels (in the case of regressive coarticulation). The full list of sentences is given in Appendix 1.

Genitive constructs were produced in two conditions, as shown in Table 4. Condition 1 is meant to ensure that coarticulation of pharyngealization does not systematically occur across word boundaries in IA. In this condition, speakers were asked to produce short internal pause between the two elements of the genitive construct. By doing so, speakers are forced to break the prosodic coherence of the genitive construct for discursive/pragmatic reasons, which should block coarticulation of pharyngealization. To try to obtain this effect, the words in Condition 1 were separated by a longer space on the PowerPoint slides used to present the

stimuli.

In Condition 2, there is no internal pause between the elements of the genitive construct. The prosodic boundary between the two elements of a genitive construct in this group should therefore be a minimal  $\omega$  boundary. In this group, coarticulation of pharyngealization is expected to apply across the word boundary and spread from the word that has a pharyngeal segment to the plain word within a genitive construct.

There is also a control group (Condition 3) that contains single words that have only plain segments and contain the vowel /a/. These words are control words that have been chosen randomly from the recordings of the same speakers in the chess-based task performed in Chapter 4. They are only meant to provide a phonetic reference point for the target vowel.

**Table 4: Groups of genitive constructs in which coarticulation of pharyngealization is tested and the Control Group.**

Group 1: internal pause	Group 2: No internal pause	Group 3: Control
		Group
		Random words
t <sup>ʕ</sup> u:ʕl <sup>ʕ</sup> ʔabu:-ha	t <sup>ʕ</sup> u:ʕ.l <sup>ʕ</sup> a <sup>ʕ</sup> b <sup>ʕ</sup> u:ʕ.h <sup>ʕ</sup> a <sup>ʕ</sup>	Isolated plain
(    ) <sub>ω</sub> # (    ) <sub>ω</sub>	((    ) <sub>ω</sub> (    ) <sub>ω</sub> ) <sub>ω</sub>	adjectives and nouns
length    father-	‘The height of his brother’	contain /a/
SG3F.REF		(e.g., aswad ‘black’).
‘The height of my father’.		

The predictions of this experiment are that there should be no measurable difference in the degree of pharyngealization of the target vowels in Condition 1 (presence of a pause) and Condition 3 (no pharyngealization at all) because coarticulation of pharyngealization should be blocked in Condition 1. This would establish that ω is the domain of application of coarticulation of pharyngealization in IA. Furthermore, there should be a clear pharyngealization of the target vowel in Condition 2, which should therefore differ from the target vowels in Conditions 1 and 3. This would demonstrate that coarticulation of pharyngealization occurs within ω and would support the claim that genitive constructs form recursive ω’s.

Function word + lexical word sequences were also recorded to determine if regressive coarticulation of pharyngealization spreads from a lexical word to a function word. Based on the hypothesis that  $\omega$  is the domain of application of pharyngealization, I predict that it should always be blocked between a function word and the following lexical word. However, it is still necessary to assess the possibility of difference between the function words that meet minimality requirements and form their own  $\omega$ , and the function words that do not meet minimality and are treated as free clitics.

Again, three types of phrases were tested (see Table 5): Condition 1 contains heavy function words produced as full forms: they should form their own  $\omega$ 's. To ensure that speakers did not reduce their function words in Condition 1, they were produced under focus. In Condition 2, the same heavy function words were produced under their reduced form and should thus behave as free clitics. Condition 3, the control group, is similar to Condition 2, but does not contain pharyngeal consonants.

**Table 5: Groups designed to define the effect of pharyngealization on cliticized function words.**

Group 1: Function words project ω's (focus).		Group 2: Free clitic/reduced function words (no focus).		Group 3: (Control Group) Plain sequences	
ka:m	t <sup>ʕ</sup> a:ʕlib	kam	t <sup>ʕ</sup> a:ʕlib	kam	tajib
( ) <sub>ω</sub>	( ) <sub>ω</sub>	( )	( ) <sub>ω</sub> Φ	( )	( ) <sub>ω</sub> Φ
How-many student	How-many student	How-many student	How-many student	How-many	repentant
“How-many students?”	“How-many students?”	“How-many students?”	“How-many students?”	“How many	repentant?”

Twenty native speakers of IA, 10 males and 10 females between 18 and 40 years old participated in this experiment. They are graduate and undergraduate students at Yarmouk University, an institution located in the city of Irbid. All of them were born and brought up around the city of Irbid. These are the same speakers that participated in the other tasks, except the experiment about the (non-)application of vowel deletion at clauses edges in Chapter 5.

The researcher, who is a native speaker of IA conducted the experiment. PowerPoint slides were presented to every participant in two blocks, with a one-minute break between blocks. The first block contained the 6 genitive constructs in Appendix 1 (one per slide). The phrases were read four times. In the first two readings, each speaker read the 6 phrases in a normal speech rate (Condition 2). In the last two readings, the experimenter asked each speaker to produce a short internal pause between the two elements of each genitive construct (Condition



1). The total number of recorded genitive constructs was 480 (6 phrases with internal breaks + the same 6 phrases with no internal breaks x 20 participants x 2 repetitions). As for Group 3, 400 tokens were chosen randomly from the chess-based task that was performed by the same speakers (Condition 3/control group).

The second block contained 8 function word-lexical word sequences. Each of the first four sequences contained a pharyngeal consonant (Conditions 1&2) while the other four sequences lacked pharyngeal consonants (Condition 3). Each sequence was consecutively read two times. The first reading of each sequence was produced at a normal speech rate. Then, the experimenter asked: ‘what did you say?’ to elicit the same sequence with focus on its elements. The total recorded sequences are 480 (4 phrases in normal rate of speech + the same 4 phrases repeated under focus + 4 phrases with no pharyngeal consonants x 20 participants x 2 repetitions).

### **§3.4.3 Data analysis**

Based on inspection of formants and waveforms, the target vowels, which are all /a/, were segmented. No /i, i:, j/ were included between the source and target of pharyngealization since they block the coarticulation of pharyngealization in IA as in many other Arabic varieties (Zawaydeh 1999, Khattab et al. 2006 among others).

Acoustically, pharyngealized segments have a higher F1 and F3 values than the values of their plain counterparts (Abudaljuh, 2011, Jongman et al 2011), but their most salient correlate, by far, is an important lowering in F2 (see § 2.3). For this reason, F2 was used as the diagnostic to

pharyngealization in this experiment. F2 was measured at the midpoint of each target vowels, using Praat, a speech analysis software.

The data was then analyzed using linear mixed models in SPSS<sup>15</sup>. The distribution of F2, as measured at the midpoint of the target vowel, was used as the dependent variable. The first fixed effect in the model is the type of condition being tested. For genitive constructs, there are three levels: internal pause, no internal pause and controls. There are also three levels for function word-lexical word sequences: focus/no reduction, focus neutral/reduction, and controls. The second fixed effect used for models of genitive constructs is the direction of coarticulation. Speaker and word were included as random factors.

### **§3.4.4 Results**

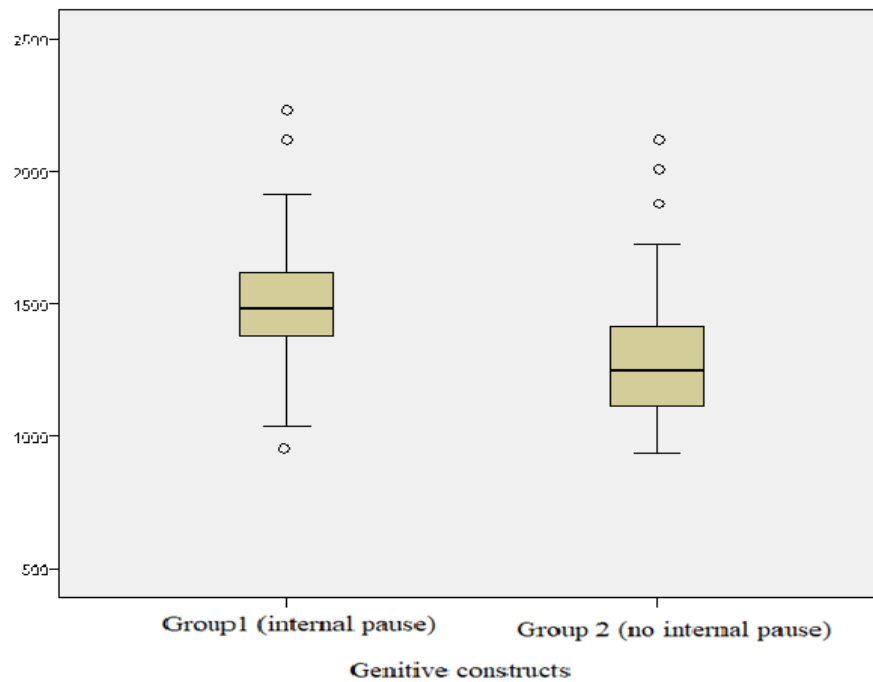
#### **§3.4.4.1 F2 values at vowel midpoint in genitive constructs**

Before presenting the results of the fitted model for F2, I present the distribution of F2 measurements of vowels in genitive constructs that belong to Group1 (internal pause) and Group 2 (no internal pause). Figure 3 indicates that the F2 measurements of vowels in Group 2 have a median that is lower than the median of those of vowels in Group 1.

---

<sup>15</sup>The syntax for the full used in SPSS is:  
DATASET ACTIVATE DataSetX.  
MIXED F2 BY group direction speaker word  
/CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)  
HCONVERGE(0,  
ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)  
/FIXED=group direction | SSTYPE(3)  
/METHOD=REML  
/PRINT=SOLUTION TESTCOV  
/RANDOM= INTERCEPT group | SUBJECT(speaker) COVTYPE(VC)  
/RANDOM= INTERCEPT group | SUBJECT(word) COVTYPE(VC).  
/SAVE=PRED(XXX\_TotPred).

**Figure3 F2 measurements at the midpoint of vowel /a/ in genitive constructs in Group 1 (internal pause condition) and Group 2 (no internal pause condition).**



The fitted model for genitive constructs (Table 6) shows that the F2 value at the midpoint of target vowels in genitive constructs without internal pauses is 271Hz lower than F2 at the midpoint of target vowels in controls. As for F2 at the midpoint of vowels in genitive constructs with have internal pauses, it is not significantly lower than F2 at the midpoint of target vowels in controls. The direction of coarticulation of pharyngealization has no significant effect on the F2 at the middle of vowels.

**Table 6: Estimates of Fixed Effects in a mixed-effects model for F2 at vowel midpoint**

**( $r^2 = .496$ ). The intercept consists in control words in the regressive coarticulation condition.**

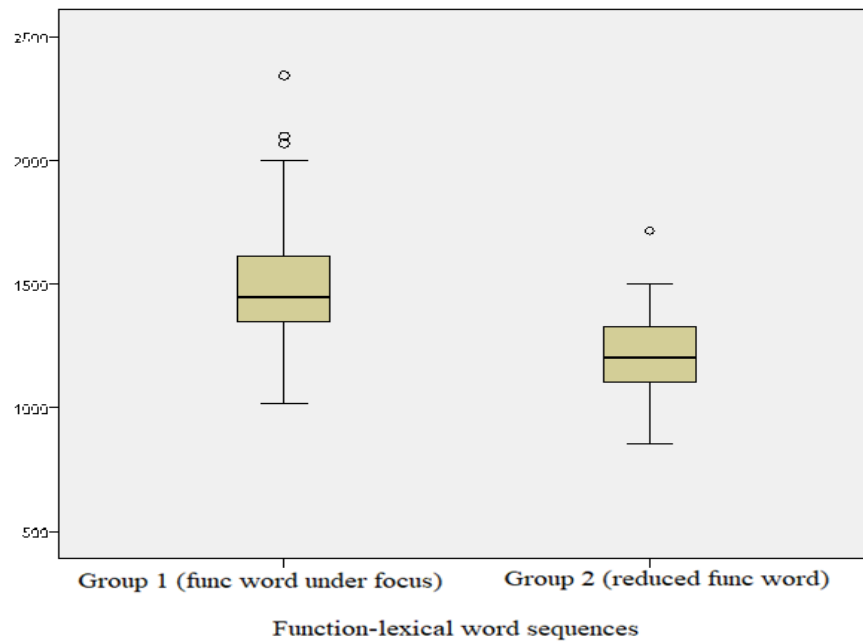
**Estimates are given in Hz.**

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	1524.449227	29.221999	33.736	52.168	.000
internal pause	-16.881920	26.248793	220.290	-.643	.521
no internal pause	-271.188048	35.428271	234.362	-7.655	.000
Control	-	-	-	-	-
-Progressive	12.325683	43.279600	239.981	.285	.776
-Regressive	-	-	-	-	-

#### **§3.4.4.2 F2 values at vowel midpoint in function word-lexical word sequences**

Similar to the distribution of F2 measurements of vowels in genitive constructs in the previous figure, F2 measurements of vowels that belong to Group 2 (reduced function words) in Figure 4 have a median that is lower than the median of those of vowels in Group 1 (function words under focus).

**Figure 4** F2 measurements at the midpoint of vowel /a/ in function-lexical word sequences in Group 1 (function word under focus) and Group 2 (reduced function word).



The model fitted for function word + lexical word sequences (Table 7) shows that F2 at the midpoint of target vowels in non-reduced function words is not significantly lower than the F2 of target vowels in controls/plain words. On the contrary, F2 at the midpoint of target vowels in reduced function words without internal break and followed by a pharyngealized segment is significantly (183Hz) lower than the F2 of vowels in controls/plain words.

**Table 7: Estimates of Fixed Effect in a mixed-effects model for F2 midpoint ( $r^2=.346$ ).**

**The default reference level (control words). Estimates are given in Hz.**

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	1602.401655	28.306111	31.179	56.610	.000
No reduction	30.564483	23.075491	278	1.325	.186
Reduction	-183.563176	23.075491	278	-7.955	.000
Control words	-	-	-	-	-

### **§3.4.4.3 Interpretation of the results**

The absence of a difference between regressive and progressive coarticulation in the genitive construct experiment first indicates that pharyngealization of coarticulation in IA is bidirectional.

As expected, the fact that the F2 of target vowels is identical in genitive constructs with inserted pause (Condition 1) and in controls (Condition 3) suggests that in IA, as in other Arabic dialects, pharyngealization does not spread across lexical word boundaries. More interestingly, the significantly lower F2 at the midpoint of target vowels in genitive constructs without internal pauses (Condition 2) indicates that pharyngealization spreads between the two members of regular genitive constructs, suggesting that they are parsed in a recursive  $\omega$ .

However, the model fitted for F2 at the midpoint of target vowels in function word-lexical word sequences does not fully conform to predictions. While coarticulation of

pharyngealization is blocked between two  $\omega$ 's, it applies beyond the  $\omega$  boundary in structures of the type (Function word (Lexical word) $_{\omega}$ ) $_{\Phi}$ : the significantly lower F2 at the midpoint of target vowels in reduced function word-lexical word sequences indicates that plain vowels of the reduced/cliticized function words are pharyngealized.

### **§3.4.5 The domain of coarticulation of pharyngealization**

At the beginning of this section, I have hypothesized that coarticulation of pharyngealization reflects the  $\omega$ -formation principles proposed in § 3.2. Specifically,  $\omega$  is the domain of application of this process. The structures under examination are genitive constructs and function word-lexical word sequences. I have proposed in § 3.1 that a reduced function word-lexical word sequence forms a  $\Phi$  in which the reduced function word is a free clitic. I have also shown that a genitive construct projects a recursive  $\omega$ . Based on these analyses, I expect that coarticulation of pharyngealization will apply within a genitive construct, but will be blocked at the left of the lexical word in a reduced function word-lexical word sequence since a  $\omega$  boundary is present in this position.

The results show that coarticulation of pharyngealization applies inside recursive  $\omega$ 's mapped from genitive constructs, as shown in (44b). On the contrary, this process is blocked when the two elements of the genitive construct are interrupted by a short break, as exemplified in (44a). This is consistent with the hypothesis that the domain of this process is the  $\omega$  and it supports mapping the genitive constructs to a recursive  $\omega$ .

(44) a. Genitive construct with an internal pause/ι boundary:

t<sup>h</sup>u:ʔ<sup>h</sup> # ʔabu:ha

( )<sub>ω</sub> ( )<sub>ω</sub>

length brother-SG3F.REF

‘The height of his brother’.

b. No internal break:

t<sup>h</sup>u:ʔ<sup>h</sup> a<sup>h</sup>b<sup>h</sup>u:ʔ<sup>h</sup>a<sup>h</sup>

(( )<sub>ω</sub> ( )<sub>ω</sub>)<sub>ω</sub>

‘The height of my brother’

#: break

However, coarticulation of pharyngealization is not blocked at the left of all lexical words.

There is coarticulation in the reduced function word + lexical word sequence in (45b).

Therefore, the application domain of coarticulation of pharyngealization is not simply the ω. In light of the other evidence for ω (stress, realization of feminine -t), the simplest way of accounting for this distribution is not to make extensive modifications to the prosodic structure adopted since the beginning of this chapter, but rather to claim that coarticulation of pharyngealization, rather than applying inside ω, is blocked by a )<sub>ω</sub>( configuration.



(45)

a. No cliticization/no reduction:

ka:m<sub>Foc</sub> t<sup>ʰ</sup>a<sup>ʰ</sup>a<sup>ʰ</sup>lib

(        )<sub>ω</sub>(        )<sub>ω</sub>

How-many student

‘How many students?’

b. Cliticization/reduction:

k<sup>ʰ</sup>a<sup>ʰ</sup>m<sup>ʰ</sup> t<sup>ʰ</sup>a<sup>ʰ</sup>a<sup>ʰ</sup>lib

(        (        )<sub>ω</sub>)<sub>Φ</sub>

### §3.5 Chapter summary

In this chapter, I have shown that both lexical and function words can project  $\omega$ 's in IA. The behavior of function words depends on their weight. Heavy function words form their own  $\omega$ 's while light ones form free clitics and attach directly to the  $\Phi$ . The prosodic structures of function words that have been established in this chapter are listed in the Table 8.

**Table 8: The inventory of possible prosodic representations of function words.**

Function words that project $\omega$ 's and are stressed	Function words that behave as free clitics
<p>1. Monosyllabic superheavy: CV:C, CCV:C, CVCC</p> <p>(fu:g)<math>\omega</math> 'up', ('gba:l)<math>\omega</math> 'on the other side', (<math>\widehat{d\zeta}</math>anb)<math>\omega</math> 'beside'</p>	<p>1. Heavy or light monosyllabic and light disyllabic ones: CVC, VC, CV, CV:, CV.CV</p> <p><i>\?aw</i> 'or', <i>il</i> 'DEF.', <i>fi</i> 'in' <i>bi</i> 'in', <i>ma:</i> 'not' <i>\?a.la</i> 'on' <i>\?i.\deltaa</i> 'if'</p>
<p>2. disyllabic containing super-heavy or heavy syllable:</p> <p>(mi\fa:n)<math>\omega</math> 'to/because', ('bar.ra)<math>\omega</math> 'outside'</p>	<p>2. Reduced function words:</p> <p>ka:n<math>\rightarrow</math>kan</p> <p>be-3SM.PST</p>

As for  $\omega$ -recursion, while function words provide no evidence for  $\omega$ -recursion, genitive constructs do, as attested by their stress pattern and *t*-liaison and coarticulation of pharyngealization. Overall, the simple hypothesis made in the first half of this chapter (i.e.  $\omega$  is the domain of coarticulation of pharyngealization) was born out. A slight modification is however required: the results of the experiment show that coarticulation of pharyngealization is not bound by  $\omega$  boundaries, but is actually blocked by a ) $\omega$   $\omega$ ( configuration. This does not require any modification of the postulated  $\omega$  structure.

Based on the empirical results in this chapter, *t*-liaison, metrical representation and restriction on minimal weight of a  $\omega$ , I have proposed that genitive constructs and function word-lexical word sequences have the following prosodic representations:

(46) a. Genitive constructs:

NP1[N[bi'na:je-t]NP2[il-ħu,ku :ma]]

((                    ) $\omega$  (                    ) $\omega$ ) $\omega$

Building-F DEF-government

'The government building.'

b. Function-lexical word sequence:

'ka:m<sub>Foc</sub>            t<sup>˘</sup>a:<sup>˘</sup>lib

(            ) $\omega$             (            ) $\omega$

How-many    student

'How many students?'

c. Reduced function word-lexical word sequence:

k<sup>˘</sup>a<sup>˘</sup>m<sup>˘</sup>t<sup>˘</sup>a:<sup>˘</sup>lib

((                    ) $\omega$ ) $\Phi$

In the next section, I address the structure of the  $\Phi$  in IA.

## **§4 The phonological phrase in Irbid Arabic**

The next level in the prosodic structure of IA, which will be empirically investigated in this chapter, is the  $\Phi$ .  $\Phi$ 's are normally recognized to match XPs (Selkirk 1986, 2011, Truckenbrodt 1999 among others). I will verify that this applies to IA. I will also look for suprasegmental evidence to  $\Phi$  boundaries and determine if there is evidence for a recursive  $\Phi$  in IA. In the following section, previous studies on the  $\Phi$  formation and the XP-to- $\Phi$  mapping in Arabic are reviewed.

### **§4.1 The phonological phrase in Arabic**

The work of Hellmuth (2004, 2007, 2011a&b, 2015) on Egyptian Arabic (EA) and Jordanian Arabic as spoken in Amman (AA) and the work of Yasin (2012) on AA are, as far as I know, the only organized attempts to investigate the construction of the  $\Phi$  in Arabic. Since these studies are directly relevant to this thesis, I review them in the following two subsections. After doing this, I present an experiment on the formation and acoustic correlates of  $\Phi$  in IA.

#### **§4.1.1 Hellmuth's research on the phonological phrase in Egyptian Arabic**

The general conclusion of Hellmuth's studies on EA is that the relation between XPs and  $\Phi$ 's is conditioned by restrictions on minimal size. In (2004), Hellmuth argued that a  $\Phi$  matches a maximal XP if this XP consists of 4  $\omega$ 's. This is due to the constraint BINMIN $\Phi$  which requires each major  $\Phi$  to embed two minor  $\Phi$ 's where each minor  $\Phi$  dominates two  $\omega$ 's (a  $\Phi$  boundary can be detected at the right edge of the third  $\omega$  in slow rate of speech). For instance, the subject NP in (47) includes three small XPs, and a  $\Phi$  boundary is inserted at the right edge of the entire NP, as indicated by the downward arrow, in fast rate of speech.

(47) ↓  
 NP3[NP2[NP1[il-mu'massil]<sub>AP</sub>[l-mu'himm]]]<sub>PP</sub>[fi-l-film]] ...

DEF-actor DEF-important in-DEF-film

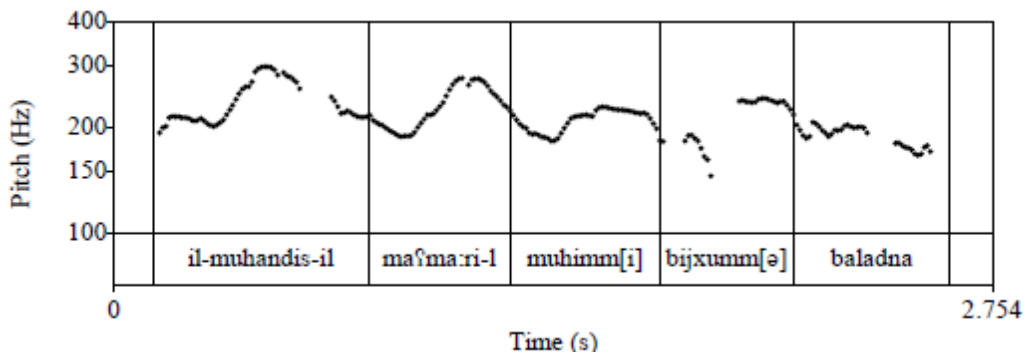
'The important actor in the movie'.

(Hellmuth 2004:4)

Φ can be marked by more than one suprasegmental correlate in EA. In Figure 5, for example, the Φ boundary at the right of the heavy subject NP is marked by final lengthening, a low phrase accent and partial reset of the verb *bij'xumm* pitch accent.

**Figure 5: Example F0 track**

(il-mu'handis l-maʕma:ri l-mu'himm)<sub>Φ</sub> (bij'xumm ba'lad-na)<sub>Φ</sub>  
 DEF-engineer DEF-architectural DEF-important cheats-3SGM.PST country-1PL.REF  
 'The important architect is cheating our country'.



(Hellmuth, 2004:6)

In (2011a), Hellmuth relied on sentences that have a VOO structure to examine the XP-to-Φ mapping in EA. In these sentences, the direct object and the indirect object are always

syntactically complex and prosodically heavy, as shown in the following example:

(48) *verb*      *Direct O*                                      *Locative*                                      *Indirect O*                                      *PP*  
bijʕallim il-ʕarabijja il-ʕammijja      fi gamʕit juna:n li-talaba nubaha      min ru:ma  
 teach.3SM DEF-arabic DEF-colloquial in university Greece to-student.PL clever from Rome  
 ‘He teaches colloquial Arabic in a Greek university for clever students from Rome.’

Hellmuth observed  $\Phi$  boundaries at more syntactic edges in VOO sentences than in her previous studies. The phrasing pattern in (49a) is the most frequent. The final PP is parsed in a  $\Phi$  if it has a sufficient weight:

- (49) a. (V DirectO) $_{\Phi}$  (Locative) $_{\Phi}$  (IndirectO PP) $_{\Phi}$   
 b. (V DirectO) $_{\Phi}$  (Locative) $_{\Phi}$  (IndirectO)(PP) $_{\Phi}$

In a (2011) paper, Hellmuth hinted on a possible  $\Phi$ -recursion cued by a gradient reset of the first pitch accent after a  $\Phi$  boundary. She identified two types of pitch accent resets in her dataset. In (49), for example, there can be either a strong or a weak pitch accent reset after the locative. This suggests that the  $\Phi$  boundary at the right edge of the locative can be either of that a large or small  $\Phi$  depending on the amount of pitch accent reset. A greater amount of pitch-accent reset would indicate the preceding boundary is that of a large  $\Phi$  and while a smaller amount of pitch accent reset would signal the boundary of a smaller  $\Phi$ .

In (2011b), Hellmuth’s dataset has sentences that contain complex subject NPs and complex

VPs, as shown in (4):

(50) *Subject NP*

*VP + direct object*

il-mudi:r    il-dʒadi:d min il-juna:n    bijʃallim    il-tadri:s    il-ħadi:s

DEF-manager DEF-new from DEF-Greece teach.3SGM DEF-teaching DEF-modern

*VP-internal PP- adjunct*

fi kullijjit il-tarbijih

in faculty DEF-pedagogy

‘The new headmaster teaches the modern teaching in the Faculty of Pedagogy.’

The VP always contained five  $\omega$ 's and the subject NP was made up of three or four  $\omega$ 's. The results showed that  $\Phi$  boundaries are at the expected syntactic positions: at the right of the subject NP and at the right of the direct object. Again, Hellmuth reported that the cues at the right edge of the subject NP are stronger than those at the right edge of the direct object, and therefore they can argue for  $\Phi$ -recursion in EA. Specifically, the stronger cues at the right edge of the subject NP can be taken as evidence for the boundary of a large/maximal  $\Phi$  and the weaker ones at the right of the direct object may indicate the boundary of a smaller/minimal  $\Phi$ .

To sum up, XPs and  $\Phi$ 's clearly match in Hellmuth's EA datasets, but this mapping is influenced by prosodic weight (an XP should contain at least three  $\omega$ 's).  $\Phi$  boundaries are marked by various suprasegmental cues, including phrase accents, final lengthening and F0 reset. Moreover, even if Hellmuth is not directly addressing the issue, there is possible evidence of  $\Phi$ -recursion in

EA: some syntactic XPs in here 2011a and 2011b datasets are marked by stronger  $\Phi$  boundaries than others.

#### §4.1.2 Research on the phonological phrase in Jordanian Arabic

In this subsection, I review Hellmuth's (2015) pilot study on  $\Phi$  formation in AA and the part of Yasin's (2012) dissertation that discusses the evidence for  $\Phi$  boundaries in AA. These studies suggest that maximal XPs project  $\Phi$ 's in AA, as in EA. Again, acoustic correlates to  $\Phi$  boundaries include final lengthening, low and high phrase accents and post-boundary F0 reset. In addition, Yasin argued that two types of segmental evidence for  $\Phi$  are found in AA: post-lexical resyllabification and vowel epenthesis to break-up complex codas.

In 2015, Hellmuth conducted a pilot study on the intonational and durational cues to  $\Phi$  boundaries in AA SVO sentences. In her test sentences, subjects vary independently in syntactic and prosodic complexity. For instance, the subject NP is syntactically simple and prosodically heavy (7syllables) in (51a), but syntactically complex and prosodically heavy (13 syllables) in (51b).

(51)

a. <i>Subject</i>	<i>verb</i>	<i>object</i>
<u>mudarri-'si:n-na</u>	<u>bij'hibb-u</u>	<u>l-'ʕa.ra.bi</u>
teacher-PL.M-1PL.REF	love-3MPL.PST	DEF-Arabic
'Our teachers love Arabic.'		



b.	<i>Subject</i>		<i>verb</i>	<i>object</i>
	<u>mu.dar.ri.'si:n.na</u>	<u>l-mu.ta.daj.ji.'ni:n</u>	<u>bij.'hib.b-u</u>	<u>l-'ʕa.ra.bi</u>
	teacher-PL.M-1PL.REF	DEF-devout-PLM	love-3MPL.PST	DEF-Arabic

‘Our devout teachers love Arabic.

The results of this pilot study indicate that the subject NP, which is a maximal XP, projects a  $\Phi$  independently of its prosodic weight. Hence, the recurring prosodic pattern in AA, is  $(S)_\Phi(VO)_\Phi$ . In most of the collected tokens, the  $\Phi$  boundary at the right of the subject NP is marked by a low phrase accent (L-) that is followed by a pitch reset up to the next word.

Like Hellmuth (2015), Yasin (2012) reported that  $\Phi$ 's match maximal XPs in AA. In these studies, unlike Hellmuth's work in 2011 on EA  $\Phi$ , there are no indications to  $\Phi$ -recursion. This is, may be, due to the fact that potential cues at edges of non-maximal XPs were not investigated. According to Yasin,  $\Phi$  boundaries are marked by high phrase accent and final lengthening, and by segmental cues like resyllabification and vowel epenthesis to break complex codas. In (52), for example, Yasin assumed that *gd*, *gl* and *ft* are all complex onsets and subject to simplification by resyllabification, independently from their sonority profiles. He reported that the complex onset clusters *gd* and *gl* are repaired by resyllabification by virtue of the fact that they are not at the beginning of  $\Phi$ 's projected by maximal XPs. On the contrary, *ft* is preserved because it sits at the left boundary of the  $\Phi$ , which coincides with the maximal VP.



issues of recursion in EA obviously needs to be addressed directly, but for the time being (and in Chapter 6), I will assume that EA does not tolerate  $\Phi$ -recursion.

In the following section, I will also present an experiment on the formation of the  $\Phi$  in IA. I will explore syllable duration and F0 contour at the edges of maximal and embedded XPs. This experiment is designed to determine the exact nature of the relation between XPs and  $\Phi$ 's in IA: do  $\Phi$ 's only match maximal XPs as they do in AA? The other possibility is that  $\Phi$ 's can also match low level/simple XPs, which would be evidence to  $\Phi$  recursion. If the second scenario were correct, EA, AA and IA would have different way of referring to the syntax when forming  $\Phi$ 's.

## **§4.2 An experiment on the phonological phrase in Irbid Arabic**

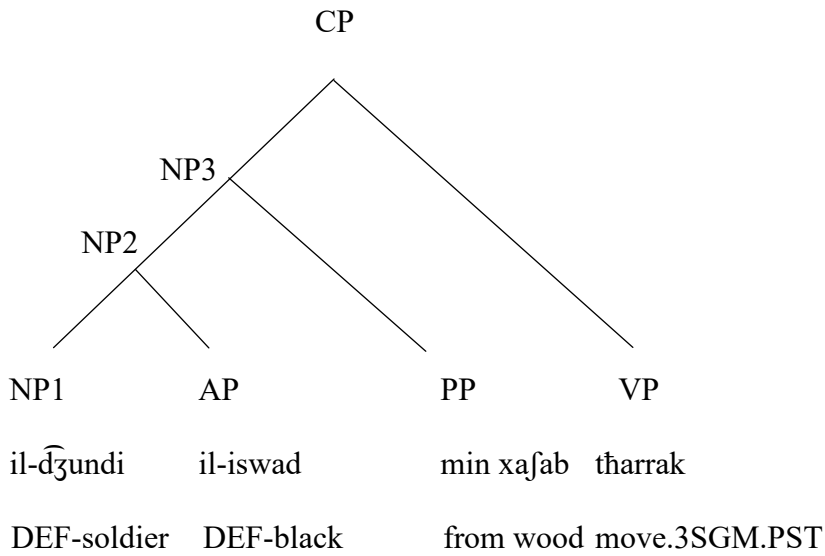
### **§4.2.1 Hypotheses**

My starting point will be the strong hypothesis that  $\Phi$  boundaries, as marked by intonational and durational properties, match XPs and directly reflect syntactic embedding in IA. The choice to assume the direct match hypothesis is a practical one: since there is a large number of possible ways to have mismatching domains, it is easier to make testable predictions for the direct match. If the direct match hypothesis is correct, recursive right-branching and left-branching extra-complex XPs in (53&54) are expected to have different prosodic representations based on their internal syntactic structures, but both of them are expected to trigger prosodic recursion (i.e. three-layer recursive  $\Phi$ ). In the prosodic representation of the right-branching extra-complex NP in (53b), I assume that there are three recursive layers: NP1 and AP in (53a) form minimal  $\Phi$ 's that are dominated by a larger  $\Phi$  which corresponds to NP2, as shown in (53b&c). Then, the  $\Phi$

containing PP joins the  $\Phi$  of NP2 in a maximal  $\Phi$  that matches NP3 in the bottom-up syntactic tree in (53a). Finally, the entire sentence is contained in an  $\iota$ .

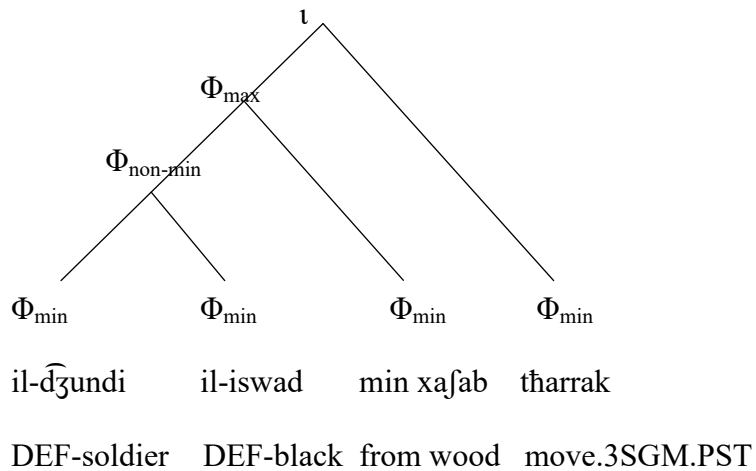
(53) A sentence with a right-branching extra-complex XP:

a. Simplified bottom up syntactic representation:



'The black wooden pawn was moved'.

b. Prosodic representation:



'The black wooden pawn was moved'.

Based on previous studies, I expect that this prosodic representation will be cued by two suprasegmental correlates: F0 and syllable duration. These cues are expected to be correlates of boundary tones and pre-boundary syllable lengthening. I first expect final lengthening, i.e. a longer syllable duration at the end of all  $\Phi$ 's projected by simple XPs. Assuming prosodic recursion, this final lengthening should be gradient and incrementally greater at the right edges of higher XPs, as shown in (53c), such as the NP2-final and NP3-final positions, as they also match recursive  $\Phi$ 's. I also predict, for reasons that will be fully laid out in the next chapter, that the greatest amount of lengthening should be found in sentence-final position where an  $\iota$  boundary is inserted (the end of the VP in (53c)).

c. Syntactic-prosodic bracketing and expected cues to boundaries:

L-	L-	L-	L%
Small FL	FL	Greater FL	Greatest FL
↓	↓	↓	↓
(( ( ) $\Phi_{\min}$	(( ( ) $\Phi_{\min}$ ) $\Phi_{\text{non-min}}$ (	( ( ) $\Phi_{\min}$ ) $\Phi_{\text{max}}$ (	( ( ) $\Phi_{\min}$ ) $\iota$
CP[NP3[NP2[NP1[il-dʒundɪ]	AP[il-iswad]]	PP[min xaʃab]]	VP[tharrak]]

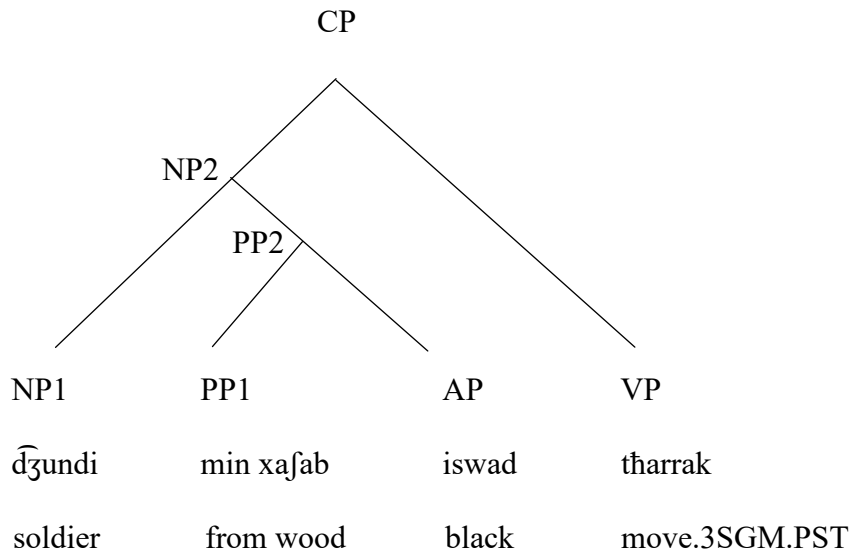
High or low phrase accents are expected to demarcate the final edge of  $\Phi$ 's, as shown in (53c). Assuming a close mirroring of syntax by prosody, they should be realized as F0 movement in XP-final positions. A question can be raised here is: can F0 raising or lowering demarcate the right edges of more complex XPs in a gradient manner, similar to what I predict for final

lengthening? For the time being, there are two theoretically potential ways in which F0 could reflect prosodic recursion: a phrase accent could be more exaggerated at the edges of larger  $\Phi$ 's that match more complex XPs; NP2 and NP3. On the other hand, phrase accents realization could be limited to  $\Phi$ 's projected by minimal or maximal XPs.

In the prosodic representation of the left-branching extra-complex NP in (54b&c), the minimal  $\Phi$ 's that match PP1 and AP are dominated by a larger  $\Phi$  that corresponds to PP2 in the syntactic structure in (54a), and then the entire recursive phrase NP2 projects a maximal  $\Phi$ . Similar to (53b), the entire sentence is contained in an  $\iota$ .

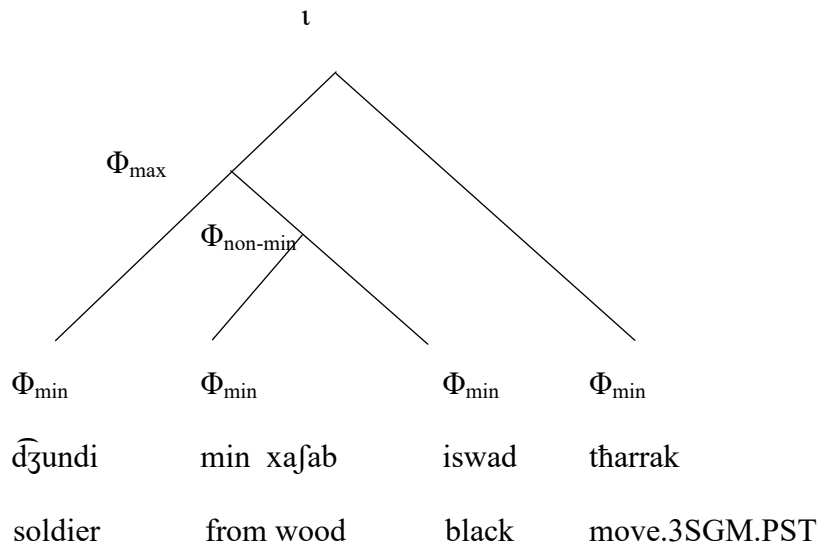
(54) Sentence with left-branching extra-complex XP:

a. Simplified syntactic representation:



'A pawn made of black wood was moved'.

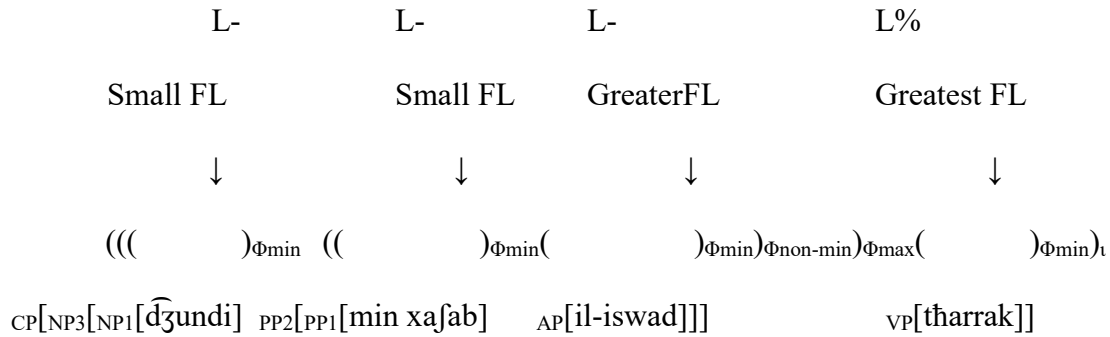
b. Prosodic representation:



'A pawn made of black wood was moved'.

Again, final lengthening is expected at all simple XP-final positions that match the right boundaries of small  $\Phi$ 's, as shown in (54c), but the final syllable of *iswad* in (54a) should be the longest of NP2 since it simultaneously occupies PP2-final and NP2-final positions. There should also be phrase-final accents at the end of  $\Phi$ , but as was discussed for the sentence with a left-branching extra-complex XP in (53), it is unclear if these accents will surface at the end of each XP or only at the end of certain types of XPs.

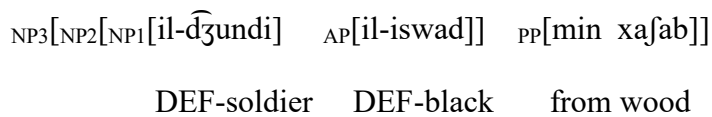
c. Syntactic-prosodic bracketing and expected cues to boundaries:



### §4.2.2 Wordlists and procedures

The goal of this experiment, which is based on a chess game, is to get participants to produce syntactically recursive right-branching and left-branching extra-complex XPs. The collected data is based on the description of chess pieces in terms of colors and materials. In (55a), for example, the AP *il-iswad* directly modifies the NP1 *il- $\widehat{d\bar{z}undi}$*  and the PP *min xaʃab* modifies the NP2 *il- $\widehat{d\bar{z}undi}$  il-iswad*, while both NP2 and PP form a right-branching extra-complex NP, NP3. On the other hand, the AP *iswad* in (55b) modifies the PP1 *min xaʃab*. They form a PP2 which modifies the NP1  *$\widehat{d\bar{z}undi}$* . This forms a left-branching extra-complex NP, NP2.

(55) a. AP and PP modify NP2 independently:



'The black wooden pawn'.



b. PP1 modifies NP2:

NP2[NP1[ $\widehat{d\bar{z}undi}$ ] PP2[PP1[*min xaʃab*] AP[*iswad*]]]

soldier from wood black

'A pawn made of black wood'.

The same 10 male and 10 female speakers who performed the production experiment in Chapter 3 also performed this task. Two speakers participated in each session and sat on opposite sides of a table. Each session was divided into two rounds: the first consisted in gathering utterances containing right-branching NPs and the second in recording utterances with left-branching NPs.

To record right-branching XPs, the experimenter (the author) introduced some chess pieces, made five moves and described his actions orally using full sentences that contained right-branching extra-complex NPs, as shown in (56).

(56) NP3[NP2[NP1[*il-d̄zundi*] AP[*il-iswad*]] PP[*min xaʃab*] VP[*tharrak*]

Soldier black from wood move.PST

'The black wooden pawn moved.'

After the experimenter completed all five moves while the speakers watched his actions, he gave each speaker a cue card on which a move was described using a sentence with a right-branching extra-complex NP. One of the speakers was asked to start the game and perform the first move after reading the cue card. Roles were then reversed. This was repeated few times to make sure that the speakers could produce natural utterances containing right-branching extra-complex

NPs. The speakers were given an opportunity to ask questions or request further instructions about the game, and then the real experiment started. The participants resumed the same round. The round was stopped by the experimenter when each speaker had produced 15 utterances.

In order to record left-branching extra-complex NPs, the experimenter followed the same procedures, but used left-branching NPs: he described his actions using full utterances that contained left-branching extra-complex NPs and distributed two cards contained a recursive NP, as exemplified in (57).

(57) NP<sub>2</sub>[NP<sub>1</sub>[il-dʒundi] PP<sub>2</sub>[PP<sub>1</sub>[min xafab] AP[iswad]]] VP[tharrak]  
DEF-soldier from wood black move.PST step

'The pawn made of black wood was moved.'

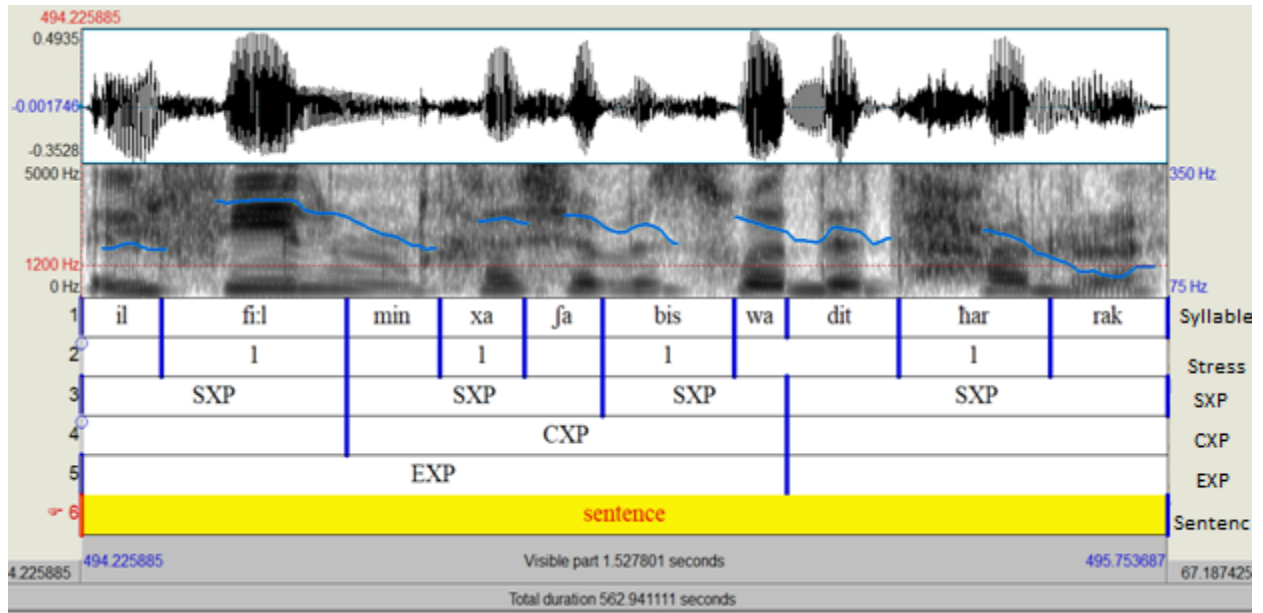
Each session lasted about 30 minutes per pair of participants. Thirty utterances were collected from each speaker: 15 right-branching and 15 left-branching extra-complex NPs (30 utterances X 20 speakers = 600 collected tokens). It is worth noting that each speaker was free to choose any piece and describe his/her action based on the descriptions of the piece he/she picked. The pieces were either black or white and were either made of wood or plastic. The full list of stimuli is given in Appendix 3.

### §4.2.3 Measurements

Six types of information were labeled in Praat textgrids by the researcher. First, target utterances were segmented into syllables based on auditory impression, an inspection of the pitch trace and

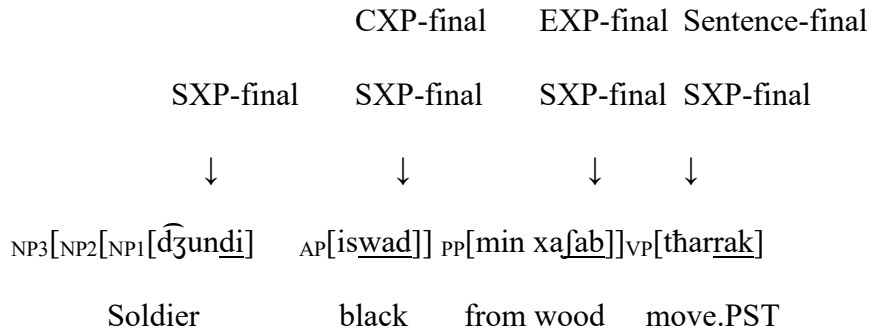
the spectrogram, and were labeled using IPA symbols for Arabic phonemes, as shown in the following figure:

**Figure 6. Aspectrogram and labeled textgrid for a sentence embedding a left-branching extra-complex XP.**



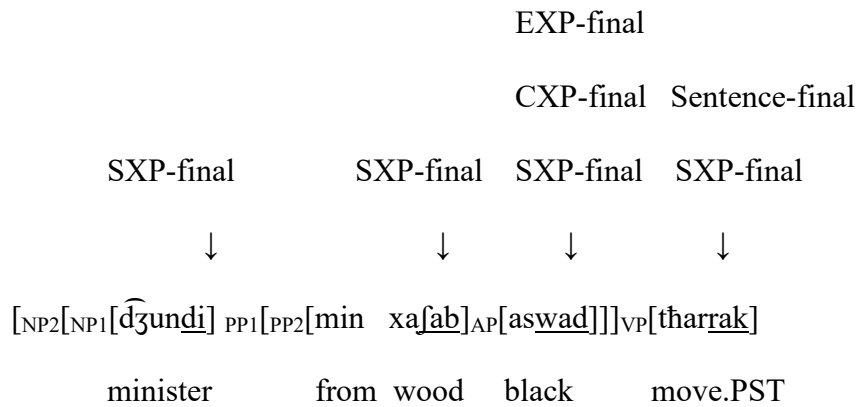
Stressed syllables were marked. Boundaries, as indicated by arrows in (58&59), were labeled at the edges of the target constituents: simple XP (SXP), complex XP (CXP), extra-complex XP (EXP) and sentence. Note that these final edges are not necessarily mutually exclusive, as the edge of a low level XP can also be the edge of a larger XP encompassing it.

(58) Right-branching extra-complex NP:



'A black wooden pawn moved.'

(59) Left-branching extra-complex NP:



'A pawn made of black wood was moved.'

The first acoustic property used to diagnose prosodic boundaries is the duration of syllables in (58&59). In the related literature (e.g. Turk (1999)), it is either the final syllable or its nucleus that is normally measured to determine if a syllable or a vowel gains non-phonemic pre-boundary lengthening. From a physiological perspective, pre-boundary lengthening should influence not only the final vowel, but also the entire syllable since this lengthening is a result of slowing down of articulators when they reach the target position of a sound and return to

their original position before a boundary. In addition, measuring the duration of the entire syllable is more consistent as some vowels in a preboundary position do not seem to show significant lengthening in closed syllables. Therefore, the duration of syllables in final positions are measured.

Significant increments in syllable duration in these final positions, if any, will be interpreted as pre-boundary syllable lengthening. The second acoustic property used as a diagnostic is F0.

Maximum, mean and minimum F0 were measured on each syllable to determine the presence of high or low phrase accents. These acoustic properties were measured automatically with a Praat script.

The statistical significance of the factors of interest was investigated using linear mixed effects models<sup>16</sup>. The dependent variables were mean F0, minimum F0 and maximum F0 and syllable duration. F0 values for all male and female speakers were normalized using z-scores to control for F0 range variation between speakers (and especially between genders). The fixed effects

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<sup>16</sup>The full model structure used in SPSS is:  
DATASET ACTIVATE DataSetX.  
MIXED (Y) BY stress SXPfinal CXPfinal EXPfinal sentencefinal speaker syllable  
/CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)  
HCONVERGE(0,  
ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)  
/FIXED=stress SXPfinal CXPfinal EXPfinal sentencefinal | SSTYPE(3)  
/METHOD=REML  
/PRINT=SOLUTION TESTCOV  
/RANDOM= INTERCEPT sentencefinal | SUBJECT(speaker) COVTYPE(VC)  
/RANDOM= INTERCEPT sentencefinal | SUBJECT(syllable) COVTYPE(VC).  
/SAVE=PRED(XXX\_TotPred).

Collinearity between fixed factors was assessed by dummy coding the categorical variables as ordered gradient values and by measuring their variance inflation factors (VIF) in regressions.

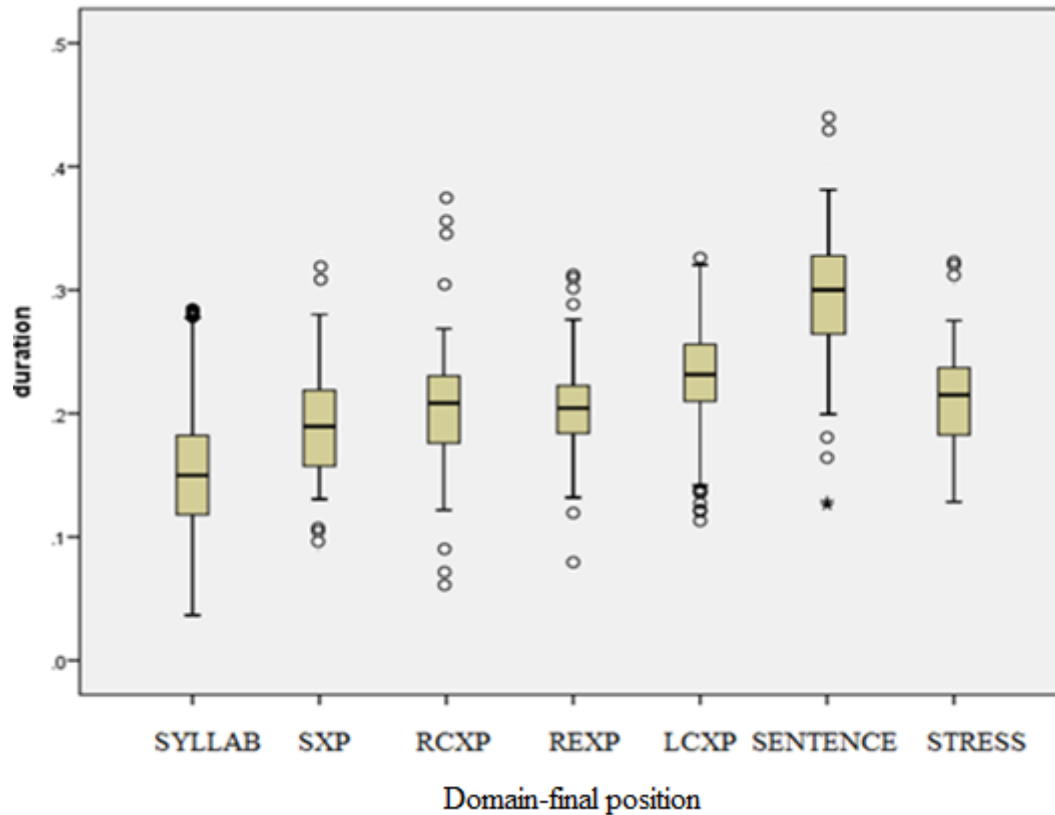
were stress (two levels: stressed and unstressed) and a number of relevant syntactic positions: simple XP, complex XP, extra-complex XP and sentence (each had two levels: final syllable and non-final syllable). Speaker and syllable were specified as random intercepts to control for variation based on speaker and the segmental structure of syllables, respectively. As for pitch tracking errors, they were identified by finding outliers and manually corrected them if needed.

## **§4.2.4 Results**

### **§4.2.4.1 Duration**

Before presenting the results of the fitted model for syllable duration, I am presenting the distribution of duration measurements of syllables in non-final and final positions. Figure 7 indicates that syllables in simple XP-final position (SXP) have a median that is higher than that of syllables that do not appear in any final position (syllab). This seems to indicate that syllables in simple XP-final position are generally longer than syllables in non-final position. It can also be noticed in this figure that syllables in right-branching complex position (RCXP) and left-branching complex XP-final position (LCXP) have greater median duration than syllables in simple XP-final position. Syllables in sentence-final position have the longest duration.

**Figure 7. Boxplot showing the distribution of duration measurements for syllable in final positions.**



The fitted model for syllable duration (Table 9) shows that syllables in simple XP-final position are significantly lengthened by 13ms compared to non-final syllables. In left-branching complex XP-final position, syllables are lengthened by an additional 24ms. It is important to note that right-branching complex XP-final position exhibits a large syllable lengthening (17ms), which almost reaches significance ( $p=.062$ ): if the dataset had been larger, it is very probable that this position would have a significant positive impact on syllable duration. The results also show that right-branching and left-branching extra-complex XP-final positions do not have an impact on syllable duration. The duration of stressed syllables is longer than the duration of unstressed

syllables by a weak but significant 9ms, and the duration of syllables in sentence-final position is significantly lengthened by 96ms.

**Table 9: Estimates of Fixed Effects in a mixed-effects model for syllable duration ( $r^2=0.67$ ).**

**Reference level of the intercept: unstressed, non-final syllables. Estimates are given in msec.**

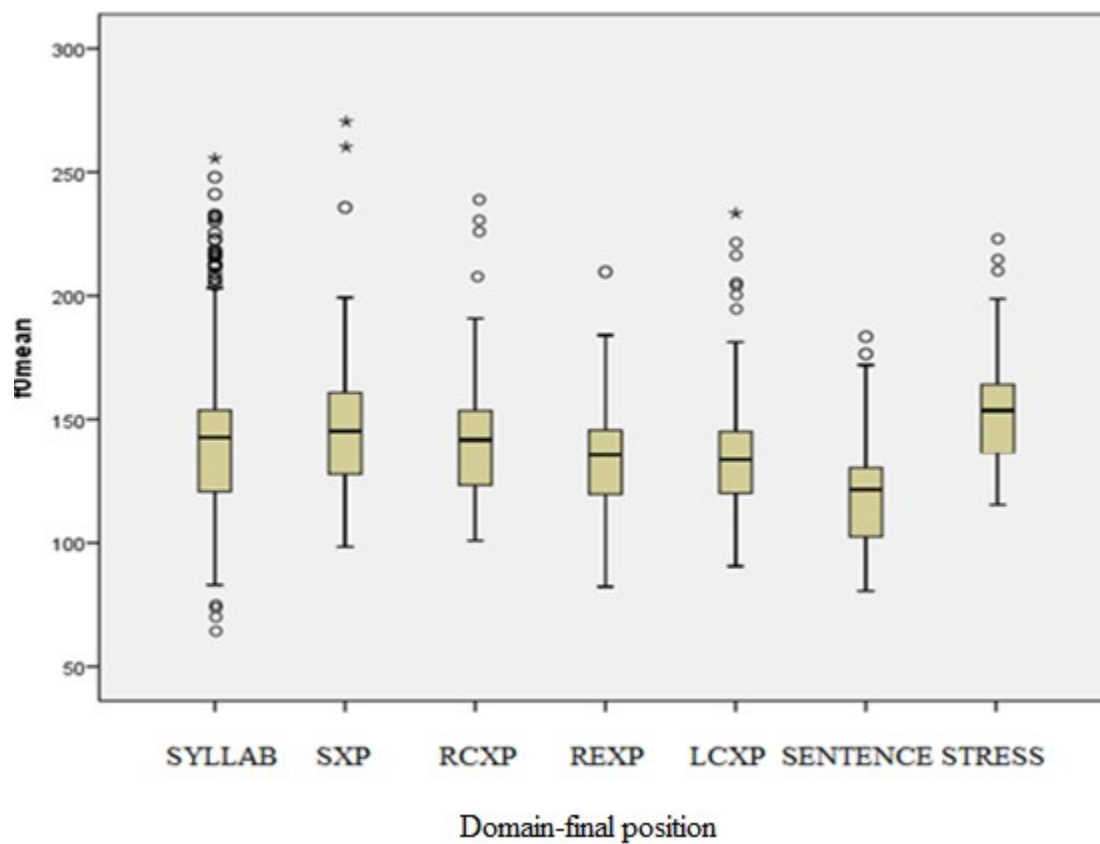
Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	175.839	.007380	93.395	23.828	.000
Stress	9.343	.004116	2138.745	2.270	.023
Simple XP-final	13.144	.005340	2081.152	2.461	.014
Right branching complex XP-final	17.324	.009277	2235.966	1.868	.062
Left branching complex XP-final	23.869	.006375	2324.297	3.744	.000
Right branching extra-complex XP-final	2.541	.009625	2238.644	.264	.792
Left branching extra-complex XP-final	-4.298	.008177	2319.049	-.526	.599
Sentence-final	95.597	.007034	2274.054	13.590	.000

#### §4.2.4.2 Mean F0

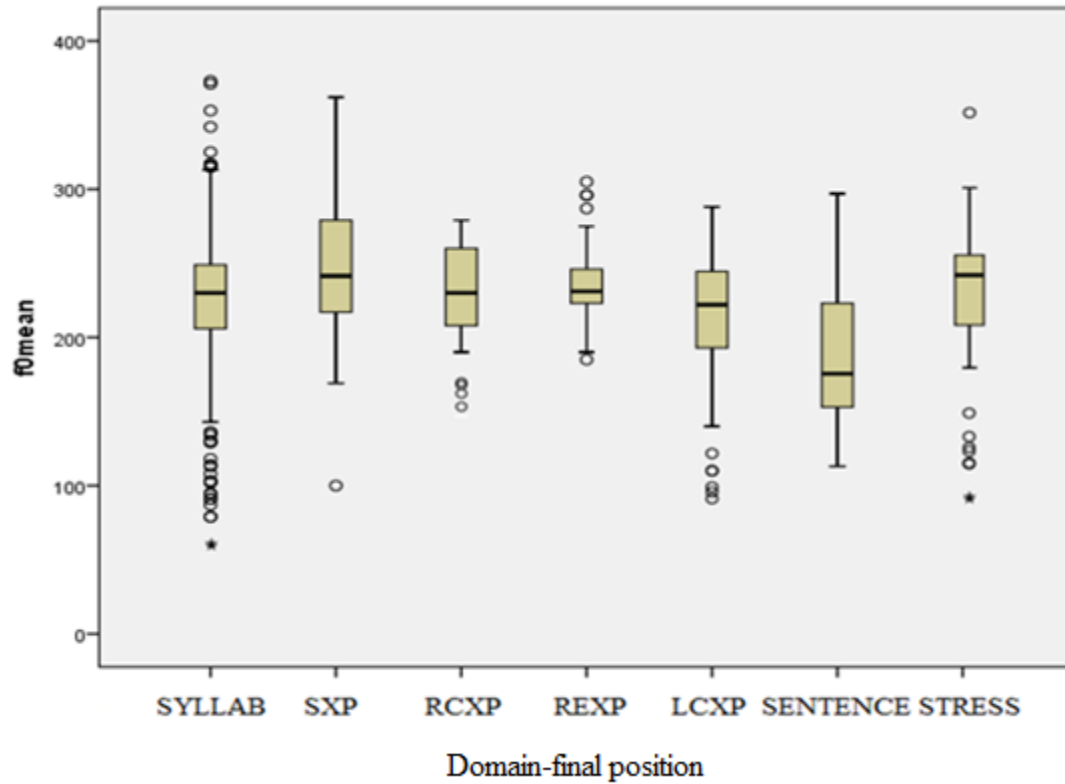
The following two figures show the distribution of mean F0 measurements for syllables in final positions for males and females respectively. They suggest that there are some variations in mean F0 measurements in most final positions. Syllables in sentence-final position obviously have the lowest mean F0 in both figures.



**Figure 8. Boxplot showing the distribution of F0 mean measurements for syllables in final positions for male speakers.**



**Figure 9.** Boxplot showing the distribution of F0 mean measurements for syllables in final positions for female speakers.



The fitted model for mean F0 (Table 10) shows that none of the final positions has a significant effect on mean F0 of syllables. Stress significantly raises mean F0 by .12 SD (standard deviation) and sentence-final position significantly lowers it by .58SD.

**Table 10: Estimates of Fixed Effects in a mixed-effects model for mean F0 ( $r^2=.721$ ).**

**Reference level of the intercept: unstressed, non-final syllables. Estimated are given in standard deviation (SD).**

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Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.228018	.218729	17.462	1.042	.311
Stress	.117664	.043668	397.877	2.695	.007
Simple XP-final	.028374	.055557	409.470	.511	.610
Right branching complex XP-final	-.133528	.116910	2293.365	-1.142	.254
Left branching complex XP-final	-.052026	.075754	1456.841	-.687	.492
Right branching extra-complex XP-final	.114767	.121287	2294.313	.946	.344
Left branching extra-complex XP-final	-.066799	.094830	791.508	-.704	.481
Sentence-final	-.581939	.077102	562.977	-7.548	.000

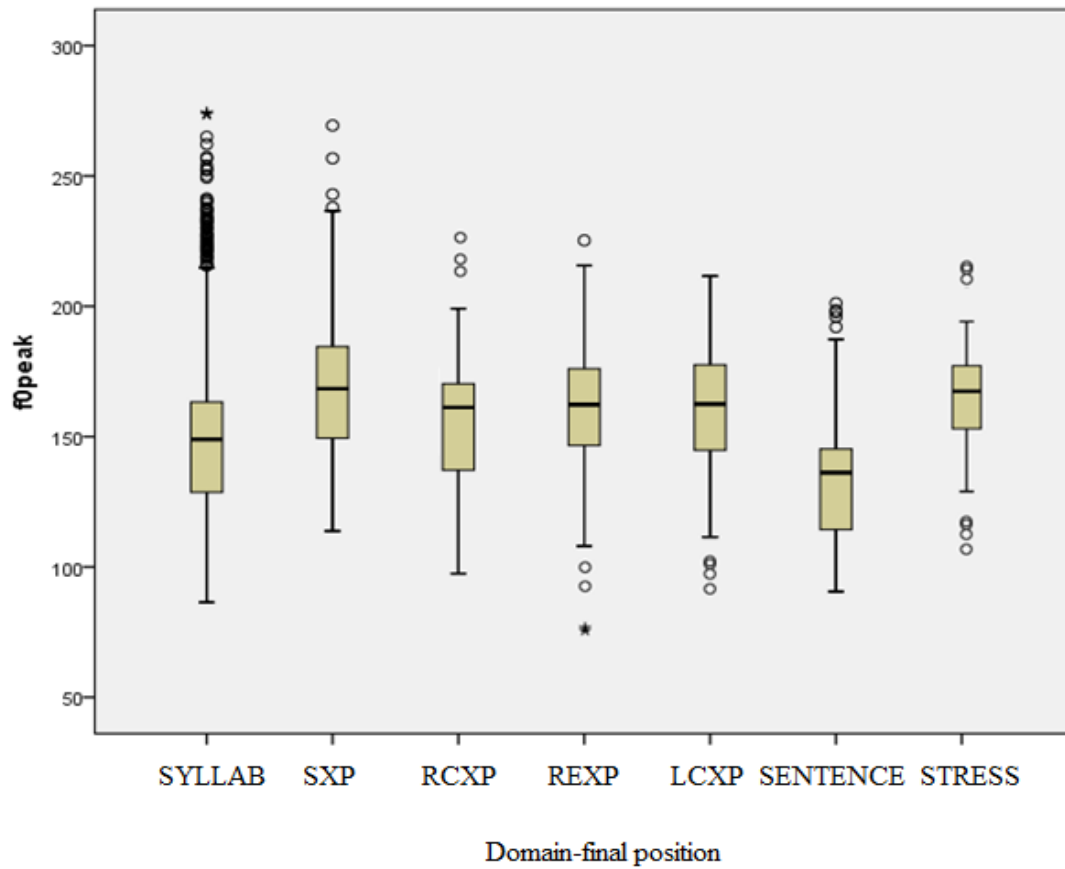
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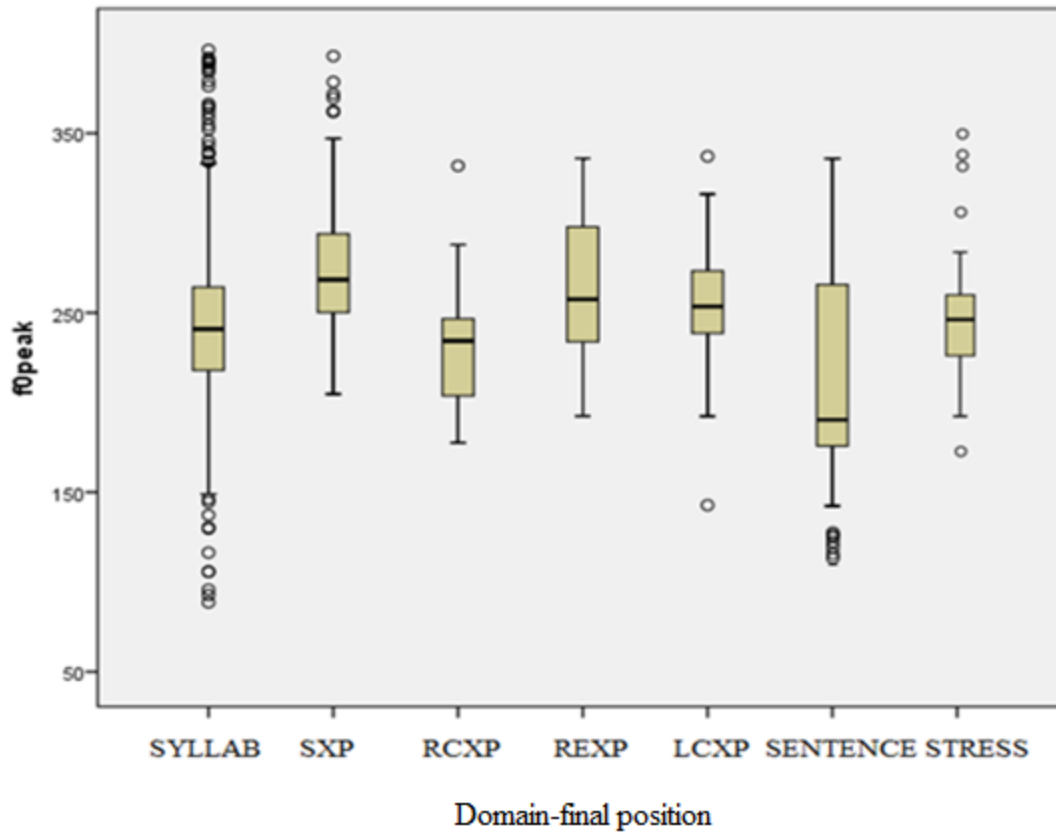
#### **§4.2.4.3 Maximum F0**

As for the distribution of F0 maximum measurements, most syllables in simple XP-final position have higher F0 maxima than syllables that are not in final position in Figure 10 and 11. Maximum F0 is only lower at the end of sentences.

**Figure 10.** Boxplot showing the distribution of F0 maximum measurements for syllables in final positions for male speakers.



**Figure 11.** Boxplot showing the distribution of F0 maximum measurements for syllables in final positions for female speakers.



The fitted model for maximum F0 (Table 11) shows that the maximum F0 over syllables in simple, complex and extra-complex XP-final positions is very similar to the results of the mean F0 in that none of these positions have a significant effect on maximum F0. The maximum F0 of stressed syllables is significantly raised by .2SD and maximum F0 significantly drops by .48SD in sentence-final position.

**Table 11: Estimates of Fixed Effects in a mixed-effects model for F0 maximum (r2=.638).**

**Reference level of the intercept: unstressed, non-final syllables. Estimates are given in SD.**

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Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.132868	.201264	18.400	.660	.517
Stress	.196978	.050781	524.476	3.879	.000
Simple XP-final	.127230	.065265	505.707	1.949	.052
Right branching complex XP-final	-.192144	.133369	2325.950	-1.441	.150
Left branching complex XP-final	-.056741	.087309	1692.373	-.650	.516
Right branching extra-complex XP-final	.115898	.138344	2326.078	.838	.402
Left branching extra-complex XP-final	-.103095	.110176	1085.968	-.936	.350
Sentence-final	-.481732	.089889	711.534	-5.359	.000

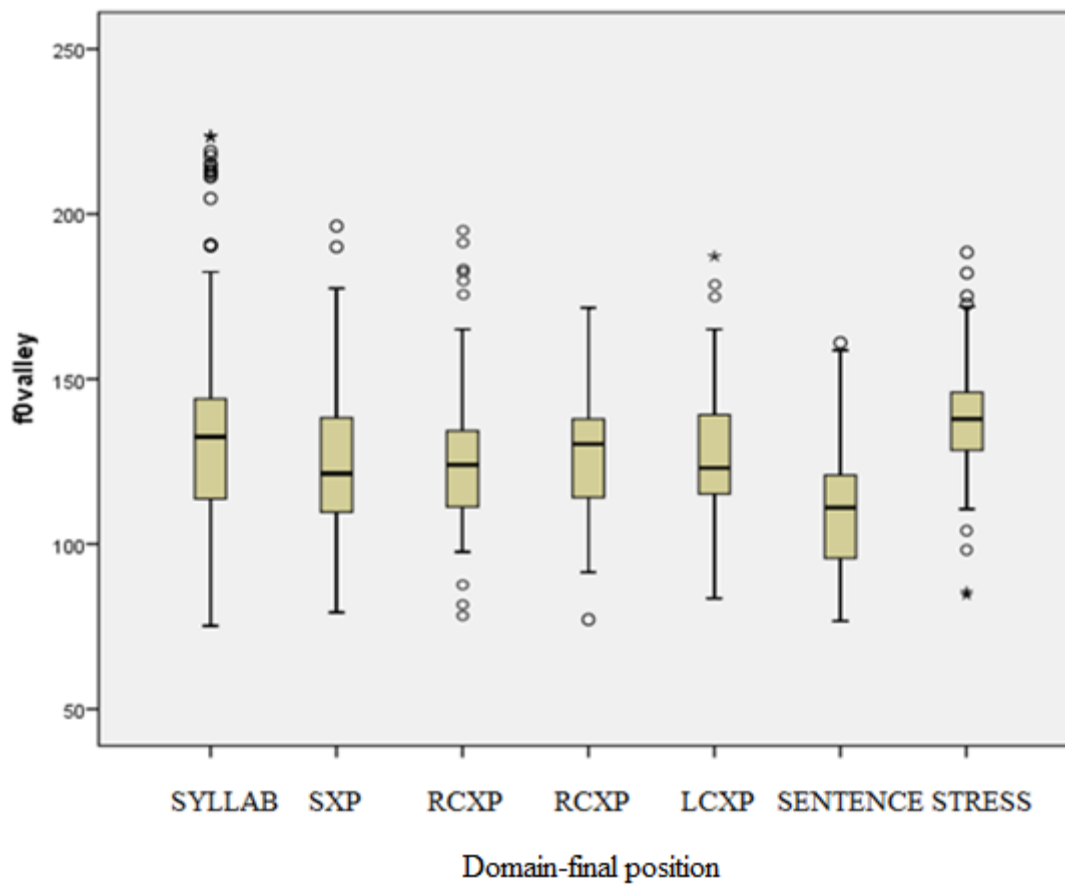
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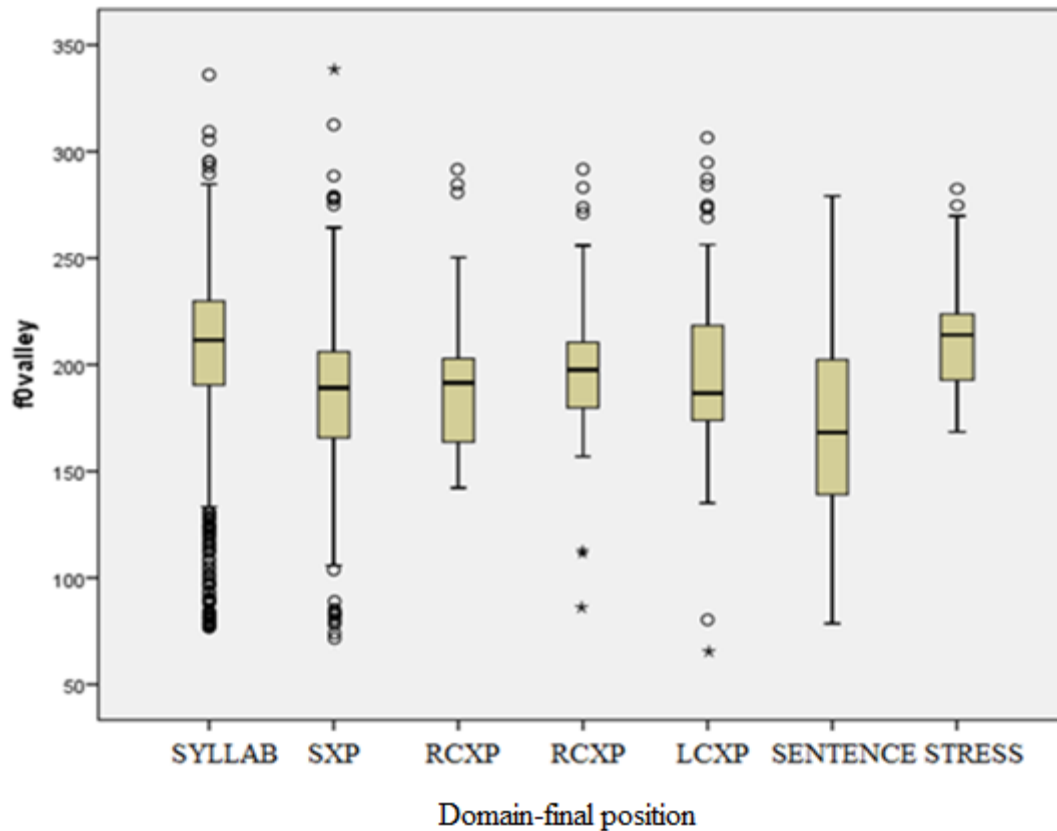
#### **§4.2.4.4 Minimum F0**

In the following two figures, the minimum F0 of syllables that appear in non-final position have a higher F0 than the values of syllables in final positions, and syllables in sentence-final position tend to have the lowest F0 minimum.

**Figure 12** Boxplot showing the distribution of F0 minimum measurements for syllables in final positions for male speakers.



**Figure 13** Boxplot showing the distribution of F0 minimum measurements for syllables at final positions for female speakers.



The fitted model for minimum F0 (Table 12) shows that the minimum F0 of syllables in simple XP-final position is significantly lowered by .2SD. There is also a drop of .37SD in sentence-final position. None of the complex and extra-complex XP-final positions has a significant effect on minimum F0. Stress does not either.



**Table 12: Estimates of Fixed Effects in a mixed-effects model for F0 minimum**

( $r^2=.438$ ). Reference level of the intercept: unstressed, non-final syllables. Estimates are given in SD.

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.228873	.152518	26.057	1.501	.145
Stress	.023481	.068741	1306.351	.342	.733
Simple XP-final	-.203024	.088647	1226.921	-2.290	.022
Right branching complex XP-final	-.118450	.167455	2307.537	-.707	.479
Left branching complex XP-final	.009236	.112291	2223.283	.082	.934
Right branching extra-complex XP-final	.169099	.173717	2309.204	.973	.330
Left branching extra-complex XP-final	.033255	.143630	2107.689	.232	.817
Sentence-final	-.373540	.119783	1616.306	-3.118	.002

#### §4.2.4.5 Summary and interpretation of the results

The results of the experiment first show that syllable duration increases in the final position of simple XPs (the lowest syntactic level). Syllable duration further increases in left-branching complex XP-final position, and it has been noted in the results that the right-branching complex XP-final position shows a non-significant, but similarly large effect (which would most probably have a significant impact given a larger dataset). On the other hand, left-branching and right-branching extra-complex XP-final positions do not have an effect on syllable duration.

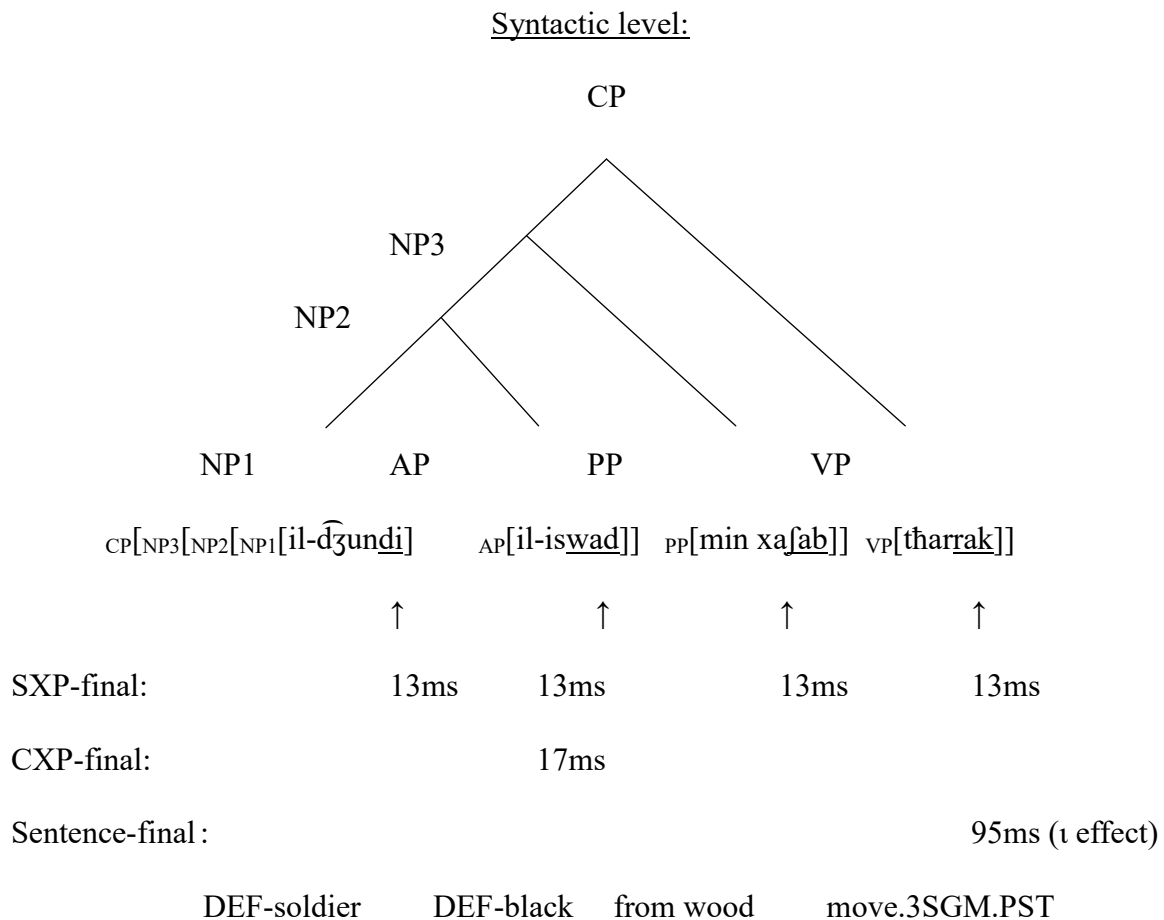
Expectedly, it is in sentence-final position that syllables gain the greatest amount of lengthening.

These results indicate that pre-boundary syllable lengthening is, to a certain extent, a gradient

marker: syllables in simple XP-final position are lengthened, and an even greater amount of lengthening is found in syllables at the right edges of complex XPs. However, this does not extend to extra-complex XPs, suggesting that only two levels of recursion are possible. These results are summarized in (60).

(60) a. A sentence with an iterative extra-complex NP:

Simplified syntactic representation:

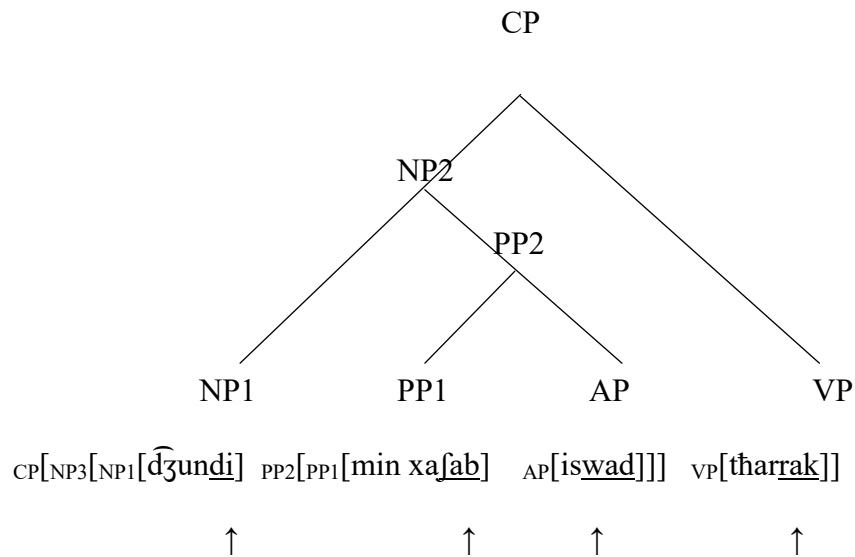


'The black wooden pawn was moved'.

c. A sentence with a recursive extra-complex NP:

Simplified syntactic representation:

Syntactic level:



	↑	↑	↑	↑
SXP-final:	13ms	13ms	13ms	13ms
CXP-final:	24ms			
Sentence-final:	95ms (1 effect)			
	soldier	from wood	black	move.3SGM.PST

'A pawn made of black wood was moved'.

The results also show that minimum F0 is lowered at the right edges of simple XPs. This suggests the presence of a low phrase accent (L-) at the end of  $\Phi$ 's corresponding to simple XPs. A further lowering of mean F0, maximum F0 and minimum F0 in sentence-final position also suggests the presence of a low boundary tone (L%) in this position. Finally, syllables are

lengthened and have higher mean F0 and maximum F0 when they are stressed, suggesting that they receive H\* pitch-accents.

Finally, collinearity between fixed factors was assessed by dummy coding the categorical variables as ordered gradient values and by measuring their variance inflation factors (VIF) in regressions. The VIF were all below 2, suggesting low collinearity (as a rule of thumb, collinearity is considered significant from 5 and problematic from 10).

#### **§4.2.5 Discussion**

Earlier in this chapter, I have hypothesized that  $\Phi$ 's match XPs and are marked by phrase accents and pre-boundary syllable lengthening. Given the assumption of a strong match between syntax and prosody, one would expect a type of  $\Phi$ -recursion in which final lengthening and phrase accents are cumulative so that they are more conspicuous in more complex XPs that match higher  $\Phi$ 's.

The results of the experiment indicate, partially consistent with my hypothesis, that final lengthening is gradient, but limited to two levels of  $\Phi$ -recursion. Syllables in simple XP-final position are lengthened and those in complex XP-final position gain further lengthening, but no further lengthening is found in extra-complex XP-final position. This suggests that there is a maximal limit to the number of levels in the recursive  $\Phi$ : the first level contains minimal/minor  $\Phi$ 's that match simple XPs and the larger/maximal  $\Phi$ 's of the second level match complex XPs, but there is no motivation to posit a third level projected by extra-complex XPs.

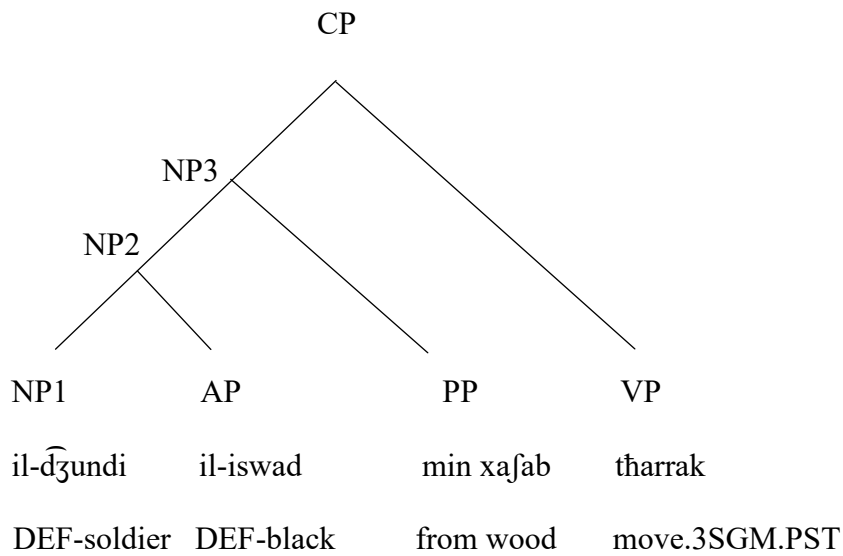
The F0 results indicate that phrase accents are assigned to  $\Phi$ 's, but that this type of phonological unit does not reflect syntactic nesting: F0 minimum lowering has been found only in simple XP-final position, and this means that each simple XP matches a minimal  $\Phi$  and is marked by L-accent. No further lowering has been observed in complex and extra-complex XP-final positions. Thus, phrase accents are not realized cumulatively at the right edges of larger XPs.

Why is lengthening recursive, but not L- tones? In Chapter 5, I will show that the  $\iota$  is also a two-level recursive prosodic domain in IA, and that major  $\iota$ 's are cued by sentence-final lowering (L%) boundary tones that are a bit lower than phrasal tones. If L- phrase accents were emphasized at boundaries of maximal  $\Phi$ 's, it would be difficult to distinguish them from L% boundary tones of maximal  $\iota$ 's. Thus, phrasal tones may fail to indicate recursion for strictly functional reasons.

The prosodic representations of sentences containing right-branching and left-branching extra-complex XPs and their cues can be formalized as in 61 and 62. In (61b and 62b), I show the bottom-up representations of the right and left-branching extra-complex XPs, and in (61c and 62c), the syntactic-prosodic bracketing for these XPs is provided.

(61) A sentence embedding right-branching extra-complex XP:

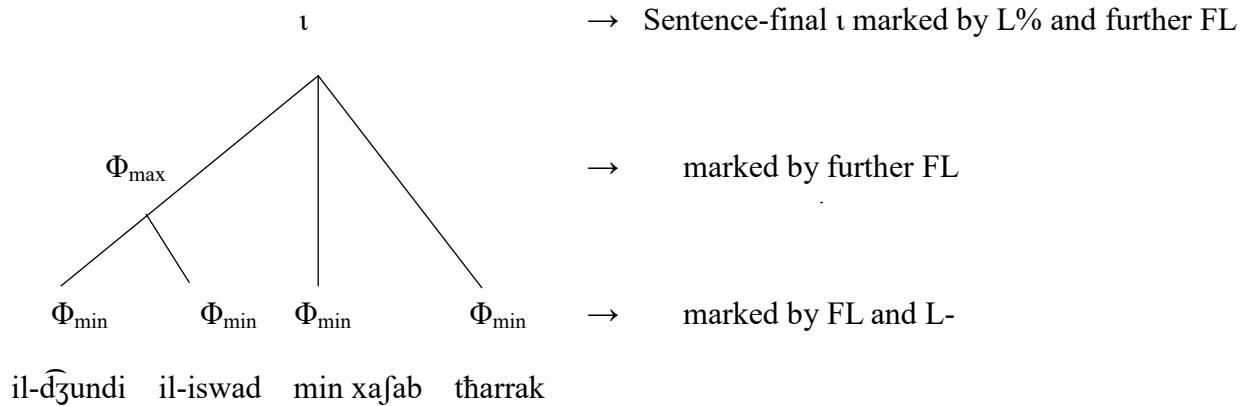
a. Simplified bottom-up syntactic representation:



'The black wooden pawn was moved'.

b. Bottom-up prosodic representation:

Cues:





c. Syntactic and prosodic bracketing:

$$(( \quad )_{\Phi_{\min}} \quad (( \quad )_{\Phi_{\min}} ( \quad )_{\Phi_{\min}} )_{\Phi_{\max}} ( \quad )_{\Phi_{\min}} )_{\iota}$$

CP<sub>[NP3[NP1[ $\widehat{d\ddot{z}}$ undi]]</sub>

PP2<sub>[PP1[ $\text{min xa} \int \text{ab}$ ]]</sub>

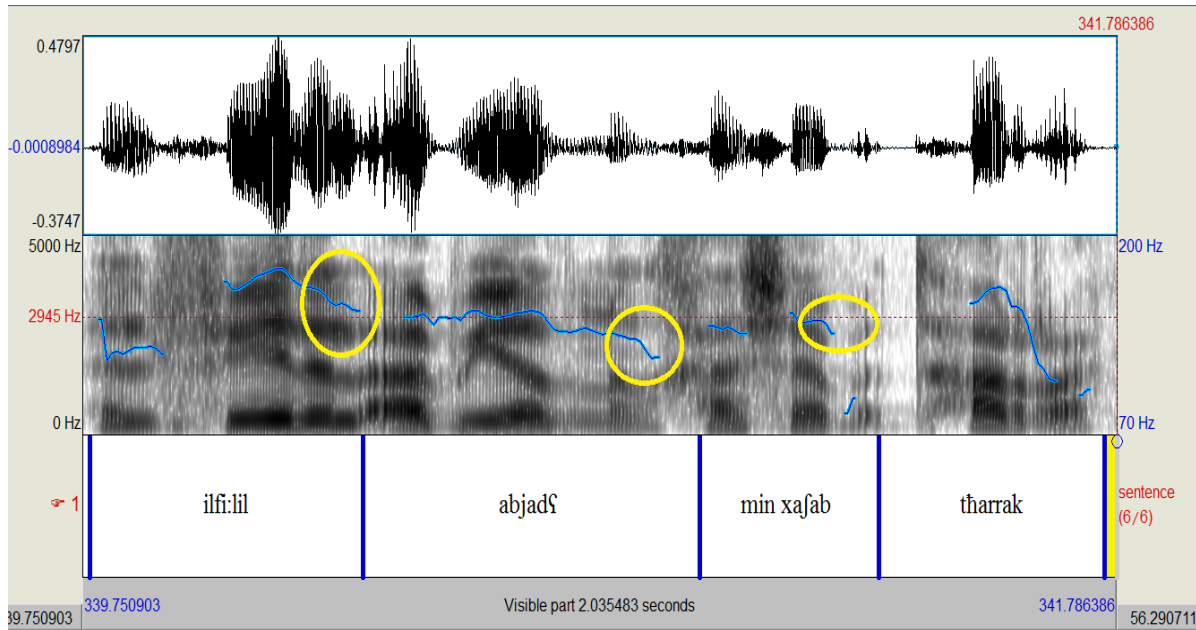
AP<sub>[ $\text{il-iswad}$ ]]]</sub>

VP<sub>[ $\text{tharrak}$ ]]</sub>

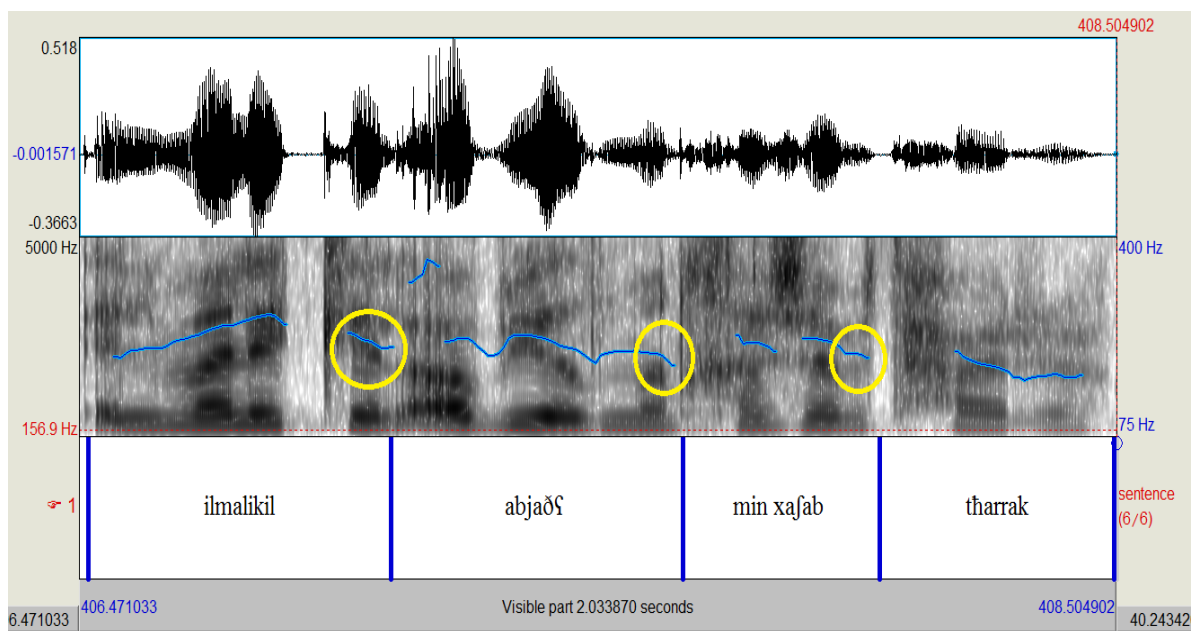
In a nutshell, the results of the experiment indicate that minimal  $\Phi$ 's match simple/small XPs and are marked by final lengthening and L- accents. In right-branching extra-complex XPs (Figure 14&15) and in left-branching extra-complex XPs (Figure 16&17), for example, L- accents are assigned by IA phonology to all minimal  $\Phi$ 's and final lengthening, which is treated as a diagnostic of  $\Phi$ -recursion, reflects a maximum of two levels of syntactic embedding: minimal  $\Phi$ 's are mapped from simple XPs and maximal  $\Phi$ 's are mapped from the next level of XP recursion. Therefore, prosodic recursion is not only found at the  $\omega$  level in IA, but also at the  $\Phi$  level. Up to this point, recursive prosodic domains are maximally binary. In the next section, I address the structure of the  $\iota$  in IA.



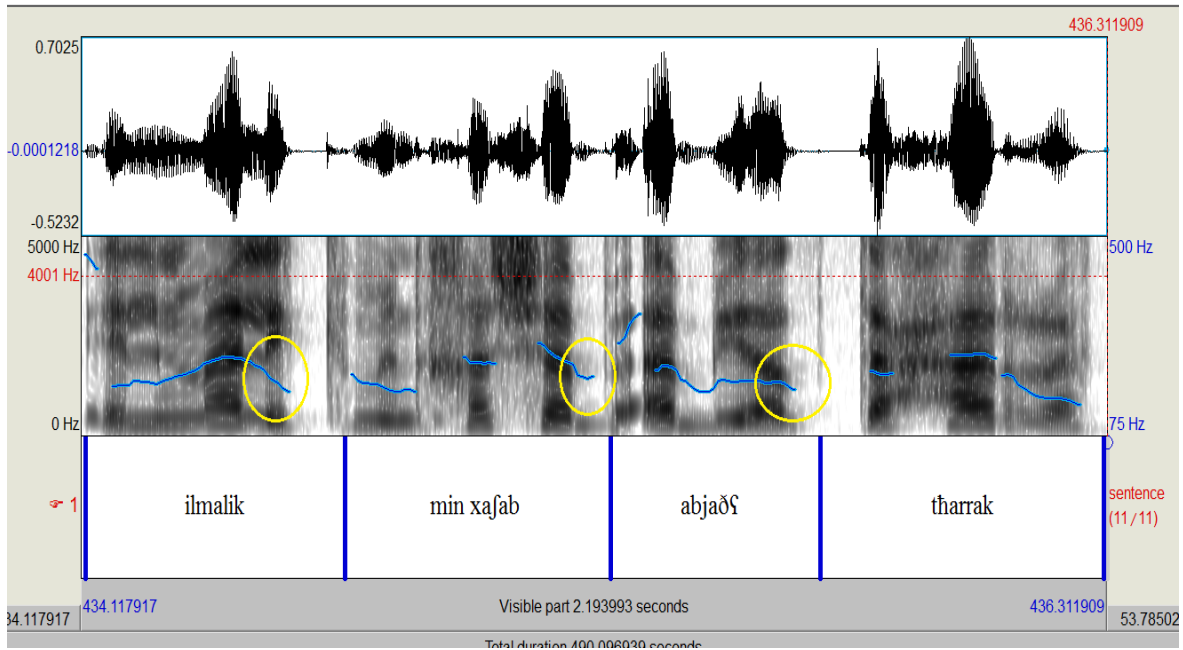
**Figure 14** L- phrase accents in the final position of each simple XP and L% tone in sentence-final position in a right-branching sentence  $NP_3[NP_2[NP_1[ilfi:l]] AP[ilabjad\text{ʕ}]] PP[min xafab]] VP[tharrak]$  'The black wooden bishop moved.'



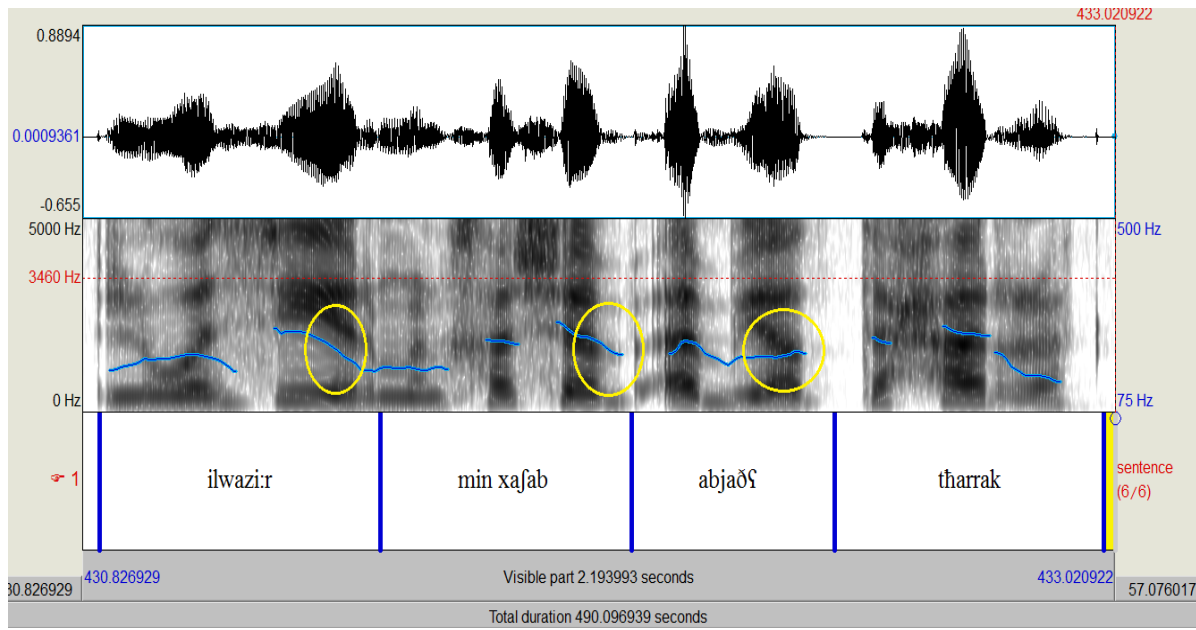
**Figure 15** L- phrase accents in the final position of each simple XP and L% tone in sentence-final position a right branching sentence  $NP_3[NP_2[NP_1[ilmalik] AP[ilabja\delta\zeta]] PP[min xafab]] VP[tharrak]$  'A black wooden king moved.'



**Figure 16** L- phrase accents in the final position of each simple XP and L% tone in sentence-final position in a left-branching sentence [NP2[NP1[ilmalik] PP1[PP2[min xafab] AP[abjaðŋ]]] VP[tharrak]‘The kingmade from white wood was moved.’.



**Figure 17** L- phrase accents in the final position of each simple XP, and L% tone in sentence-final position in a left-branching sentence [NP2[NP1[ilwzi:r] PP1[PP2[min xafab] AP[abjaðŋ]]] VP[tharrak]‘The queen made from white wood was moved.’.



## **§5 The intonational phrase in Irbid Arabic**

In this chapter, I will address the formation of  $\iota$  in IA. I will examine the mapping of syntactic clauses to  $\iota$ 's and look for two types of evidence to  $\iota$  boundaries: segmental and suprasegmental properties. In the previous two chapters, recursion has been proposed in the  $\omega$  and  $\Phi$  and has been shown to be limited to two prosodic layers: minor and major. Here, I will determine if  $\iota$  recursion is necessary and whether it mirrors all the layers of syntactic embedding or, similar to the recursive  $\omega$  and  $\Phi$ , it is limited to two prosodic layers.

### **§5.1 Intonational phrase: syntactic-prosodic mapping and evidence from Arabic dialects**

Cross-linguistically,  $\iota$ 's, as discussed in § 1.2, match matrix clauses, relative clauses, appositives, conditional clauses and parentheticals (Nespor & Vogel 1986, Truckendrodt 1995, Potts 2005, Selkirk 2006, Dehé 2009, Selkirk 2011 among others).  $\iota$  has been studied in Egyptian Arabic (EA) (Chahal and Hellmuth 2014), Lebanese Arabic (LA) (Chahal 2001) and Jordanian Arabic as spoken in Amman (AA) (Yasin 2012). In all these dialects, it normally matches a clause.

The  $\iota$  can be the domain of segmental phonological processes. Interactions between consonants and vowels at the contact point of two words have been investigated in a number of languages and it has been found that intervening prosodic boundaries can block or weaken post-lexical consonantal assimilation (Kuzla 2003, Campos-Astorkiza 2013) and hiatus resolution (Baltazani 2006, Kainada 2007). In Arabic, the prosodic conditioning of consonants clusters at word edges has gained some attention in EA: the failure of *i*-epenthesis as a strategy to repair consonant

clusters at word edges has been reported as a segmental diagnostic to  $\iota$  boundaries (Hellmuth 2004, Yasin 2012). In § 5.2, I will discuss a segmental phonological process of IA, the resolution of vowel hiatus, which I argue to be a diagnostic to  $\iota$  boundaries.

Although some segmental processes can be traced to  $\iota$ , attention has mostly been dedicated to its suprasegmental cues.  $\iota$ 's are normally marked by right boundary tones (high or low), pre-boundary lengthening (Pierrehumbert 1986, Selkirk 2011) and other cues such as  $F_0$  reset and blocking of downstepping at the left of a new  $\iota$  (Féry & Truckenbrodt 2005). In Arabic, pre-boundary lengthening and boundary tones have been reported as marking the right edges of  $\iota$  in EA, AA and LA (Yasin 2012, Chahal and Hellmuth 2014). In these studies, final lengthening has also been presented as a cue to boundaries of different strengths. In § 5.3, I explore suprasegmental cues to  $\iota$  boundaries in IA. Building on the results of the previous chapter on pre-boundary lengthening at the  $\Phi$  level, I focus on nested relative clauses and propose that syllables are further lengthened at the right edges of  $\iota$ 's. I also propose that boundary tones are realized in these positions.

Another important topic that will be tackled in §5.3 is prosodic recursion. As seen in previous chapters, the mirroring of syntactic nesting by prosodic recursion is a controversial topic in the literature on the syntax-prosody interface. Prosodic recursion has been proposed in a number of languages, such as English, Japanese and German (Wagner 2005, Itô & Mester 2007, Féry & Schubö 2010 among others). For example, recursive  $\iota$ 's are mapped from coordinate structures in German (Féry & Truckenbrodt 2005). Féry and Truckenbrodt (2005) reported that recursive  $\iota$ 's

are cued by two types of F0/pitch accent reset: partial reset at the left edge of small  $\iota$ 's and full reset at the left edge of the larger  $\iota$  which dominates the small ones. As far as I know, recursion at the  $\iota$  level has never been investigated in Arabic. My goal is to determine if recursive  $\iota$ 's are projected by nested relative clauses in IA and if this reflects syntactic embedding.

## **§5.2 Segmental evidence: an experiment on vowel hiatus resolution**

Post-lexical interactions can be conditioned by prosodic boundaries. This conditioning can have a categorical effect when interactions are blocked by inserting a prosodic boundary of a certain strength between two target words. For example, the results of the experiment on coarticulation of pharyngealization in § 3.3 indicate that the spreading of the pharyngeal feature from one word to an adjacent word is blocked when they form two different  $\omega$ 's. On the other hand, different prosodic domains can show gradient resistance to post-lexical alternations. Resistance to vowel-to-vowel co-articulation in English (Cho 2004) and vowel hiatus resolution by deletion at word edges in Greek (Baltazani 2006), for instance, are greater around  $\iota$  boundaries than around  $\Phi$  boundaries. In this section, I present a vowel reduction process that prevents the formation of vowel hiatuses in IA. I show that this process is conditioned by prosodic boundaries and determine whether its application is categorical or gradient.

Let us start with a basic description of hiatus resolution. Unlike *Al-'Arabiyya Al-Fusha*, IA normally does not tolerate diphthongs or hiatuses:





In IA, possible vowel hiatuses at edges of adjacent words are mostly limited to short vowels, as long vowels in word peripheral positions are rare in Colloquial Jordanian Arabic in general. This is largely because underlyingly long vowels appear short in word-final position, e.g. *bad-na* ‘want-1PL’ *bad.na:-f* ‘want-1PL-NEG’. However, there are cases of long vowels in word-initial position in words like *(ʔ)i:d* ‘hand’, *(ʔ)a:leh* ‘machine’, *(ʔ)o:kil* ‘eat.1SG.PRES’. Long vowels do not delete or reduce in this position. In (65), for example, the long *a:* at the left of *a:d̤zi* resists deletion or reduction.

A vowel also resists deletion if it is the only segment of a suffix. For example, the suffix *-u* in *bad.d-u* in (65) cannot be deleted. One exception is the suffix *-i* that can be deleted even if it is a person-marking affix, as in (66).

(65) *bad.d-u*            *a:d̤zi*  
 Want-3SGM            come.1SG.PRES

‘He wants me to come.’

(66) *bad.d-i*            *a:d̤zi:b* → *bad.daḍ̤zi:b*  
 Want-1SGM            bring.1SGM

‘I want to bring’.

For these reasons, only short vowels that do not constitute their own morphemes are under examination here.

### §5.2.1 Hypotheses

Following the discussion above, I hypothesize that IA speakers delete one of the short non-morphemic vowels (an exception is the suffix *-i*, that can be deleted for unknown reasons) at the contact point of two adjacent words to resolve vowel hiatus. However, based on informal observations, I also hypothesize that they resist deletion at the contact point of two clauses. In (67a), for example, no vowel is deleted at the contact point of the two clauses of the conditional sentence. The same should happen in (67b), where NP and VP are separated by a parenthetical *ismafi* which is external to the host sentence.

(67) a. *Conditional clause*                      *main clause*

CP<sub>1</sub>[ið̩a id̩ʒa]

CP<sub>2</sub>[imfi]

If come.3SGM.PST

walk.2SGM

‘If he comes, you can leave.’

b. CP<sub>1</sub>[NP[il-ra:dju]<sub>CP<sub>2</sub>[ismafi-i]</sub> VP[[ftayal]]

DEF-radio

listen.2SG-F.

work.3SGM.PST

‘The radio, listen, has started working again.’

If clause boundaries really block hiatus resolution, this could be explained within a syntactic-prosodic account: vowels would resist reduction next to an  $\iota$  boundary that matches a clause edge, as shown in (68a&b).

(68) a. (            ) $\iota$                     (            ) $\iota$   
           iða iḍʒa                        iṃʃi  
           If come.3SGM.PST    walk.2SGM

b. (            ) $\iota$  (            ) $\iota$             (            ) $\iota$   
           il-ra:dju    ismaʃi            ʃtayał  
           DEF-radio    listen            work.3SGM.PST

I begin with the hypothesis that resistance to vowel deletion is motivated by  $\iota$  boundaries at clauses edges, and that vowels surrounding  $\Phi$  boundaries at XPs edges, such as those in (69), do not resist reduction.

(69) (            ) $\Phi$                     (            ) $\Phi$   
           NP[ʃantitha]                    VP[in-sargat]  
           Bag-REF.SG3M            CAUS-stolen  
           ‘Her bag was stolen.’

The experiment presented below has been conducted to examine these hypotheses.

### **§5.2.2 Wordlists and procedures**

To test the hypotheses that have just been set, 19 sentences containing short vowels hiatuses at word edges have been composed (see Appendix 2). Vowel pairs at word edges are: *u-i*, *e-i*, *a-i*, *i-i*, *e-a*, *a-a*, *i-a*. Six sentences constitute the first wordlist and contain hiatuses at XPs edges (11 cases of hiatus). A PowerPoint presentation was presented to every participant, and the same 10 male and 10 female speakers who performed the other tasks in this dissertation read the six target sentences on the slides four times. The participants spoke in colloquial IA at a normal rate of speech. A total of 880 potential vowel hiatuses were recorded in this first part of the experiment.

The remaining 13 sentences (the second wordlist) are complex sentences, i.e. six conditionals and seven parentheticals. Each sentence contains one case of hiatus at the contact point of two clauses. In parentheticals such as in (68b), the rest of the stimuli only have vowel hiatus at the left edge. I did not find vowels at the contact point of the right of a parenthetical and the rest of the sentence. Parentheticals, I assume, form their own *ɪ*'s in IA, and finding segmental evidence (i.e. the blockage of vowel hiatus reduction) to *ɪ* boundaries at the left of parentheticals entails the existence of *ɪ* boundaries also at the right of these constituents.

Another four male and four female speakers were recruited and read these 13 sentences in six sessions. Again, the researcher presented every participant with a PowerPoint presentation that contained the target sentences and the participants spoke naturally in colloquial IA. Each

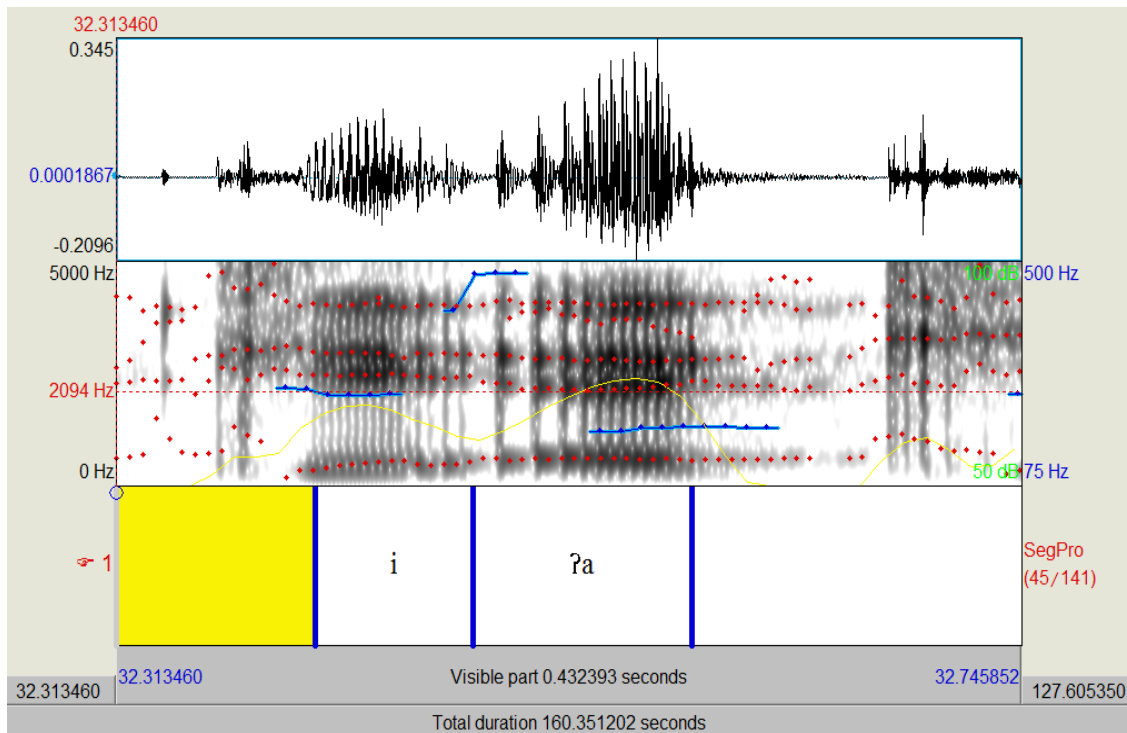
participant read the slides five times. The total number of possible vowel hiatuses recorded in this second part of the experiment is 520.

### **§5.2.3 Data analysis**

Target vowels were segmented based on inspection of spectrograms and waveforms. To determine whether vowels at XPs and clause edges were resolved by deletion or not, the following procedures were adopted. First, tokens that contained full pauses at the contact point of two words were excluded since this environment necessarily prevents vowel deletion. In the absence of a pause, the presence of an intervening period of glottalization was taken as evidence that vowels at word edges were preserved. A second type of evidence against deletion is changes in vowel formants. Both criteria are illustrated in Figure 18: (a) There is a period of glottalization between the vowels *i* and *a*, (b) The F1 of the vowel *i* is about 100 Hz lower than the F1 of the vowel *a*, and the F2 of the vowel *i* is at least 300Hz higher than the F2 of the vowel *a*.

**Figure18** Vowel preservation at word edges with an intervening period of glottalization.

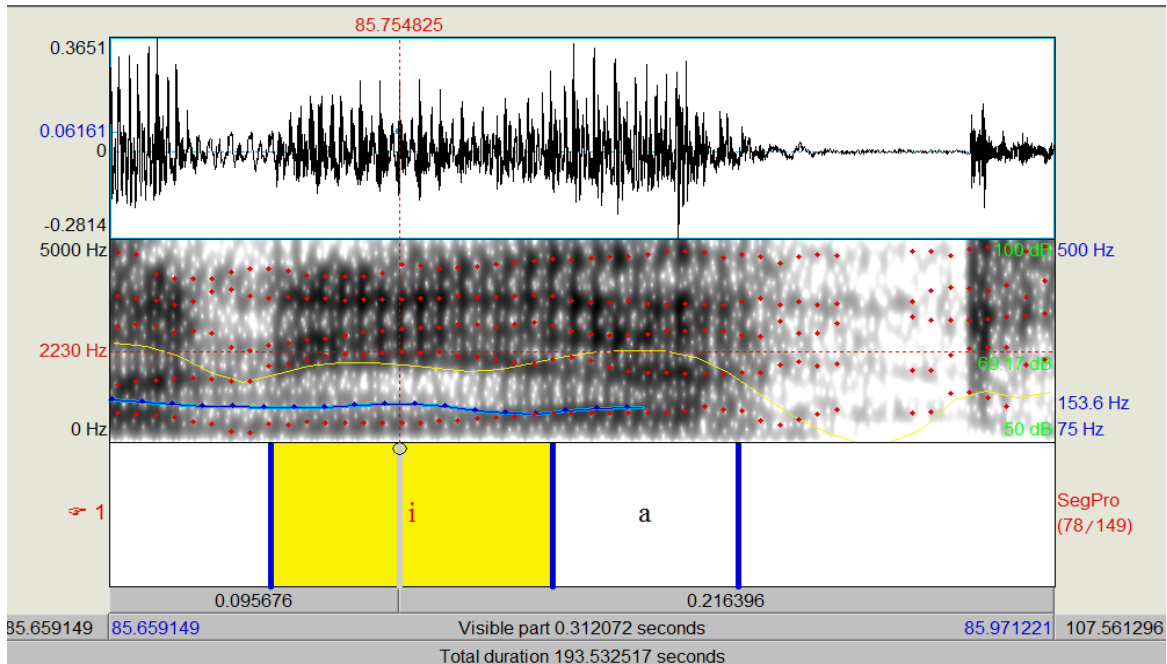
*firkīṭ-kī aḱi:d rah tīnkasīr* (Company-2SGF.REF definitely will break.3SG) ‘Definitely, your company will break down.’



Hiatuses do not necessarily entail glottalization, but in the absence of a period of glottalization, the transitional period at the offset of the first vowel and the onset of the following one is more likely to undergo partial assimilation. Therefore, F1 and F2 values were measured at vowels midpoints to ensure more robust results. In Figure 19, for example, F1 and F2 values at the midpoint of the vowel *a* are around 520 Hz and 1650 Hz. On the other hand, F1 and F2 values at the midpoint of the vowel *i* are around 370 Hz and 2230 Hz.

**Figure 19** Vowel preservation at word edges, without intervening period of glottalization.

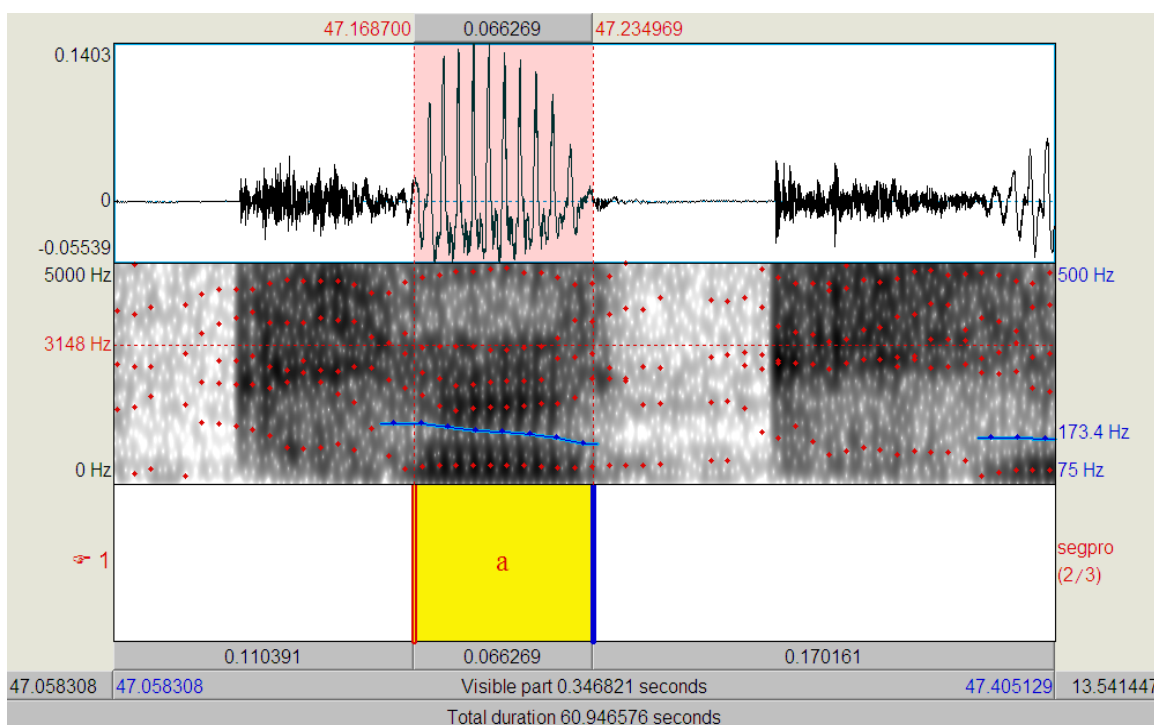
*firkit-ki aki:d rah tinkasir.* (Company-2SGF.REF definitely will break.3SG) ‘Definitely, your company will break down.’



The absence of glottalization and/or changes in formant structures indicates that one of the vowels is deleted. In Figure 20, for example, the vowel *i* of *firkit-ki* is deleted.

**Figure 20** *i*-deletion and *a*-preservation. *firkit-ki aki:d rah tinkasir.* (Company-2SGF.REF

definitely will break.3SG) ‘Definitely, your company will break down.’



## §5.2.4 Results and discussion

Cases of vowels reduction at XP and clause edges were counted. Vowel reduction occurred in 96% of the tokens at XPs edges (708 out of 738 possible hiatuses). Further, as shown in Table 13, we see that individual speakers tend to be consistent.



**Table 13: Vowels at XPs edges but not at clauses edges by speaker (n = 738).**

Speaker	?-epenthesis (4)	Hiatus (30)	Vowel deletion (708)
AH (M)	2	5	32
HA (M)		1	36
BE (M)		1	36
FS (M)			31
GJ (M)		2	28
MT (M)		1	39
LR (M)		2	41
YJ (M)		1	39
HZ (M)			34
NN (M)		1	40
JA (F)		1	30
JK (F)		2	38
AF (F)		1	33
AS (F)			41
SM (F)	1	4	25
SJ (F)	1	4	28
AA (F)		1	42
JK (F)		2	39
SA (F)			38
NM (F)		1	38

On the contrary, vowels reduction at clause edges only occurred in 15% of the tokens (72 out of 477 tokens): 27 times at the left edges of parentheticals and 45 times at conditional clauses edges. Glottal stop epenthesis was inserted 197 times at the left of clauses. In Table 14, the tokens are broken down by speaker. Again, no speaker seems to exhibit a pattern that is categorically different from others.

**Table 14: Vowels at clauses edges by speaker (n =477).**

Speaker	Hiatus	ʔ-epenthesis		Vowel deletion	
		(subset of Hiatus)	Parentheticals	Conditionals	
SN (F)	51	14	6	4	
MM (F)	51	12	2	6	
TN (F)	59	32	2	3	
AA (F)	56	31	1	4	
KA (M)	41	25	6	7	
DH (M)	44	28	5	7	
RT (M)	49	27	3	6	
RA (M)	54	28	2	8	
<b>Total</b>	<b>405</b>	<b>197</b>	<b>27</b>	<b>45</b>	

My original hypothesis is that vowels at the contact point of two adjacent words resist reduction when they are separated by an  $\iota$  boundary that matches the edge of a conditional or a parenthetical clause, but that they are reduced when separated by a  $\Phi$  boundary that matches an XP edge (or by a lower boundary). The results roughly support this hypothesis, but are not categorical: a small number of hiatuses at XPs edges resisted reduction and 15% of tokens at clauses edges were reduced. Thus, hiatus reduction is probably conditioned by prosodic factors, but this conditioning may be indirect: for instance, prosodic constituency may gradiently affect syllable lengthening (we will see in the next section that there is more final lengthening at the end of  $\iota$ 's than at the end of  $\Phi$ 's), which may in turn result in less deletion. However, it is also possible that speaker performance was affected by the reading task and that more spontaneous speech would have resulted in a more categorical pattern.

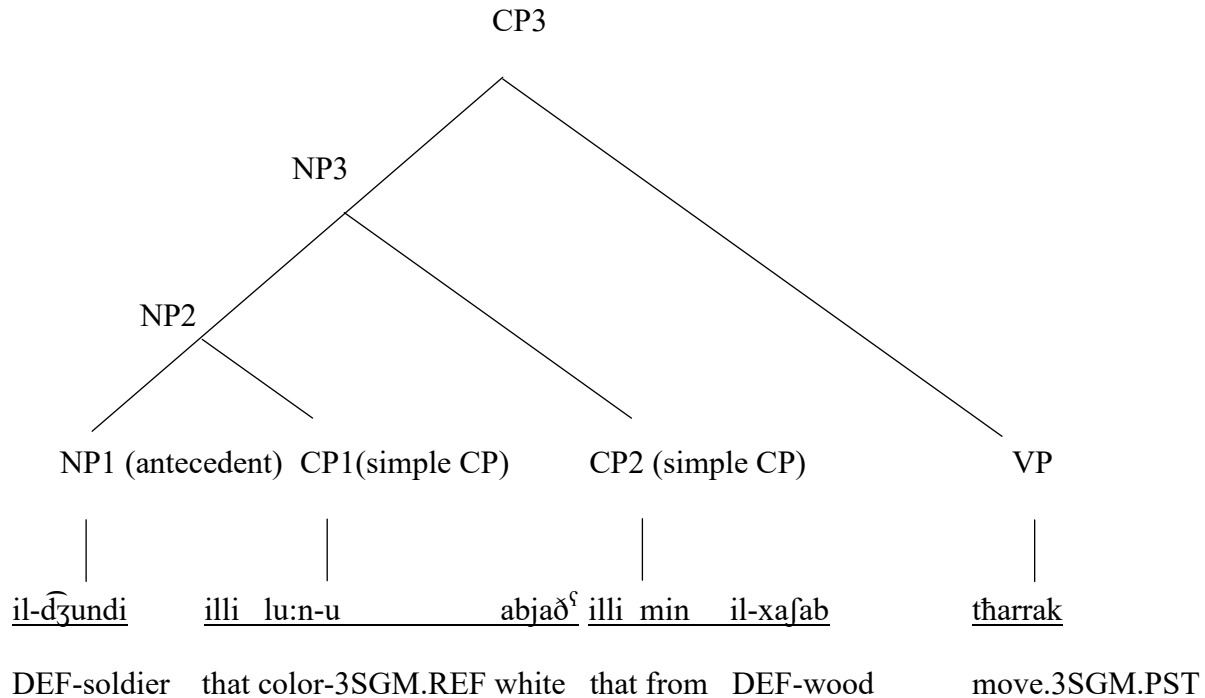
In the next section, I look for suprasegmental evidence to  $\iota$  boundaries in nested relative clauses.

## **§5.3 Suprasegmental evidence and recursion**

### **§5.3.1 Hypotheses**

As in previous sections, my starting hypothesis, following previous work (Selkirk 2009, 2011), is that prosodic boundaries, as marked by intonational and durational properties, reflect syntactic embedding in IA. If this is correct, the maximal CPs in (70&71) are expected to have different prosodic representations. In (70), both relative clauses (CP1 and CP2) directly modify the same antecedent, *il-dʒu.ni*, and on this account, they have a non-recursive (iterative) syntactic relation and NP3 branches to the right side.

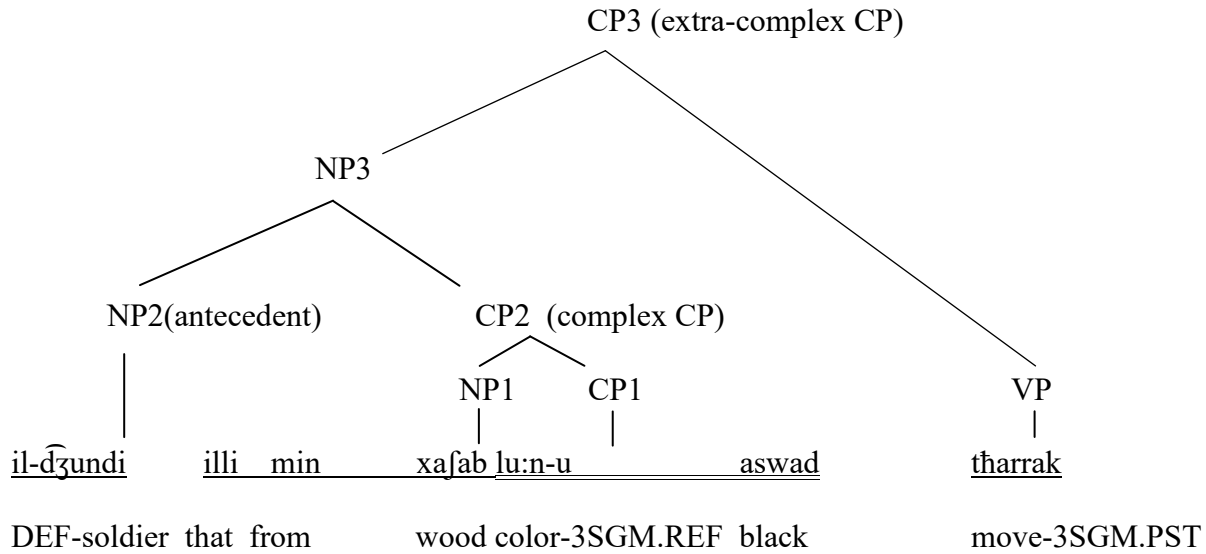
(70) A sentence with a right branching NP (NP3):



‘The pawn that is white and made of wood was moved.’

In contrast to iteration of CP1 and CP2 in (70), recursion entails that one of the two CPs of the relative clauses dominates the other one: in (71), the antecedent of CP1 is *xafab*, which is embedded in CP2. Hence, the complex CP2 dominates CP1, and NP3 branches to the left.

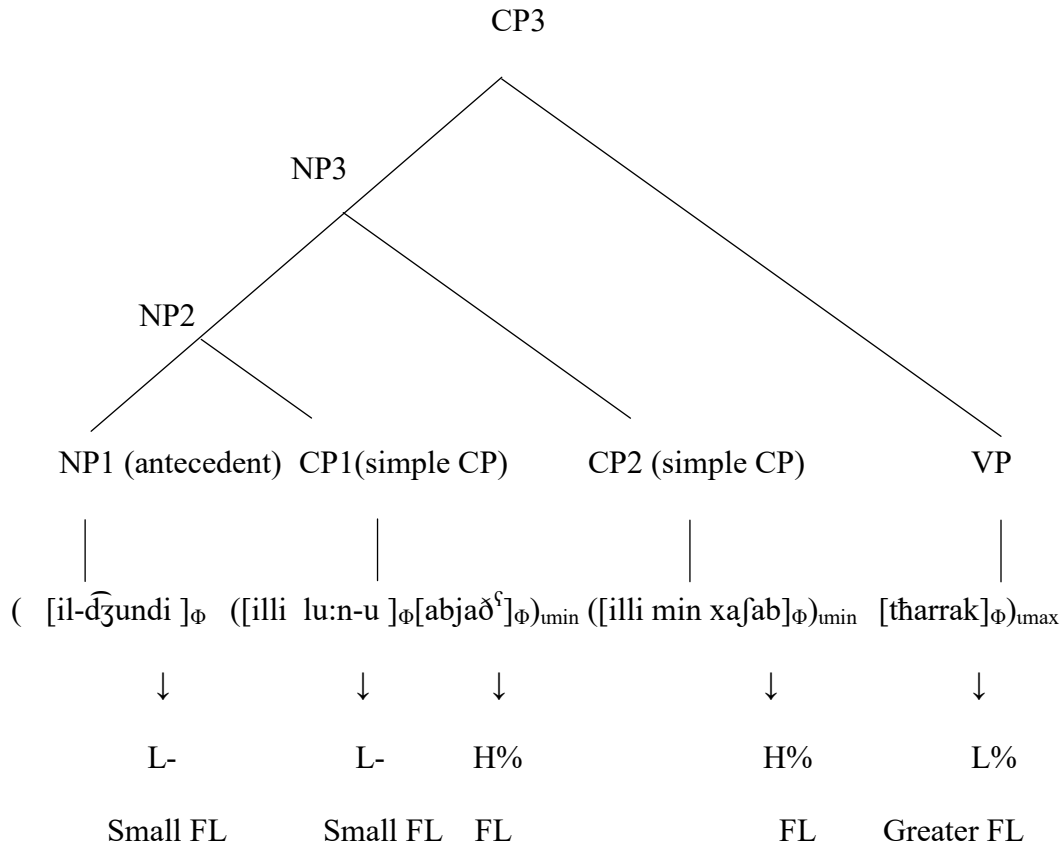
(71) A sentence with a left-branching NP (NP3):



‘The pawn that is made of wood which is black was moved.’

My starting hypothesis predicts that XPs match  $\Phi$ 's and CPs match  $\iota$ 's. Based on the results of the experiment on the  $\Phi$  in § 4.2, I expect NP1 and VP in (70) to match  $\Phi$ 's, as shown in (72): their right boundaries should be marked by a low phrase accent (L-) when they do not match the right boundaries of  $\iota$ 's and by final syllable lengthening. I also expect that CP1 and CP2 in (70) project two minimal  $\iota$ 's and that their final positions are marked by further final lengthening and continuative high boundary tones (H%). Finally, the entire sentence, CP3/complex CP, should match a maximal  $\iota$ , but its right boundary is expected to have F0 lowering, indicating a speech-finality low boundary tone (L%), and the greatest amount of pre-boundary lengthening:

(72) A sentence with a right-branching NP (NP3):



CP3[NP3[NP2[NP1[il-dʒundi]CP1[illi lu:n-u abjaðʕ]] CP2[illi min xaʃab]] VP[θharrak]]

il-dʒundi illi lu:n-u abjaðʕ illi min xaʃab θharrak

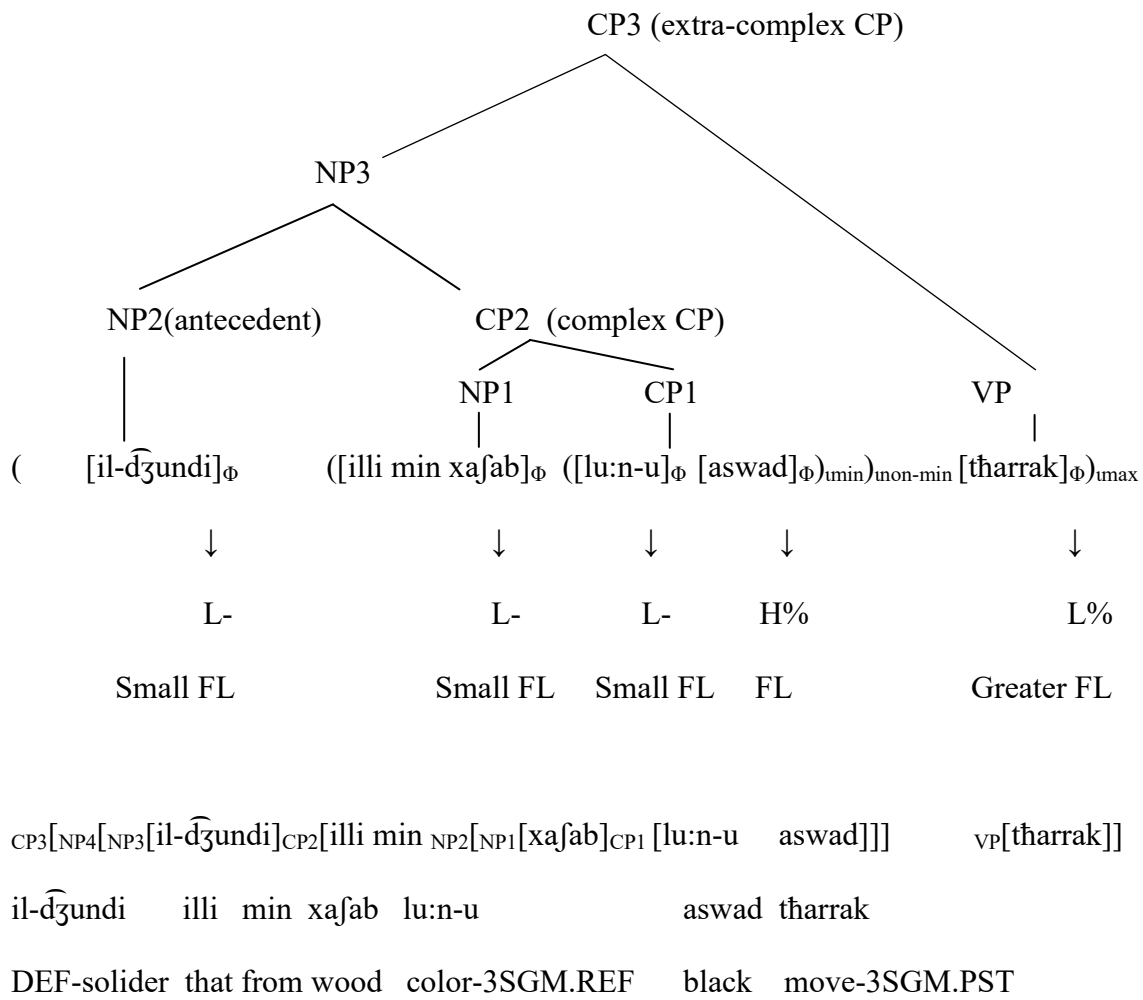
DEF-solider that color-3SGM.REF white that from DEF-wood move.3SGM.PST

‘The pawn that is white and made of wood was moved.’

If these predictions are correct, there will only be two layers of recursion at the  $\iota$  level. It is worth noting that my predictions, because they are as close to syntax as possible, contradict the requirement that each prosodic layer be exhaustive (Selkirk 1996): the  $\Phi$ 's of NP1 and VP skip the minimal  $\iota$  layer and link directly to the maximal  $\iota$ .

In the syntactic tree of the recursively structured relative clauses in (71), CP2 is a complex syntactic projection that embeds CP1, but the two domains have the same right edge. Since the complex CP (CP2) is expected to match an intermediate level of  $\iota$  (non-min), it should have a continuative H% tone and a right  $\iota$ -boundary with a greater amount of syllable lengthening than the minimal  $\iota$ 's in (72). Finally, the entire sentence is contained in an  $\iota$  that matches CP3, the extra-complex CP. Similar to the CP3-final position in (72), an L% tone and the greatest amount of lengthening should be found in CP3-final position.

(73) A sentence with a left-branching (NP) NP3:



‘The pawn that is made of wood which is black was moved.’

Following these lines, only sentences that contain recursively structured relative clauses (left-branching sentences) are expected to project recursive  $\iota$ 's that are composed of three layers.

Again, the prosodic representation in (73) violates exhaustivity: the  $\Phi$ 's of the antecedent and VP are directly associated to the maximal/major  $\iota$ . I also expect that NP1 *xa/ab* (CP1 antecedent) to match a  $\Phi$  and be marked by final lengthening and a low phrase accent.

As mentioned in 1.5, the original plan was to investigate potential cues to prosodic boundaries at both the left and right edges of syntactic constituents. Left edge cues that I intended to investigate included F0 reset and downstep. However, it turned out that IA speakers who participated in the experiments were not consistently using the same cues to mark left edge boundaries (if they used them at all). Furthermore, these cues seemed to be used to mark left edges of different prosodic domains ( $\iota$  or  $\phi$ ), depending on the speaker or on conditions that are still unclear. Experiments specifically designed to test these various factors are needed and I have therefore decided to focus on cues to prosodic boundaries at the right edges of syntactic constituents. In the conclusions, I will provisionally assume that the left edge of prosodic constituents follows the predictions of Match Theory.

### **§5.3.2 Wordlists and procedures**

In § 4.2, I have introduced a chess-based task to collect right-branching and left-branching extra-complex NPs. A similar task was performed by the same speakers an hour later. This time, the goal was to get participants to produce utterances with complex relative clauses: utterances with



right-branching and left-branching NPs. Similar to the previous task, this task was performed in two rounds: the first aimed at gathering utterances containing two relative clauses with a flat syntactic relation (each relative clause directly modifies the external antecedent) and the second at collecting utterances containing two relative clauses with a recursive syntactic relation (CP1 is embedded in CP2 and modifies a CP2-internal antecedent). Both rounds lasted about half an hour.

To record utterances with iteratively nested relative clauses, the experimenter introduced some chess pieces, and then made few moves. These actions were orally described by the experimenter using full sentences embedding right-branching NPs while moving the pieces. After the experimenter completed five moves while the speakers watched his actions, he gave each speaker a cue card on which a move was described using a sentence with right-branching NPs which have iteratively nested relative clauses. Then, one of the speakers was asked to start the game and perform the first move described on the cue card. This was repeated a few times to make sure that the speakers could produce natural utterances. The speakers were given an opportunity to ask questions or request further instructions about the game, and then the real experiment started. The participants then resumed the round, which was stopped by the experimenter when each speaker had produced 15 utterances. In the second round, the experimenter followed the same procedures, but with sentences with left-branching NPs which dominate recursively nested relative clauses. Overall, thirty utterances were collected from each speaker: 15 utterances embedding iteratively structured relative clauses and 15 utterances containing recursively structured relative clauses (30 utterances X 20 speakers = 600 collected tokens) (see Appendix 4).

It is worth noting that in the time between the chess game on extra-complex XPs and those on nested relative clauses, the same speakers performed the two other tasks: the coarticulation of pharyngealization task and the vowel hiatus resolution task discussed in § 3.4 and § 5.2, respectively.

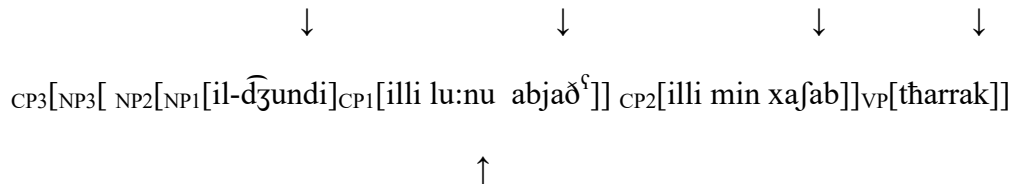
### **§5.3.3 Measurements**

The following types of information were labeled in Praat textgrids by the researcher. Target utterances were segmented into syllables based on auditory impression, an inspection of the pitch trace and the spectrogram, and were labeled using IPA symbols for Arabic phonemes. Stressed syllables were marked. Boundaries, indicated by the upwards and downwards arrows in (74&75), were labeled at the edges of the target constituents. These boundaries are at the right of the following constituents: XPs, XPs that match the right edges of higher syntactic constituents, antecedents and CPs. Examples of the coding system for sentences that have iteratively and recursively structured relative clauses are given in Figure 21 and 22 below:

(74) Sentences that have right-branching NPs with iteratively structured relative clauses:

a. XP-final positions:

XP-final positions that match another syntactic domain edge (XP-final + other final boundary)

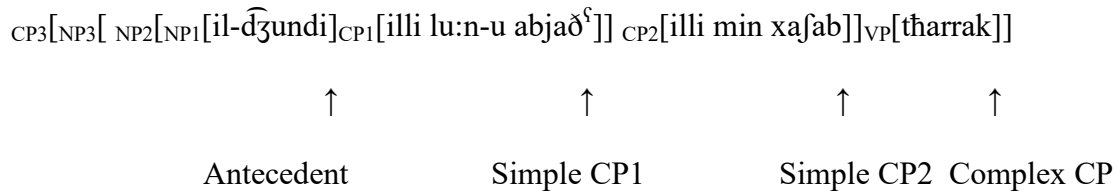


XP-final position that does not match any other syntactic domain edge

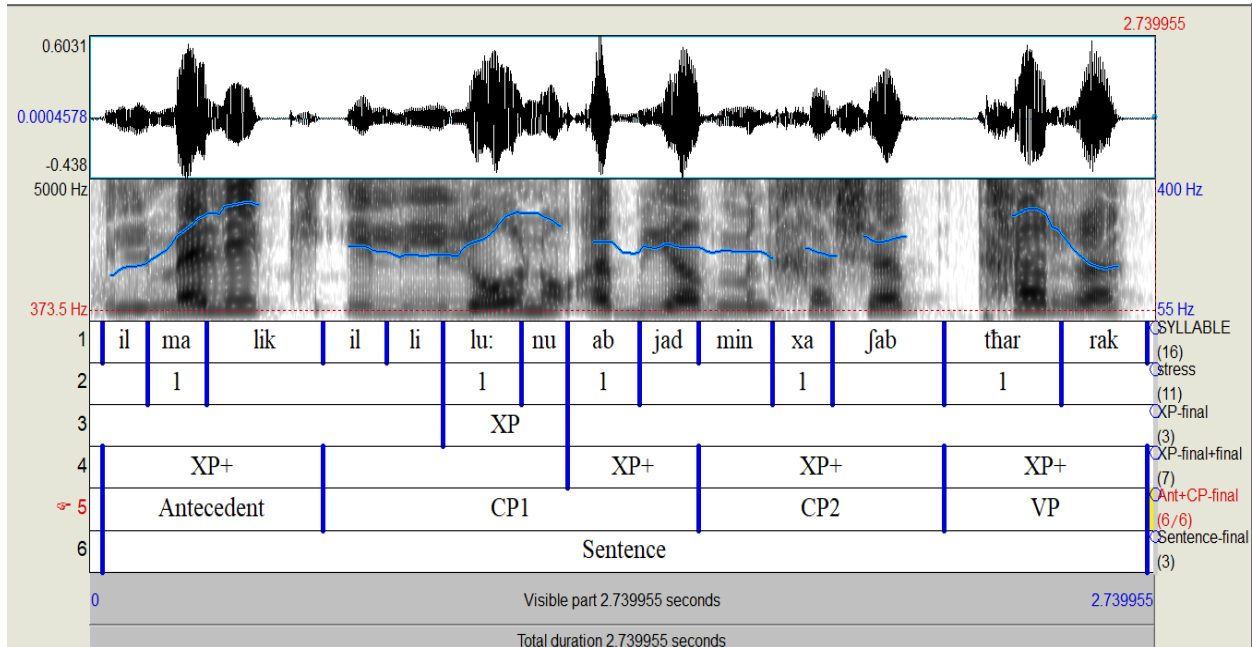
il-ḍʒundi	illi lu:n-u	abjað <sup>s</sup>	illi min xaʃab	tħarrak
DEF-solider	that color-3SGM.REF	white	that from DEF-wood	move.3SGM.PST

‘The pawn that is white and made of wood was moved.’

b. Antecedent and CPs-final positions:



**Figure 21** A spectrogram and labeled textgrid for a sentence with a right-branching NP/iterative relative clauses. *il-malik illi lu:n-u abjad<sup>δ</sup> illi min xafab tharrak* ‘The king that is white and made of wood was moved.’



(75) Sentences that have left-branching NPs with recursively structured relative clauses:

a. XP-final positions:

XP-final that match another syntactic domain edge



CP<sub>3</sub>[NP<sub>4</sub>[NP<sub>3</sub>[il-ḍʒundi]CP<sub>2</sub>[illi min NP<sub>2</sub>[NP<sub>1</sub>[xafab] CP<sub>1</sub>[lu:n-u aswad]]]VP[tharrak]]



XP-final that does not match any other syntactic domain edge

il-ḍʒundi illi min xafab lu:n-u aswad tharrak

DEF-solider that from wood color-3SGM.REF black move-3SGM.PST

‘The pawn that is made of wood which is black was moved.’



automatically with a Praat script.

The effects and statistical significance of the factors of interest were investigated using linear mixed effects models. The dependent variables were mean F0, minimum F0 and maximum F0 and syllable duration. F0 values for all male and female speakers were normalized using z-scores to filter out F0 variation between speakers (and especially between genders). The fixed effects were stress (two levels: stressed and unstressed) and a number of syntactic position listed in (76) (each had two levels: final and non-final). Speaker and syllable were specified as random intercepts to control for variation based on speaker and the segmental structure of syllables, respectively.

(76) a. Syntactic iteration (and levels):

XP-final only (Y/N)

XP-final + other final boundary (Y/N)

Simple CP1-final (Y/N)

Simple CP2-final (Y/N)

Complex CP-final (Y/N)

b. Syntactic recursion:

XP-final only (Y/N)

XP-final + other final boundary (Y/N)

Antecedent-final (Y/N)

CP1 antecedent-final (Y/N)

Complex CP-final (Y/N)

Extra-complex CP-final (Y/N)

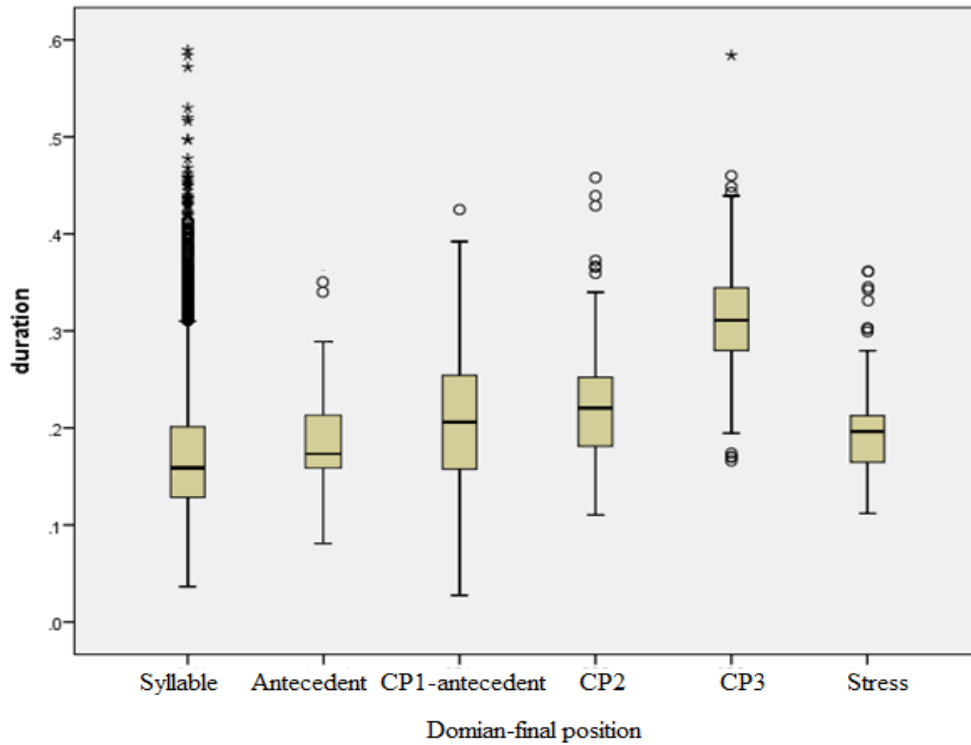
## **§5.3.4 Results**

### **§5.3.4.1 Sentences with iterative relative clauses**

#### **§5.3.4.1.1 Duration**

Similar to the results in Chapter 4, I begin this part by presenting the distribution of syllable duration at final positions. As shown in Figure 23, it can be noticed that syllables in final positions (antecedent-final (antecedent), CP1-final, CP2-final and CP3-final) are longer than syllables in non-final position (syllable). Syllable duration is the longest in sentence-final position (CP3).

**Figure 23. Boxplot showing the distribution of syllable duration in final positions.**



The fitted model for syllable duration (Table 15) indicates that all syntactic constituent-final positions significantly affect syllable duration except XP-final only position. Syllables that are simultaneously in XP-final and CP-final or CP-external position are longer by an estimate of 14 ms. Syllables are lengthened by an additional 18ms, 14ms and 16ms in antecedent-final, simple CP1-final and simple CP2-final positions, respectively. In sentence-final position, i.e. complex CP-final position, syllable duration increases by another 27ms.



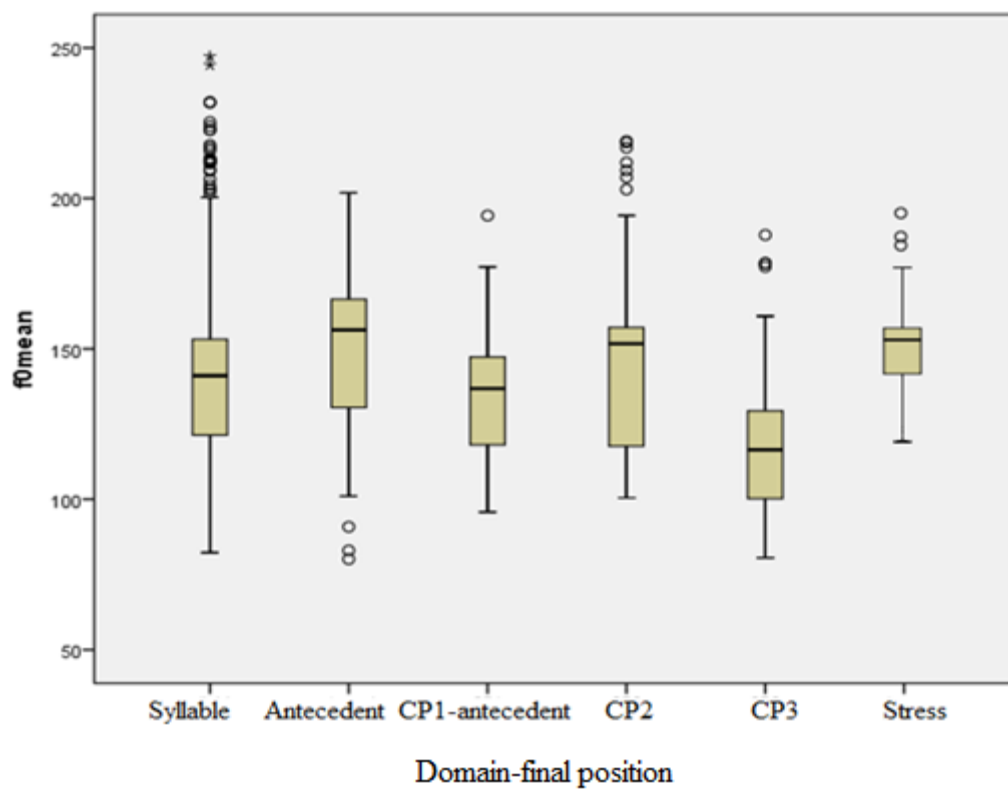
**Table 15: Estimates of fixed effects in a mixed-effects model for duration in iterative sentences. Reference level of the intercept: unstressed, non-final syllables. Estimates are given in ms.  $r^2 = .846$**

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	182.607	.009340	179.988	19.551	.000
XP-final only	-5.184	.015492	3528.806	-.335	.738
XP-final + other final boundary	13.682	.003291	5995.354	4.157	.000
Antecedent-final	17.764	.004919	6050.936	3.611	.000
Simple CP1-final	13.638	.005095	6032.225	2.677	.007
Simple CP2-final	16.285	.004416	6010.230	3.688	.000
Complex CP-final	26.847	.004374	6027.081	6.137	.000
Stress	6.686	.003530	5776.322	1.894	.058

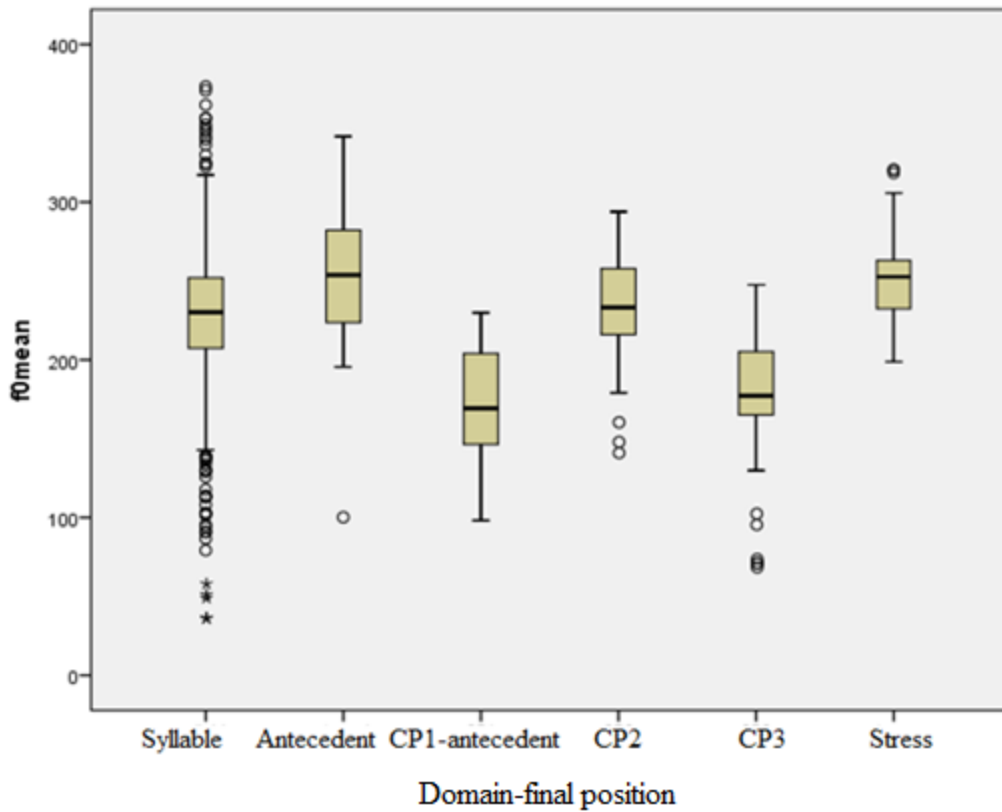
### §5.3.4.1.2 Mean F0

Figure 24 shows the distribution of mean F0 in syllables in final positions for male speakers. The mean F0 of syllables in antecedent-final position and CP2-final position, unlike that of syllables in CP1-final position, is higher than that of syllables in non-final position. In sentence-final position, syllables have the lowest mean F0. As for the mean F0 of females in Figure 25, what can be noticed is that most of syllables in antecedent-final position have the highest mean F0 and that most syllables in CP1-final position have lower values than syllables in non-final position.

**Figure 24.** Boxplot showing the distribution of mean syllable F0 in final positions for male speakers.



**Figure 25.** Boxplot showing the distribution of mean syllable F0 in final positions for female speakers.



The fitted model for mean syllable F0 (Table 16) shows that syllables in XP-final positions that also match the final position of CPs or antecedents have their mean F0 raised by .13SD. In simple CP1-final position, the mean F0 of syllables is lowered by an additional .23 SD, but it is raised by an extra .19 SD in simple CP2-final position. Complex CP-final position lowers mean F0 of syllables by a further .25 SD. Stressed syllables are raised by .10 SD.

**Table 16. Estimates of Fixed Effects in a mixed-effects model for mean F0 in iterative sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

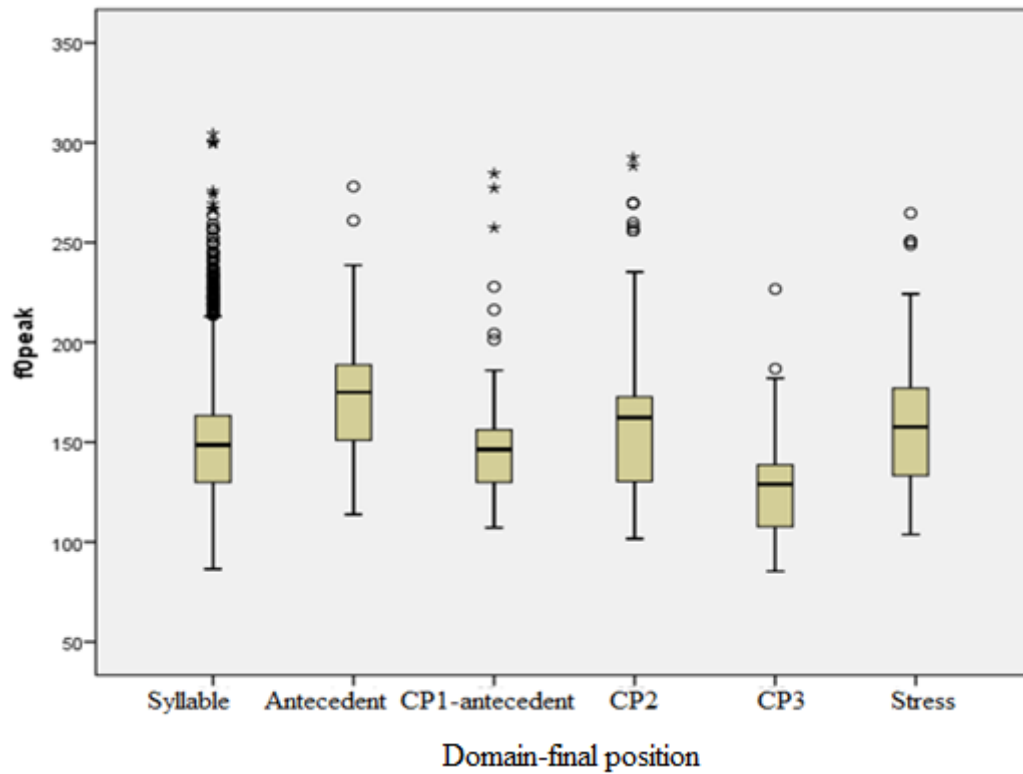
Estimated are given in standard deviations.  $r^2 = .901$ .

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.078989	.252184	14.797	.313	.758
XP-final only	.076903	.138259	1215.393	.556	.578
XP-final + other final boundary	.125685	.031744	4042.646	3.959	.000
Antecedent-final	.083691	.048880	6052.678	1.712	.087
Simple CP1-final	-.229732	.050735	6075.254	-4.528-	.000
Simple CP2-final	.185976	.044123	6070.490	4.215	.000
Complex CP-final	-.250525	.043639	6086.608	-5.741-	.000
Stress	.103730	.033579	3087.024	3.089	.002

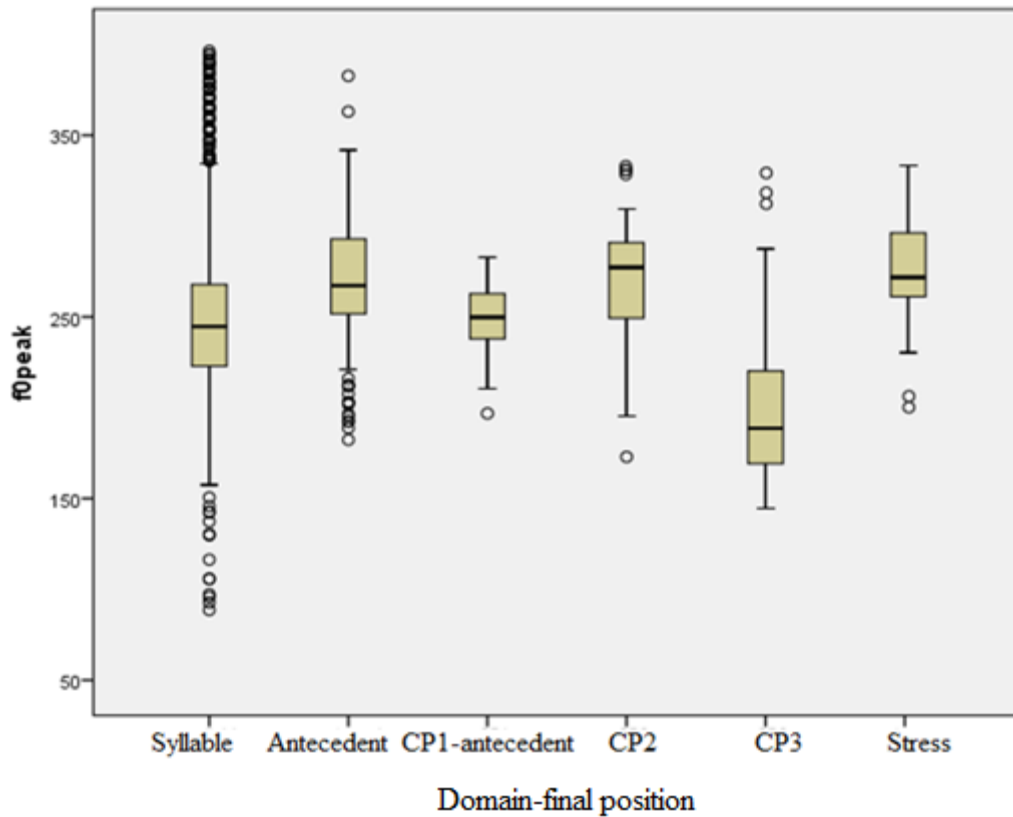
### §5.3.4.1.3 Maximum F0

In Figures 26 and 27, the maximum F0s in antecedent-final position and CP2-final position are generally higher than those of syllables in non-final position. As for syllables in CP1-final position, the majority of syllables have maximum F0 that are close to those of syllables in non-final positions in Figure 26. On the other hand, syllables in CP1-final position in Figure 27 are a bit higher than syllables in non-final position. Syllables in sentence-final position (CP3) have the lowest maximum F0.

**Figure 26.** Boxplot showing the distribution of maximum syllable F0 in final positions for male speakers.



**Figure 27. Boxplot showing the distribution of maximum syllable F0 in final positions for female speakers.**



The fitted model for maximum F0 (Table 17) shows that in a XP-final only position that coincides with another final position maximum F0 is raised by .16 SD. In antecedent-final and simple CP2-final positions, maximum F0 is respectively raised by an additional .16 SD and .13 SD. Complex CP-final positions lower mean F0 of syllables by an extra .19 SD. The maximum F0 of stressed syllables is raised by .16 SD.

**Table 17: Estimates of Fixed Effects in a mixed-effects model for maximum F0 in iterative sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

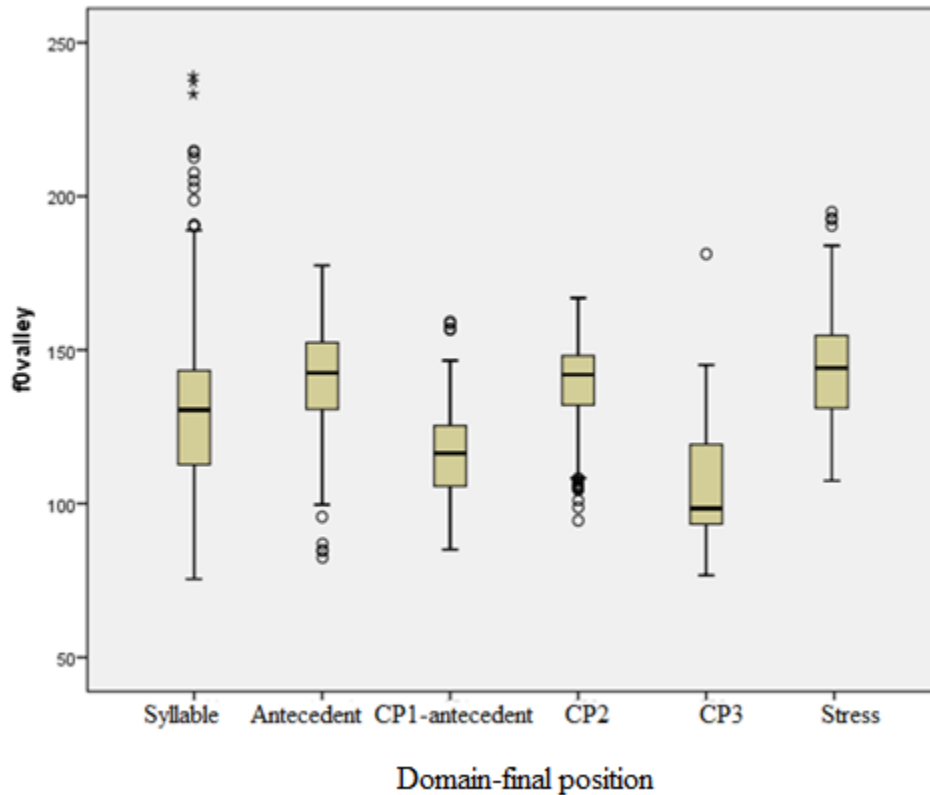
**Estimates are given in standard deviations.  $r^2 = .839$**

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.047627	.227982	14.862	.209	.837
XP-final only	.116505	.154637	593.824	.753	.452
XP-final + other final boundary	.157500	.037638	2109.629	4.185	.000
Antecedent-final	.164004	.059955	5668.686	2.735	.006
Simple CP1-final	-.000265	.062266	5625.984	-.004	.997
Simple CP2-final	.134088	.054514	6085.387	2.460	.014
Complex CP-final	-.191254	.053826	6051.630	-3.553	.000
Stress	.160076	.039265	1433.583	4.077	.000

#### §5.3.4.1.4 Minimum F0

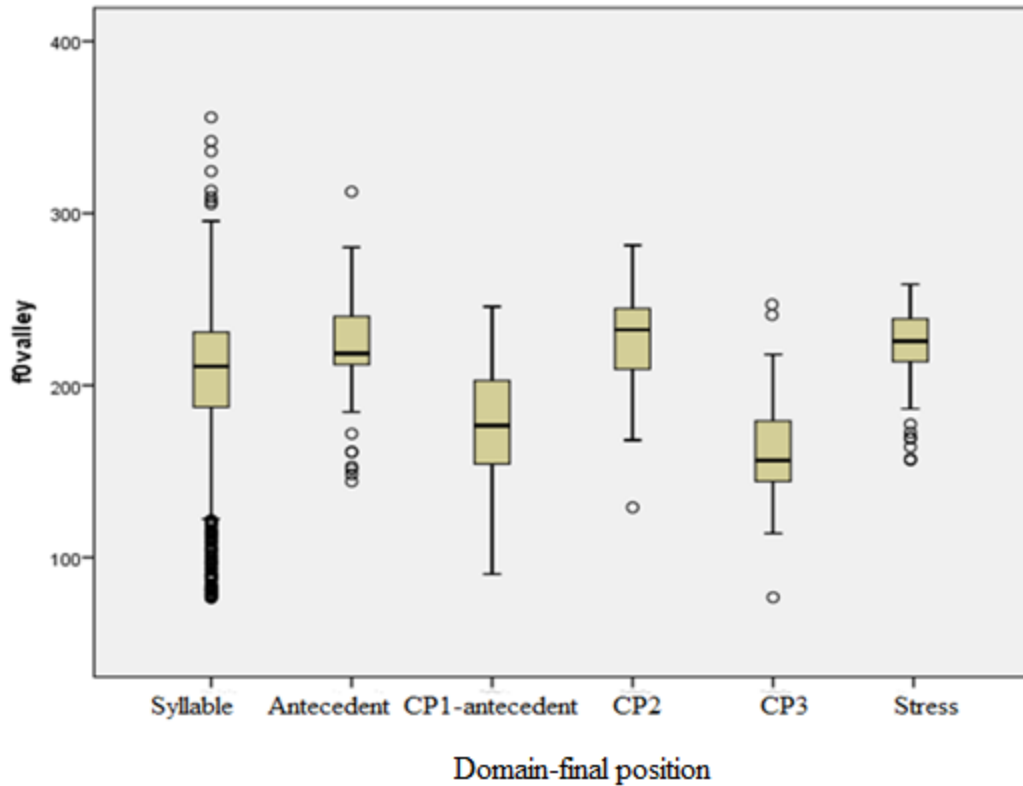
Similar to the maximum F0 distributions in Figures 26 and 27, the minimum F0 in antecedent-final position and CP2-final position are generally higher than those of syllables in non-final position and in CP1-final position, as shown in Figure 28. This can also be said about Figure 29; however, the maximum F0 in antecedent-final position in Figure 29 is not as high as that of syllables in non-final position. As expected, the majority of syllables in sentence-final position (CP3) have low minimum F0.

**Figure 28** Boxplot showing the distribution of minimum syllable F0 in final positions for male speakers.





**Figure 29** Boxplot showing the distribution of minimum syllable F0 in final positions for female speakers.



The fitted model for minimum F0 (Table 18) shows that syllables in XP-final only position, when they do not coincide with the edge of another syntactic constituent, are dropped by .27 SD. In antecedent-final and simple CP2-final positions, minimum F0 is raised by an additional .12 SD and .22 SD respectively. On the contrary, simple CP1-final and complex CP-final positions further lower the minimum F0 of syllables by .26 SD and .27 SD.

**Table 18: Estimates of Fixed Effects in a mixed-effects model for F0 minimum in iterative sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

Estimated are given in standard deviations.  $r^2 = .853$ .

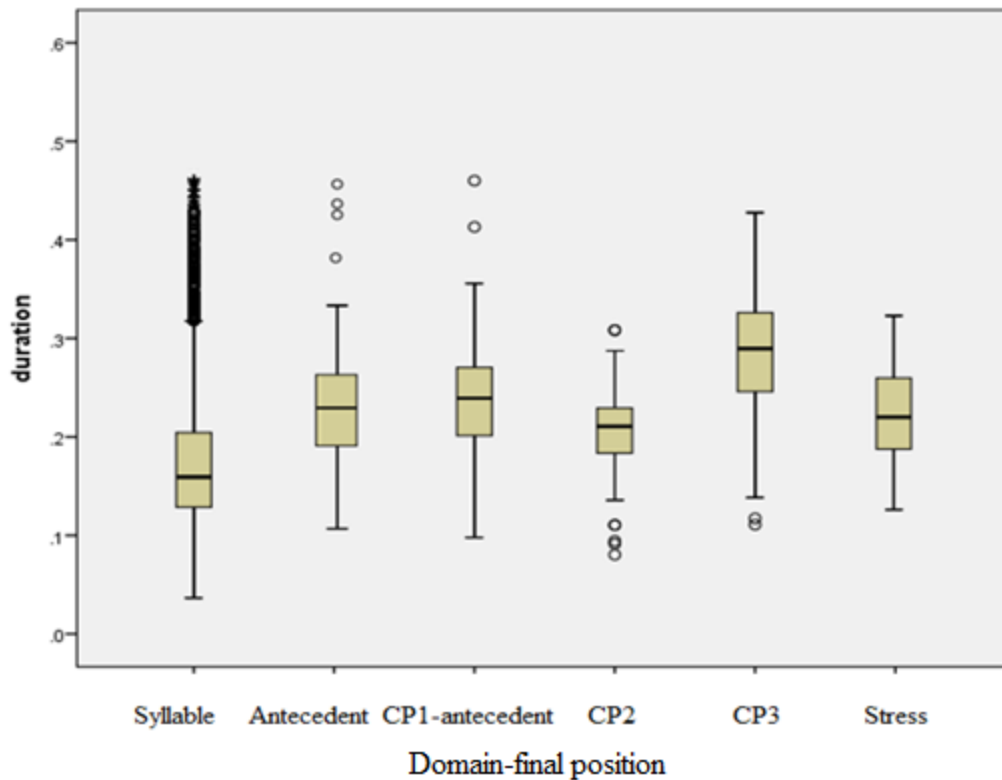
Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.144617	.238366	15.125	.607	.553
XP-final only	-.267749	.051020	6088.961	-5.248	.000
XP-final + other final boundary	.068377	.037737	3279.144	1.812	.070
Antecedent-final	.118865	.058507	5997.089	2.032	.042
Simple CP1-final	-.256512	.060744	6035.409	-4.223	.000
Simple CP2-final	.217220	.052888	6082.937	4.107	.000
Complex CP-final	-.267939	.052289	6094.119	-5.124	.000
Stress	-.023358	.039801	2351.887	-.587	.557

### §5.3.4.2 Recursive sentences

#### §5.3.4.2.1 Duration

In the following figure, the majority of syllables in final positions are longer than syllables in non-final position.

**Figure 30** Boxplot showing the distribution of syllable duration in final positions.



The fitted model for syllable duration (Table 19) indicates that all syntactic-constituent-final positions significantly affect syllable duration except XP-final only. Syllables that are simultaneously in XP-final and CP-final or antecedent-final are lengthened by 17 ms. Antecedent-final, CP1 antecedent-final, complex CP-final and extra-complex CP-final respectively lengthen syllables by an additional 11ms, 15ms, 11ms and 17ms.

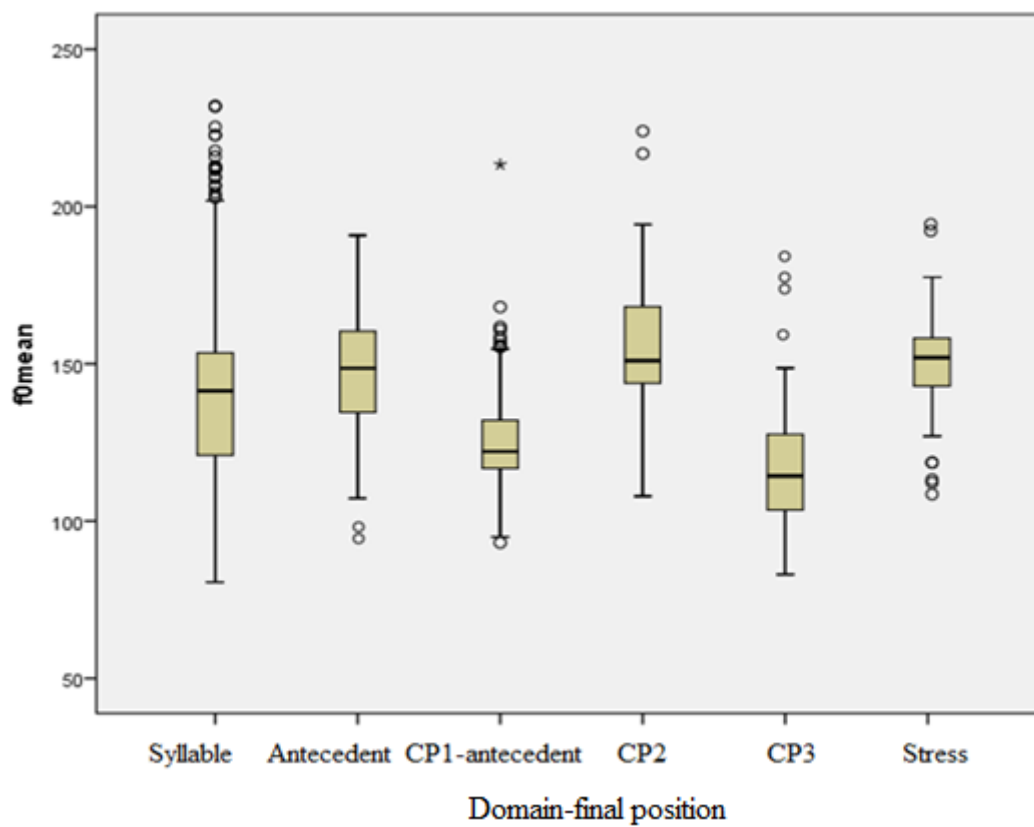
**Table 19: Estimates of fixed effects in a mixed-effects model for duration in recursive sentences. Reference level of the intercept: unstressed, non-final syllables. Estimates are given in ms.  $r^2 = .846$ .**

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.168124	.009407	178.778	17.872	.000
XP-final only	-.000133	.013229	4592.075	-.010	.992
XP-final + other final boundary	16.700	.003325	6024.642	5.023	.000
Antecedent-final	10.569	.004283	6090.693	2.468	.014
CP1 antecedent-final	15.468	.004668	5984.305	3.314	.001
Complex CP-final	11.360	.004459	6039.035	7.033	.000
Extra-complex CP-final	16.785	.004347	6046.667	3.861	.000
Stress	5.374	.003524	5797.446	1.525	.127

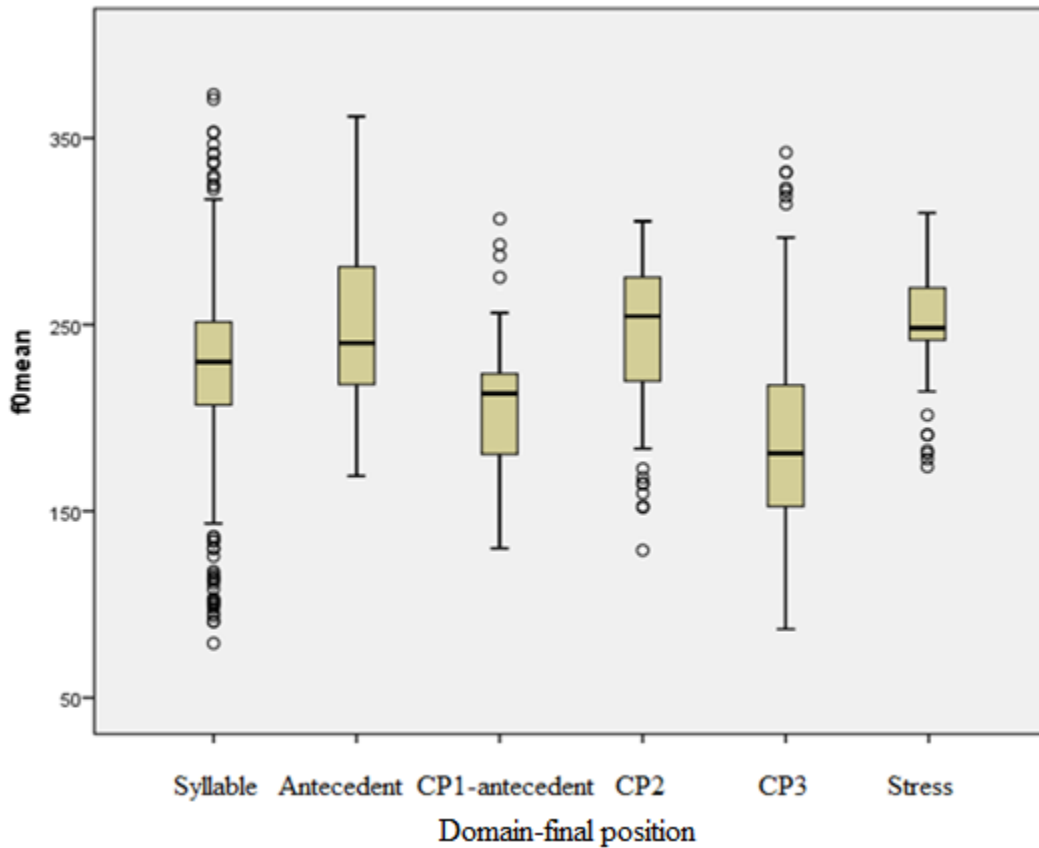
#### §5.3.4.1.2 Mean F0

In Figures 31 and 32, mean syllable F0 is higher in antecedent-final position and Complex CP-final position than in other syllables, especially in CP1-antecedent final position and sentence-final position (CP3).

**Figure 31** Boxplot showing the distribution of F0 mean measurements of syllables in final positions for male speakers.



**Figure 32** Boxplot showing the distribution of F0 mean measurements of syllables in final positions for female speakers.



The fitted model for syllable mean F0 (Table 20) shows that mean F0 of syllables in XP-final position that matches another syntactic constituent edge is raised by .09 SD. As for the mean F0s of syllables in antecedent-final and complex CP-final positions, they respectively increase by an additional .11 SD and .31 SD. The final position of CP1 antecedent lowers mean F0 by .2 SD. Extra-complex CP-final position further lowers the mean F0 of syllables by .12 SD and the mean F0 of stressed syllables is raised by 11 SD.

**Table 20: Estimates of Fixed Effects in a mixed-effects model for mean F0 in recursive sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

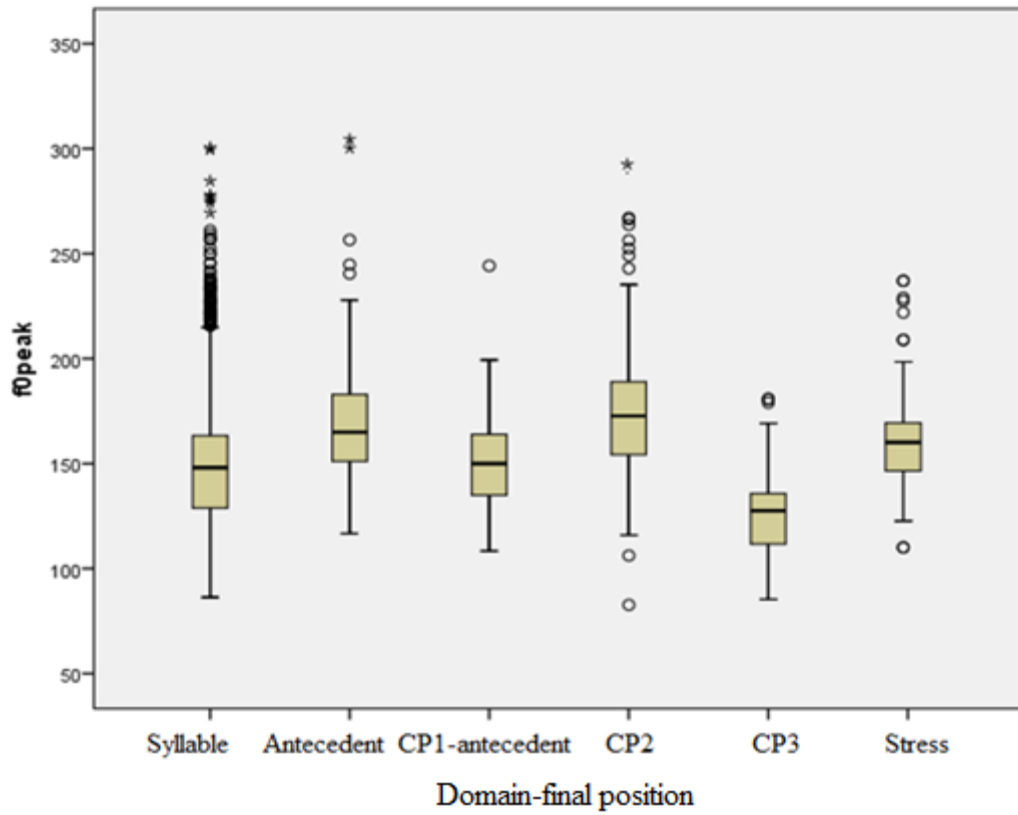
Estimated are given in standard deviations.  $r^2 = .901$ .

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.070628	.252828	14.808	.279	.784
XP-final only	-.061155	.122087	1905.146	-.501	.616
XP-final + other final boundary	.085388	.032268	4332.953	2.646	.008
Antecedent-final	.106940	.042410	5880.512	2.522	.012
CP1antecedent-final	-.195214	.046872	6040.492	-4.165	.000
Complex CP-final	.309763	.044521	6082.045	6.958	.000
Extra-complex CP-final	-.117868	.043417	6089.018	-2.715	.007
Stress	.114074	.033668	3184.879	3.388	.001

### §5.3.4.1.3 Maximum F0

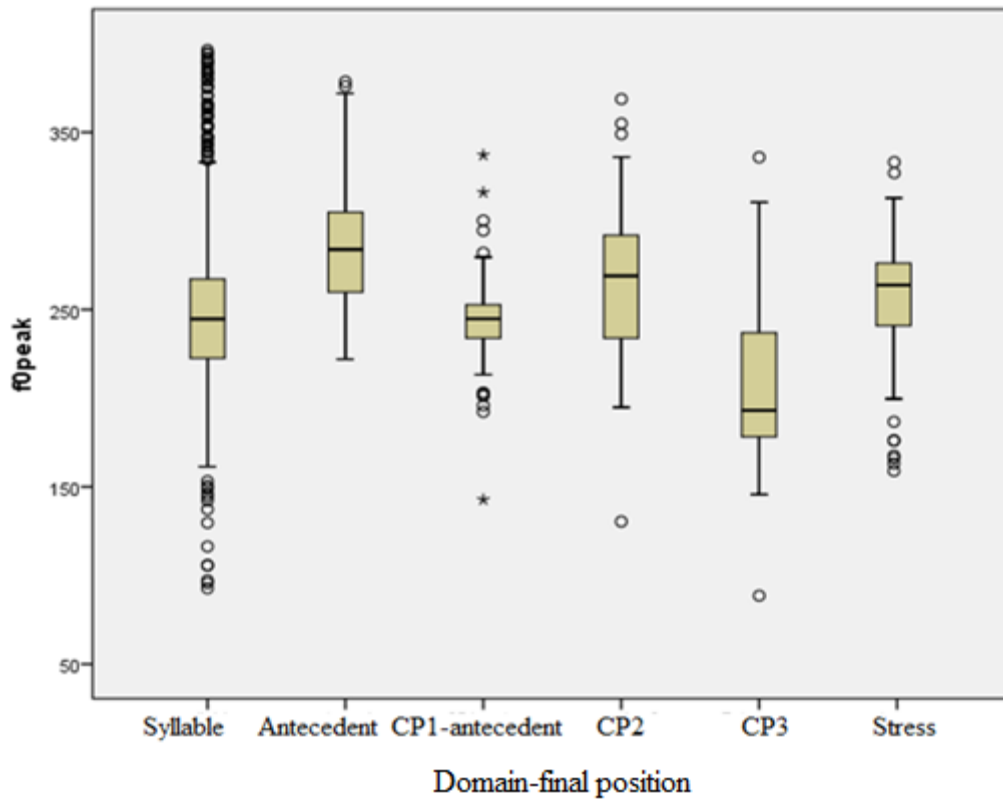
In Figure 33, most syllables in antecedent-final and complex CP-final position have maximum F0s that are higher than 150 Hz. This range of values is higher than that of syllables in non-final and CP1-final position. As for Figure 34, similar conclusions can be drawn.

**Figure 33** Boxplot showing the distribution of F0 maximum measurements of syllables in final positions for male speakers.





**Figure 34** Boxplot showing the distribution of F0 maximum measurements of syllables in final positions for female speakers.



The fitted model for maximum F0 (Table 21) shows that syllables in an XP-final position that coincides with the boundary of another syntactic constituent are raised by .13 SD. Antecedent-final and complex CP-final positions respectively raise maximum F0 by an additional .22 SD and .17 SD. Extra-complex CP-final position lowers maximum F0 by an extra .11 SD. The maximum F0 of stressed syllables is raised by .16 SD.

**Table 21 Estimates of Fixed Effects in a mixed-effects model for maximum F0 in recursive sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

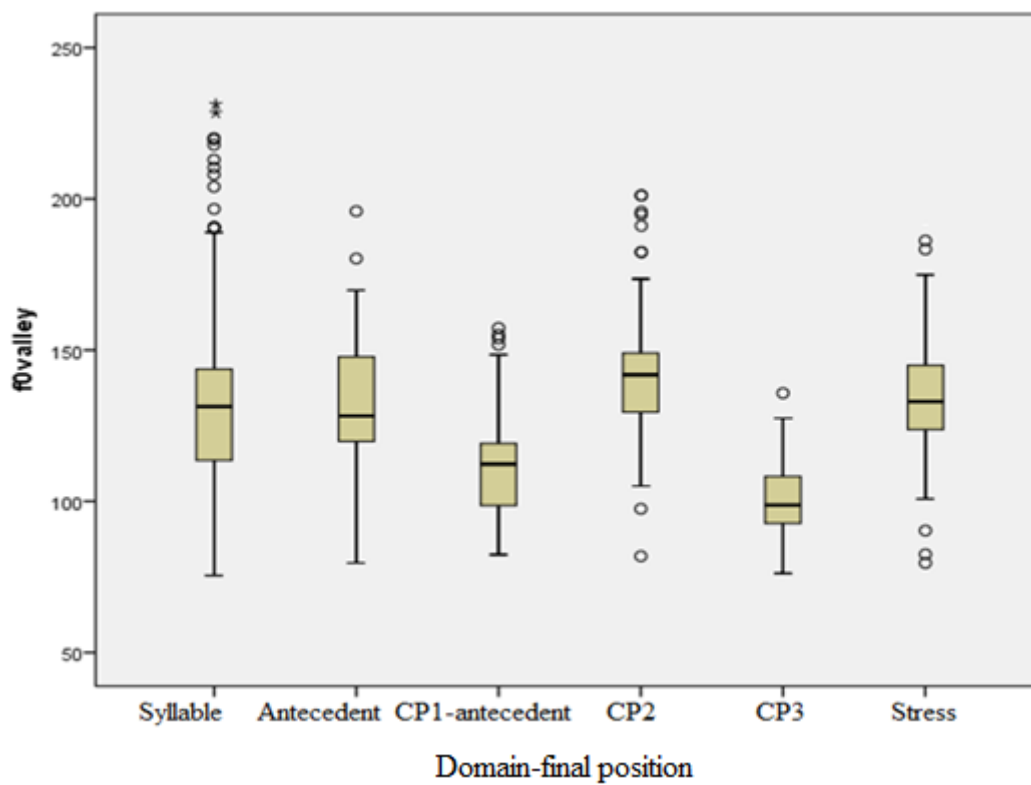
Estimates are given in standard deviations.  $r^2 = .839$ .

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.041993	.227738	14.865	.184	.856
XP-final only	.014733	.139367	896.116	.106	.916
XP-final + other final boundary	.127300	.038345	2331.229	3.320	.001
Antecedent-final	.218573	.051719	5155.551	4.226	.000
CP1 antecedent-final	-.087213	.057997	6093.880	-1.504	.133
Complex CP-final	.165833	.054713	5844.712	3.031	.002
Extra-complex CP-final	-.110140	.053514	6055.052	-2.058	.040
Stress	.161894	.039333	1448.987	4.116	.000

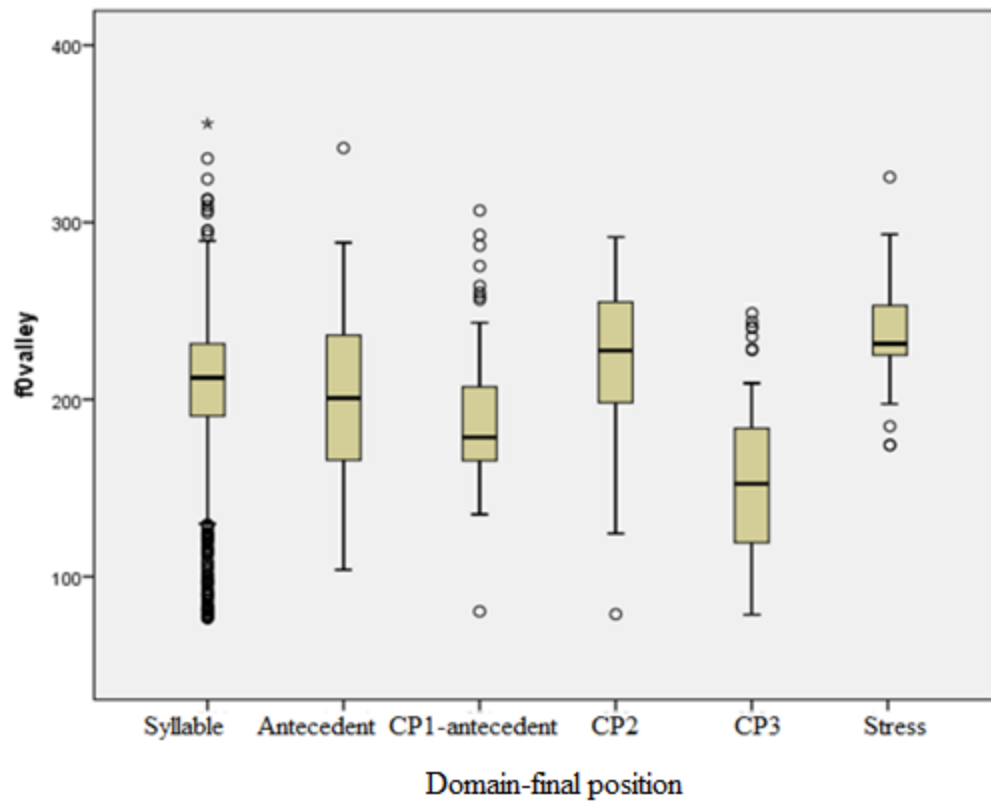
#### **§5.3.4.1.4 Minimum F0**

In Figures 35 and 36, minimum syllable F0 is highest in complex CP-final position. On the contrary, minimum F0 is lowest in both CP1-antecedent final position and sentence-final position.

**Figure 35** Boxplot showing the distribution of F0 minimum measurements of syllables in final positions for male speakers.



**Figure 36** Boxplot showing the distribution of F0 minimum measurements of syllables in final positions for female speakers.



The fitted model for the minimum F0 of syllables (Table 22) shows that the final position of CP1 antecedent lowers minimum F0 by .26 SD. In complex CP-final position, minimum F0 is raised by .33 SD. On the contrary, extra-complex CP-final position lowers the minimum F0 of syllable by .18 SD.

**Table 22 Estimates of Fixed Effects in a mixed-effects model for F0 minimum in recursive sentences. Reference level of the intercept: unstressed, non-final/non-medial syllables.**

Estimated are given in standard deviations.  $r^2 = .852$ .

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	.140050	.239192	15.138	.586	.567
XP-final only	-.160356	.144055	1395.711	-1.113	.266
XP-final + other final boundary	.042459	.038442	3553.967	1.104	.269
Antecedent-final	-.017692	.050797	5698.012	-.348	.728
CP1 antecedent-final	-.260011	.056323	6054.105	-4.616	.000
Complex CP-final	.325123	.053420	6058.990	6.086	.000
Extra-complex CP-final	-.181484	.052118	6090.683	-3.482	.001
Stress	-.008994	.039960	2393.178	-.225	.822

### §5.3.4.5 Summary and interpretation of the results

I will summarize the results of the experiment in steps, starting with XPs and then moving on to CPs. Table 23 summarizes the effect of the XP-final position in sentences containing iteratively structured relative clauses. This position should match  $\Phi$ -final boundaries, and its effect could differ when it coincides with the right edge of higher boundaries (3<sup>rd</sup> column) and when it does not (2<sup>nd</sup> column). We first see that the final position of XPs, when it does not coincide with the final syllable of other prosodic domains, only affects minimum F0, lowering it by 0.27SD. This

is similar to the empirical results in Chapter 4 in which XP-final position is marked by L- phrase accent. On the other hand, no syllable lengthening is found in this position, contrary to expectations.

On the opposite, the XP-final position raises duration, mean F0 and maximum F0 when it coincides with another boundary. This indicates that the L- phrase accent in XP-final position is overridden by another high boundary tone when this position matches the right edge of a higher syntactic constituent. The final lengthening effect found here should probably be attributed to the higher prosodic boundaries.

**Table 23: The effect of XP-final and XP-final + other final boundary positions on the four variables in sentences with iterative relative clauses.**

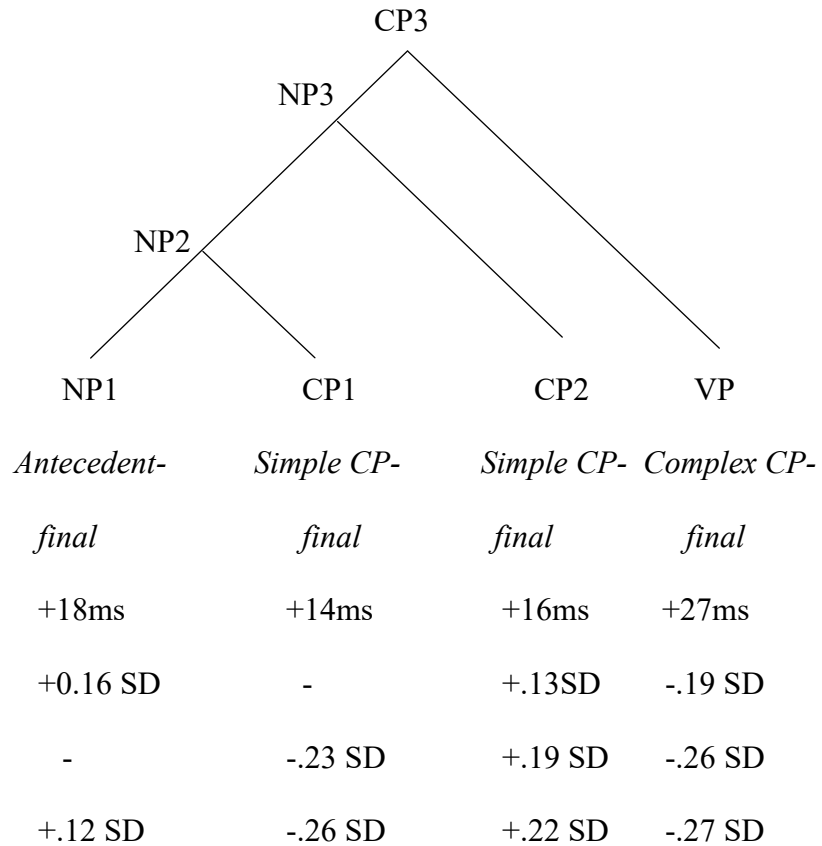
	XP-final	XP-final + other final boundary
Duration	-	14 ms
Maximum F0	-	+ .16 SD
Mean F0	-	+ .13 SD
Minimum F0	-.27 SD	-

The tree in (77) summarizes the phonetic effects of the other prosodic domains in sentences that have iteratively structured relative clauses/right-branching NPs. The antecedent-final position is marked by final syllable lengthening and an H% tone, realized as maximum and minimum F0 raising. In simple CP1-final position, syllables are also lengthened, but mean F0 and minimum F0 are lowered. This entails that this position is more likely accompanied by a L- phrase accent,

similar to XP-final position in Table 23 above. At the first glance, the amount of final lengthening in CP1-final position and the low F0 indicators suggest a right  $\uparrow$  boundary cued by final lengthening and a L% tone. However, L% boundary tones normally mark the right edges of  $\uparrow$ 's that match utterance-final position and represent final lowering. If there was a  $\uparrow$  boundary in CP1-final position which is not an utterance-final position, it should have been cued by a continuative H% tone.

In simple CP2-final position, in contrast, mean F0, maximum F0 and minimum F0 are raised, and therefore this position, beside final lengthening, is marked by a continuative H% boundary tone. Finally, CP3-final/complex CP-final position is marked by the greatest amount of final syllable lengthening and a low boundary tone (L%) suggested by final lowering of maximum, mean and minimum F0.

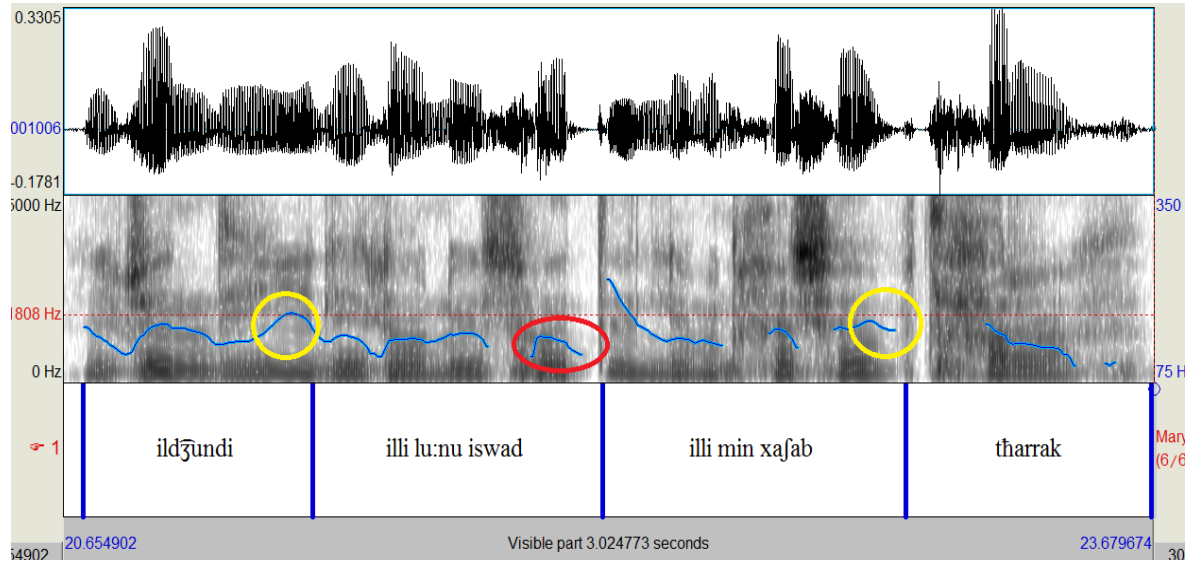
(77) Sentence with iterative relative clauses/right-branching NPs:



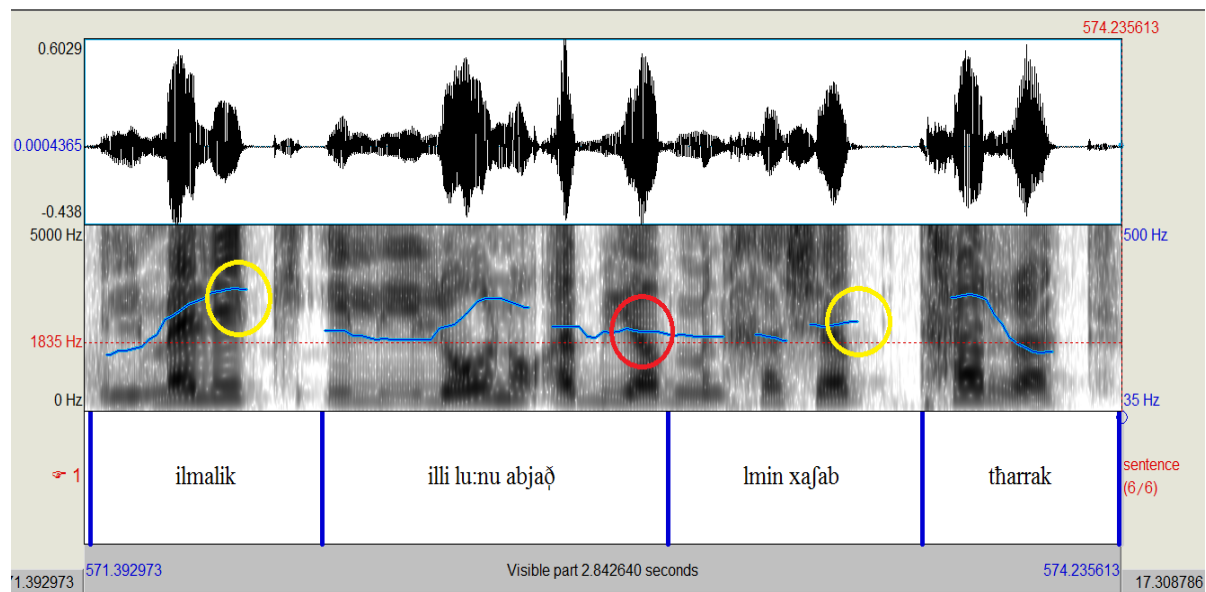
This structure is illustrated in the following three figures. We see that the intonation of the sentences departs from our original hypothesis in two ways: the antecedent seems to end in a H% boundary tone, and the first relative clause differs from the second in that it bears a L- phrase accent rather than a H% boundary tone.



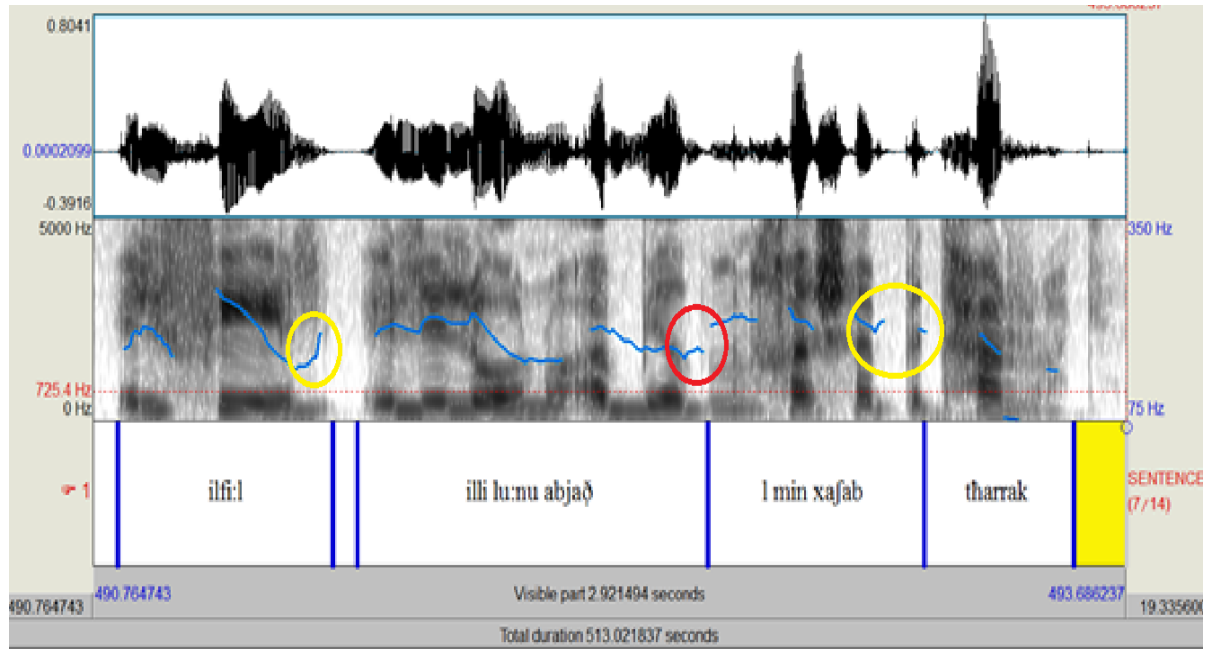
**Figure 37** H% tones in antecedent-final, simple CP1-final and simple CP2-final position in CP3[NP3[ NP2[NP1[ildʒundi]CP1[illi lu:n-u aswad]] CP2[illi min xafab]]VP[tharrak]] ‘The pawn that is black and is made from wood was moved.’.



**Figure 38** H% tones in antecedent-final, simple CP1-final and simple CP2-final position in CP3[NP3[ NP2[NP1[ilmalik]CP1[illi lu:n-u abjað<sup>s</sup>]] CP2[illi min xafab]]VP[tharrak]] ‘The king that is white and is made from wood was moved.’.



**Figure 39** H% tones in antecedent-final, simple CP1-final and simple CP2-final position in CP3[NP3[ NP2[NP1[ilfi:l]CP1[illi lu:n-u abjað<sup>s</sup>]] CP2[illi min xaɣab]]VP[tharrak]] ‘The bishop that is white and is made from wood was moved.’.



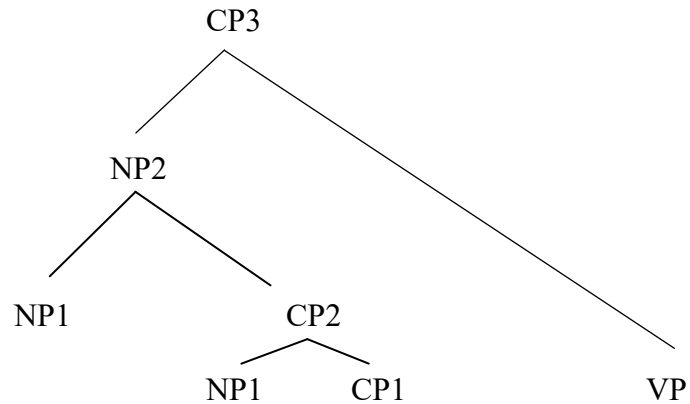
Let us now turn to sentences containing recursive relative clauses/left-branching NPs. Table 24 first deals with XP boundaries. In XP-final only position, neither final lengthening nor F0 variables lowering have been detected. This may be due to the small numbers of words in this position (300 words, compared to 600 words in its counterpart in iterative sentences); note that in Table 20, the mean F0 is lowered by a large estimate, by that this estimate is not significant. The final syllable of XPs, when it matches the boundary of a higher prosodic domain, is lengthened and has an increased F0, indicating a H% boundary tone of a higher syntactic domain.

**Table 24 The effect of XP-final and XP-final + other final boundary positions on the four variables in sentences with recursive relative clauses.**

	XP-final only	XP-final + other final boundary
Duration	-	17 ms
Maximum F0	-	+ .13 SD
Mean F0	-	+ .09 SD
Minimum F0	-	-

The boundaries of higher prosodic domains are summarized in (78). We see that the antecedent-final position, as in sentences with iteratively structured relative clauses, is marked by final syllable lengthening and an H% tone. In CP1 antecedent-final position, however, syllable duration increases and mean F0 and minimum F0 are lowered, suggesting final lengthening and a L- phrase accent, as in any normal XP. In complex CP-final position, all four variables of interest are raised, indicating that this position is accompanied by final lengthening and an H% boundary tone. Extra-complex CP-final position, similar to complex CP-final position in iterative sentences (both are sentence-final), is marked by the greatest amount of final syllable lengthening and a low boundary tone (L%) suggested by final lowering of maximum, mean and minimum F0.

(78) Sentence with recursive relative clauses/left-branching NPs:



	<i>Antecedent-final</i>	<i>CP1-ant</i>	<i>CCP-final</i>	<i>ECP-final</i>
Duration:	11ms	15ms	11ms	17ms
Maximum F0:	+.22 SD	-	+.17 SD	-.11 SD
Mean F0:	+.11 SD	-.2 SD	+.3 SD	-.12 SD
Minimum F0:	-	-.26SD	+.33 SD	-.18 SD

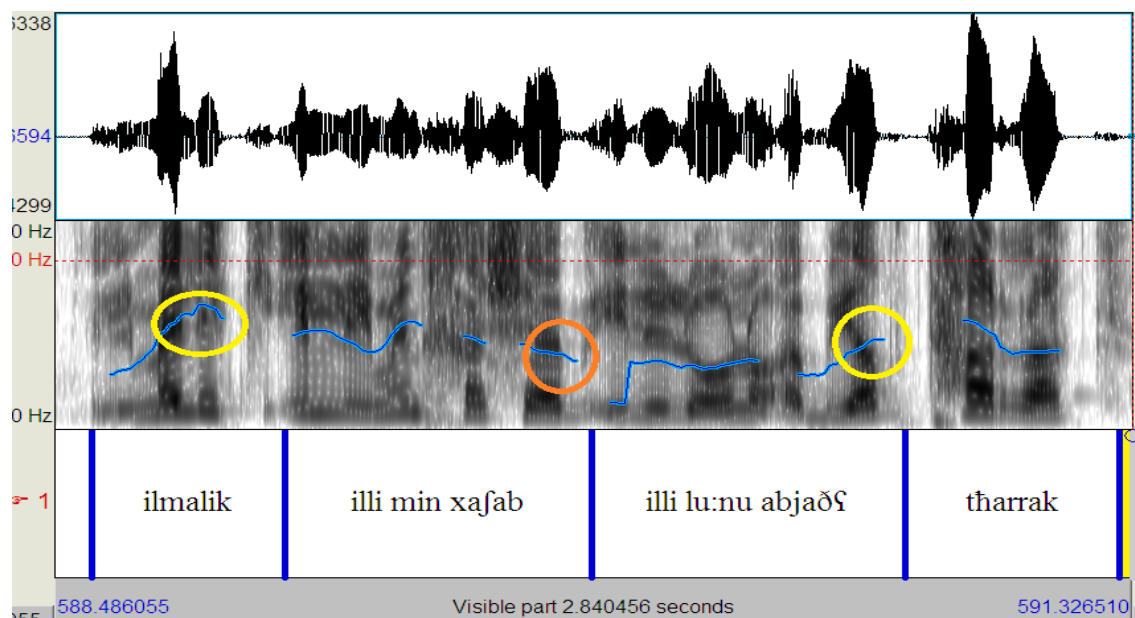
Earlier in this section, I have hypothesized that the amount of final lengthening in complex CP-final position should be larger than the amount of lengthening at the right edge of any other minor because the right edges of CP1 and CP2 coincide at that position. However, the durational increment of the last syllable of CCP is not greater than that of any other minor  $\iota$  in (78).

These results are illustrated with real sentences in the following figures. We see that despite their different syntactic structures, the intonational structures of the iterative and recursive sentences are identical. In the following figures, the final syllable of the antecedent in each sentence gets a H boundary tone, like the final syllable of the complex CP. The final syllable of CP1 antecedent *xafab*, on the other hand, gets a L- phrase accent, just like the CP1 final position in Figures 40-

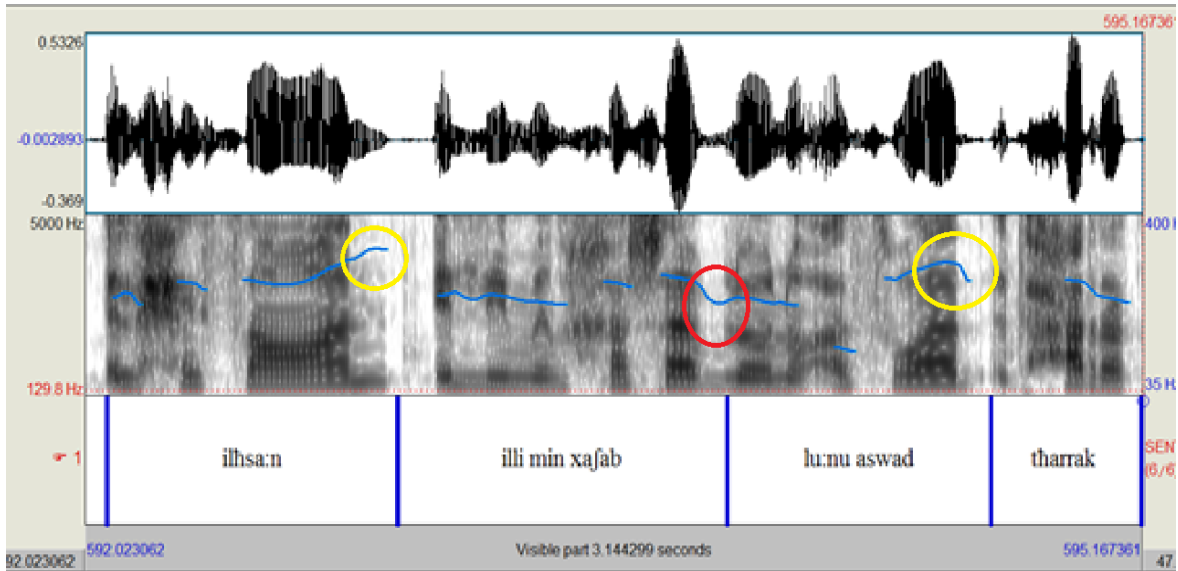
42. As in iterative sentences, the sentence-final position gets a L% and the most dramatic final lengthening.

**Figure 40** H% tones in NP3-final and CP2-final position and L- phrase accent in NP1-final position in CP3[NP4[NP3[il-malik]CP2[illi min NP2[NP1[xafab] CP1[lu:n-u abjaðs]]]VP[tharrak]]

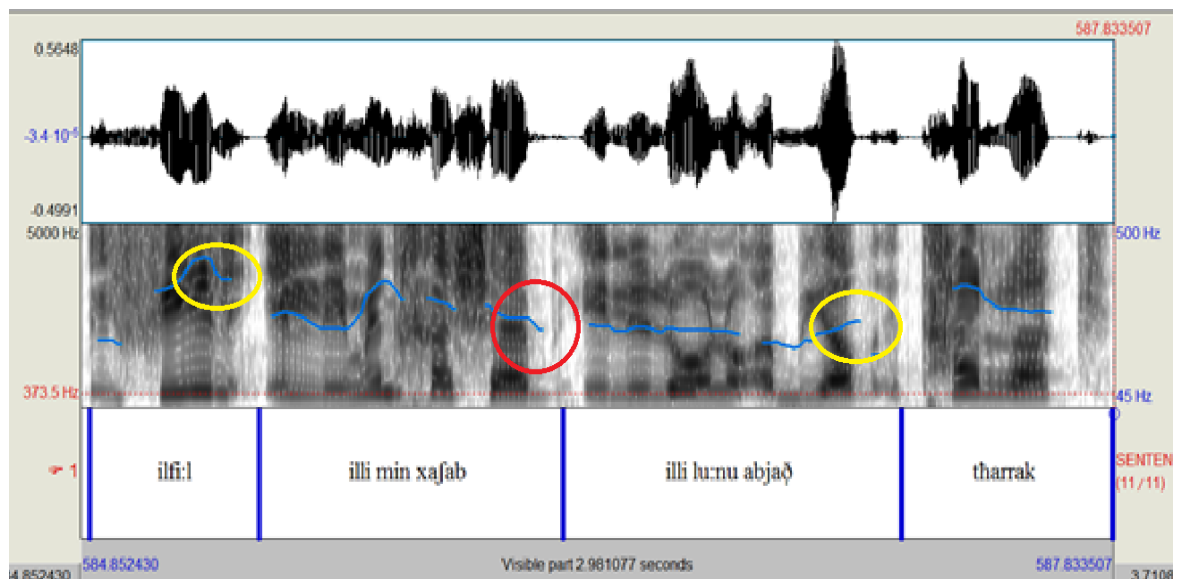
‘The king that is made from wood that is white was moved.’



**Figure 41** H% tones in NP3-final and CP2-final position and L- phrase accent in NP1-final position in CP3[NP4[NP3[ilḥṣa:n]CP2[illi min NP2[NP1[xafab] CP1[lu:n-u aswad]]]VP[tharrak]] ‘The knight that is made from wood that is black was moved.



**Figure 42** H% tones in NP3-final and CP2-final position and L- phrase accent in NP1-final position in CP3[NP4[NP3[il-fi:l]CP2[illi min NP2[NP1[xafab] CP1[lu:n-u abjað<sup>ɕ</sup>]]]VP[tharrak]] ‘The bishop that is made from wood that is white was moved.



### §5.3.5 Discussion

I expected, based on the results of the previous chapter, that  $\Phi$ 's would match XPs and that their boundaries would be marked by final lengthening and L- phrase accents. I also expected that CPs would match  $\iota$ 's (Selkirk 2009, 2011) and would be cued by further final lengthening and boundary tones. Following the assumption of a strong syntactic-prosodic domains correspondence, recursive  $\iota$ 's were expected to be marked by cumulative cues: final lengthening and phrase accents were expected to be more prominent at edges of more complex CPs.

The results of the experiment only partly match these strong predictions. First of all, final lengthening mirrors syntactic recursion at the CP level, with a gradual increase in final lengthening as one goes up the syntactic tree. However, the small final lengthening found at the end of XPs (that do not coincide with the right edge of other domains) in the previous chapter could not be replicated in the current experiment. I speculate that this is due to the fact that the collected dataset in this chapter contained sentences that are much more complex and longer than those in Chapter 4. This may have led the participants to utter their sentences in faster rate of speech, which may have neutralized the effect of final lengthening at the right edges of smaller syntactic constituents, i.e. simple XPs.

The F0 results are a bit more complex. First of all, even if the right edges of some XPs that do not coincide with other boundaries do not show final lengthening, their lower F0 in sentences with iterative relative clauses does suggest that they have a L-phrasal tone, as found in the previous chapter. A similar phrasal tone is suggested by statistical estimates in sentences with recursive relative clauses, but the low number of words in this position may have prevented the

effect from reaching significance.

F0 effects in higher domains reveal additional complex patterns. In sentences with iteratively structured relative clauses, as shown in (79) below, the second simple CP-final position is accompanied by a H boundary tone, but there is no evidence for the presence of such a boundary tone in the first simple CP-final position, which is rather marked by a L- phrase accent. This likely entails that an  $\iota$  boundary is only inserted at the final position of the second simple CP. A similar pattern is found in sentences with recursively structured relative clauses, as exemplified in (80), despite their different syntactic structures; only the right edge of the complex CP is marked by a H% boundary tone. It seems that IA speakers parse the two simple CPs in the sentence with iterative relative clauses as one large  $\iota$ , dealing with them as a kind of parenthetical. Sentences with recursive relative clauses have a similar structure for a different reason: their embedded CPs form a single  $\iota$  with the rest of the host CP in which they are contained because of the binary limit to prosodic recursion already found for lower prosodic domains. As the root CP already forms an  $\iota$ , only one other level of CP can project an  $\iota$ .

I do not have a straightforward explanation for why iterative relative clauses form a single parenthetical  $\iota$ , and this is an issue that will need to be investigated beyond this dissertation. However, prosodic weight and speech rate may be involved. We know that a large  $\iota$  can be restructured into smaller  $\iota$ 's if it is long or is uttered in a slow rate of speech (Nespor & Vogel 1986). Conversely, it is possible that a faster rate of speech favors the formation of larger  $\iota$ 's to minimize the number of  $\iota$ 's within an utterance. Faced with the option of merging the iterative relative clauses into a single  $\iota$  or of merging them independently with the antecedent or the verb,



speakers may choose the first option to maintain a prosodic structure that allows a maximal recoverability of the syntactic structure of the sentence.

In sentence-final positions (complex CP-final position in iterative sentences and extra-complex CP-final position in recursive sentences), declarative L% boundary tones are found. I propose that the fact that sentence-final boundary tones are L% rather than H% tones, along with the extreme lengthening found in sentence-final position, is evidence that sentences form a prosodically recursive  $\iota$ 's. IA would thus have at least two levels of  $\iota$ 's: those matching simple CPs, that have some final lengthening and continuative boundary H%, and those matching the CP at the top of the syntactic utterance, which have an even stronger final lengthening and a boundary L% (or possibly another final boundary tone with different sentence types).

Another result that was not predicted by the hypothesis of a strong match between syntax and prosody is that the external antecedent-final positions in all sentences are accompanied by the same cues as simple CP2-final position in sentences with iterative relative clauses and complex CP-final position in sentences with recursive relative clauses (i.e. final lengthening and H% boundary tones). This suggests that relative-clause-external XPs match  $\iota$ 's in order to make the minor  $\iota$  level exhaustive (Selkirk 1995, 2011, Truckenbrodt 1999). Note that the sentences tested here contain two such XPs: the antecedent NP1 and the VP in (79) and the antecedent NP3 and the VP in (80). However, the effects are not visible on the VPs because they are sentence-final and thus receive the prosodic cues of major  $\iota$ 's (extreme lengthening and final declarative L%).

(79) The prosodic representation of sentences with iterative relative clauses:

H%	L-	L-	H%	L%
FL	small FL	smallFL	FL	greater FL
(( [            ] $\Phi$ ) <sub>min</sub> ( [            ] $\Phi$ [            ] $\Phi$ [            ] $\Phi$ ) <sub>min</sub>				( [            ] $\Phi$ ) <sub>min</sub> ) <sub>max</sub>
CP3[NP3[ NP2[ NP1[il-ḍzundi]	CP1[illi lu:n-u	abjað <sup>s</sup> ]]	CP2[illi min xaʃab]]	VP[tharrak]]

il-ḍzundi    illi    lu:n-u                      abjað<sup>s</sup> illi    min    xaʃab                      tharrak  
 DEF-pawn    that color-3SGM.REF white    that from    DEF-wood    move.3SGM.PST  
 ‘The pawn that is white and made of wood was moved.’

(80) The prosodic representation of sentences with recursive relative clauses:

H%	L-	L-	H%	L%	
FL	small FL	small FL	FL	greater FL	
(( [            ] $\Phi$ ) <sub>min</sub> ( [            ] $\Phi$ [            ] $\Phi$ [            ] $\Phi$ ) <sub>min</sub> ( [            ] $\Phi$ ) <sub>min</sub> ) <sub>max</sub>					
CP3[NP4[NP3[il-ḍzundi]	CP2[illi    min	NP2[NP1[xaʃab]	CP1[lu:n-u	aswad]]]]	VP[tharrak]]

il-ḍzundi    illi    min    xaʃab    lu:n-u                      aswad    tharrak  
 DEF-pawn    that from wood    color-3SGM.REF black    move-3SGM.PST

It is worth noting that CP1-internal antecedents in sentences with recursive relative clauses are also expected to be parsed in minimal *t*'s. In the present case however, this effect is erased by the restructuring of the *t*'s projected by CP1 and CP2.

To wrap up this chapter, the proposed prosodic structures for the two types of sentences tested in this chapter are given in (81) and (82).

(81) The prosodic representation of sentences with iterative relative clauses:

$$\begin{array}{l} ( \qquad \qquad \qquad \text{CP3} \qquad \qquad \qquad )_{\text{max}} \\ (\text{NP1})_{\text{min}} ( \qquad \text{CP1} \qquad \qquad \text{CP2} \qquad )_{\text{min}} (\text{VP})_{\text{min}} \\ (\text{NP1})_{\Phi} \qquad \qquad \qquad \qquad \qquad \qquad \qquad (\text{VP})_{\Phi} \end{array}$$

(82) The prosodic representation of sentences with recursive relative clauses (the complex CP2 which embeds CP1 is parsed in a minimal  $\iota$ ):

$$\begin{array}{l} ( \qquad \qquad \qquad \text{CP3} \qquad \qquad \qquad )_{\text{max}} \\ (\text{NP3})_{\text{min}} ( \qquad \qquad \text{CP2} \qquad \qquad )_{\text{min}} (\text{VP})_{\text{min}} \\ (\text{NP3})_{\Phi} \qquad \qquad \qquad \qquad \qquad \qquad \qquad (\text{VP})_{\Phi} \end{array}$$

## **§6 The Prosodic Structure of Irbid Arabic**

I begin this chapter with a general discussion of the universality of the  $\omega$ ,  $\Phi$  and  $\iota$ , based on evidence from previous chapters. In § 6.2, I attempt to account for the possible prosodic phrasing patterns of IA within a framework based on the syntactic-prosodic correspondence constraints of Match Theory (Selkirk 2011). In § 6.3, I focus on the similarities and the differences between IA prosodic structure and the prosodic structures of some other Arabic dialects that have been previously studied, i.e. Egyptian Arabic (EA), Lebanese Arabic (LA) and Jordanian Arabic as spoken in Amman (AA), and attempt to account for the differences with minimal changes to the formal tools developed for IA to assess their typological validity.

### **§6.1 Universality of Prosodic Domains and Prosodic Recursion?**

In early work on the Prosodic Hierarchy (Selkirk 1984, 1986, Nespor & Vogel 1986), the formation of  $\iota$ ,  $\Phi$  and  $\omega$  made indirect reference to syntactic constituency in such a manner that the boundaries of a prosodic domain were usually aligned with a specific edge of a syntactic constituent, but could be overridden by rhythmic restructuring processes. In later versions of the Prosodic Hierarchy,  $\iota$ ,  $\Phi$  and  $\omega$  are also constructed with reference to morphological and syntactic information:  $\iota$ 's and  $\Phi$ 's normally match clauses and XPs respectively, and  $\omega$ 's mostly correspond to stems and combinations of stems and surrounding affixes (Truckenbrodt 1995, 1999, Selkirk 2009, 2011). These later models put a greater focus on edge alignment and are typically framed in Optimality Theory.

In early work on the Prosodic Hierarchy (Nespor & Vogel 1986, Selkirk 1986), prosodic domains were considered universal and could not be skipped. Similarly, in recent theoretical frameworks such as Match Theory (Selkirk 2009 & 2011), the one-to-one correspondence of prosodic and syntactic constituents ensures the universality of these prosodic domains<sup>18</sup>. However, the universality of these domains has recently become controversial in the literature on prosody and syntax-prosody interface: some studies have cast doubt on the existence of the three prosodic domains in all languages. For example, Vietnamese has neither word stress nor other processes that could be used as diagnostics for the  $\omega$ , and many language-specific prosodic domains have been proposed in some Tibeto-Burman languages (Hildebrandt 2007, Schiering et al. 2008, Brunelle 2017).

I have shown so far that all these prosodic domains (i.e.  $\omega$ ,  $\Phi$  and  $\iota$ ) are present in the prosodic structure of IA and are built with reference to the expected syntactic constituents: grammatical word, syntactic phrase and clause. More specifically, lexical words and bimoraic function words project  $\omega$ 's, simple XPs match  $\Phi$ 's, and relative clauses form  $\iota$ 's (even if the results of Chapter 5 suggest that there is significant restructuring at the  $\iota$  level). No evidence has been found in favor of additional prosodic domains in IA. Therefore, IA does not provide evidence against the universality of the traditional Prosodic Hierarchy.

Another important theoretical issue that is closely related to the universality of the prosodic hierarchy is prosodic recursion. While it was strictly prohibited by the Strict Layer Hypothesis in

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<sup>18</sup>In theory, a high-ranking constraint banning a prosodic domain, like  $*\Phi$ , could prevent it from being realized as the surface in a specific language. However, the constraints for forming all prosodic domains would still be universal.

early Prosodic Phonology (Nespor & Vogel 1986, Selkirk 1986), it is now built-in as a direct consequence of the universal correspondence constraints of Match Theory (Selkirk 2009, 2011). We have seen in previous chapters that there is abundant evidence of prosodic recursion in IA, where it is neither prohibited, nor unconstrained. The  $\omega$ ,  $\Phi$  and  $\iota$  in IA are all equally limited to two levels of recursion (a minor and a major layers), contrary to the theoretically infinitely recursive nature of the syntactic constituents to which they are anchored. Therefore, the recursive  $\omega$ ,  $\Phi$  and  $\iota$  can mirror no more than two levels of syntactic nesting in this dialect.

This maximally binary prosodic recursion is diagnosed by restrictions on complex metrical structures, final lengthening and boundary tones. The two levels of  $\omega$  have been diagnosed in Chapter 3 by means of stress: there are only two types of stress, primary and secondary. They are assigned to syntactic constructions (i.e. genitive constructs) which project recursive  $\omega$ 's: stress is assigned to each minor  $\omega$ , and the leftmost one is promoted to primary status after forming the major  $\omega$ . At the  $\Phi$  level, final lengthening is presented in Chapter 4 as evidence that there are only two possible recursive layers (minimal and maximal  $\Phi$ ), even in the presence of more complex syntactic nesting: when the role of  $\iota$ 's is carefully controlled for, only two degrees of final lengthening are detected at the edges of  $\Phi$ 's.

The same binary restriction applies to the  $\iota$  level: the two layers of  $\iota$ 's are cued by two degrees of final lengthening: there is more lengthening in sentence-final position than in sentence-medial  $\iota$ -final positions. In addition, there are two types of boundary tones at the end of  $\iota$ 's: continuative H%'s that are found at the end of sentence-internal  $\iota$  and declarative L%'s that have a lower F0 value and are found at end of sentence (i.e. the recursive  $\iota$ ). It is worth noting that it is very possible that the declarative L% in sentence-final position can be substituted by other boundary tones that deliver different meanings, such as final rising to cue yes/no questions.

One remaining question is: why is prosodic recursion found to be restricted to two layers? I hypothesize that this language-specific constraint on prosodic recursion is a grammaticalization of restrictions imposed by performance. Even if full recursion was allowed in terms of competence, it would be very difficult for speakers to realize several gradient levels of phrase-final lengthening at both the  $\Phi$  and  $\iota$  level or to produce more than two levels of clearly distinctive stress. Learners (i.e. children) are therefore likely to internalize these restrictions as a language-specific constraint. BINREC could therefore have become a part of IA grammar through inference from learners rather than as a universal constraint that is part of UG. This scenario could explain why some dialects/languages have no prosodic recursion (e.g. I assume that EA has a non-recursive  $\omega$ ) and others have more than two recursive levels (English has a three-layer recursive  $\omega$ ). EA speakers do not tolerate recursion at all (and have a highly-ranked universal NOREC), while English speakers have a stress system that relies on a richer set of acoustic cues than Arabic, allowing for finer-grained categories.

## §6.2 Irbid Arabic Prosodic Structure in Match Theory

In this section, I argue that Match Theory (Selkirk 2011) can adequately account for the syntactic-prosodic mappings and the mechanisms of prosodic recursion that have been introduced in the previous three chapters. I will show that the universal correspondence constraints proposed in Match Theory (Selkirk 2011) can be used to obtain the prosodic structures uncovered in previous chapters, with minimal reliance on language-specific constraints or principles.

Match constraints (Selkirk 2011) have been formulated based on the correspondence framework of Optimality Theory (McCarthy and Prince 1995). In Match Theory (Selkirk 2009, 2011), prosodic domains refer to syntactic constituents by means of violable syntactic-prosodic correspondence constraints. These constraints require the prosodic structure and syntactic structure to be faithful to each other. Selkirk (2011) has posited two sets of violable constraints that define syntax-prosody correspondence: input-output (syntactic domains-prosodic domains) and output-input (prosodic domains-syntactic domains) constraints.

The first set of constraints (e.g. *MATCH<sub>PHRASE</sub>*) is similar to *MAX* constraint in the correspondence framework of Optimality Theory. They are violated when the input, the syntactic structure, contains an element that does not have a corresponding element in the output, the prosodic structure. As for the second set of constraints (*MATCH<sub>Φ</sub>*), it is similar to *DEP* constraints: they are violated once an element in the output (the prosodic structure) does not have a counterpart in the input (the syntactic structure).



In this section, rather than following a top-down or bottom-up approach, I will start with the  $\Phi$ , which is the simplest prosodic domain to account for. I will then generalize the analysis to the  $\iota$ , and will conclude with the  $\omega$ , which requires more detailed explanatory principles.

### §6.2.1 The Phonological Phrase

In § 4.2, my initial hypothesis was that the syntactic embedding of right-branching and left-branching XPs in (83) is directly mirrored in their prosodic representations:

(83) a. The expected prosodic representation of a right-branching extra-complex XP:

$((\text{wazi:r})_{\Phi_{\min}} (\text{ʔiʃfar})_{\Phi_{\min}})_{\Phi_{\text{non-min}}} (\text{min xaʃab})_{\Phi_{\min}})_{\Phi_{\max}}$

Minister      yellow                      from wood

'A yellow queen made of wood'.

b. The expected prosodic representation of a left-branching extra-complex XP:

$((\text{wazi:r})_{\Phi_{\min}} ((\text{min xaʃab})_{\Phi_{\min}} (\text{ʔiʃfar})_{\Phi_{\min}})_{\Phi_{\text{non-min}}})_{\Phi_{\max}}$

Minister      from wood                      yellow

'A queen made of yellow wood'.

In these examples, it was expected to observe three layers of prosodic recursion: each simple XP had a corresponding minimal  $\Phi$  in the prosodic representation. Furthermore, syntactic complexity should have had an impact on the prosodic representation: a complex XP that consists of two simple XPs matches a non-minimal  $\Phi$  and a more complex XP that contains three simple XPs should project a maximal  $\Phi$ . This hypothesis was based primarily on a temporal phenomenon: syllables at the right of simple XPs should be longer than those in non-final position, and a greater amount of final lengthening is expected at the right edge of a more complex XP.

The empirical results have shown that there are only two layers of prosodic recursion. These two layers are formed in a bottom-up fashion: they correspond to simple XPs and complex XPs that embed two simple XPs. This type of complex XPs is characterized by further lengthening. No further lengthening is detected at the right of more complex XPs. In the right-branching extra-complex XP in (84a), for example, the simple XPs, *wazi:r* and *ʔiʃfar*, that have corresponding minimal  $\Phi$ 's, both form a complex XP that projects a maximal  $\Phi$ . The same can be said about the simple XPs, *min xaʃab* and *ʔiʃfar*, in the left-branching extra-complex XP in (84b).

(84) a. The prosodic representation of a right-branching extra-complex XP:

$((wazi:r)_{\Phi_{min}} \quad (ʔiʃfar)_{\Phi_{min}})_{\Phi_{max}} \quad (min \quad xaʃab)_{\Phi_{min}}$

Minister      yellow                      from wood

'A yellow queen made of wood'.

b. The prosodic representation of a left-branching extra-complex XP:

(wazi:r)<sub>Φ<sub>min</sub></sub> ((min xaʃab)<sub>Φ<sub>min</sub></sub> (ʔiʃfar)<sub>Φ<sub>min</sub></sub>)<sub>Φ<sub>max</sub></sub>

Minister from wood yellow

'A queen made of yellow wood'.

My initial hypothesis, which turned out to be erroneous, would have been easily captured by the standard Match constraints on  $\Phi$ -formation in (85) (Selkirk 2011): the winner would have been the candidate in which prosodic domains perfectly match syntactic constituents (the three-layer recursive  $\Phi$ 's) in (83).

(85) a. **MATCH<sub>PHRASE</sub>**: an XP in the syntactic structure must be matched by a corresponding  $\Phi$  in the prosodic representation.

b. **MATCH $\Phi$** : a  $\Phi$  in the prosodic representation must be matched by a corresponding XP in the syntactic structure.

However, the actual prosodic phrasing pattern in IA is the candidate that has imperfect syntactically-based prosodic recursion in (84). In this prosodic representation, the maximal  $\Phi$  is limited to two layers of recursion. This phonological restriction on the maximum number of recursive layers of the  $\Phi$  in IA is formulated as the markedness constraint in (86).

(86) BINREC: a prosodic domain can have a maximum of two recursive layers.

In Tableau 3, a hypothetical tableau, BINREC is ranked high, and therefore the maximally recursive candidate (i.e. candidate *b*) is ruled out by this constraint. Candidate *e* loses due to its violations of low-ranking constraints: it violates BINMAX $\Phi$  by having a  $\Phi$  that embeds more than two  $\omega$ 's and Violates MATCHPHRASE four times by leaving four XPs without corresponding  $\Phi$ 's. Candidate *d* loses by incurring violations of MATCHPHRASE more than candidate *a*: it leaves two XPs without corresponding  $\Phi$ 's. As can be seen in this tableau, neither BINREC nor Match constraints are crucial when evaluating candidates *a* and *c*<sup>19</sup> for the left-branching extra-complex XP. Both candidates equally have two recursive prosodic layers and each incurs one violation of MATCHPHRASE.

**Tableau 3: BINREC >> \*BINMAX $\Phi$ , MATCHPHRASE, MATCH $\Phi$ .**

**Left-branching XP: *wazi:r min xaʃab ʔiʃfar* ‘A queen made of a yellow wood’.**

NP2[NP1[wazi:r] PP2[PP1[min xaʃab] AP[ʔiʃfar]]]	BINREC	MATCHPHRASE	MATCH $\Phi$
☺a. (wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$		*	
b. ((wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$ ) $\Phi$	*!		
☹c. ((wazi:r) $\Phi$ (min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$		*	
d. (wazi:r) $\Phi$ (min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$		**!	
e. (wazi:rmin xaʃabʔiʃfar) $\Phi$		**!***	

Candidate *c* forms maximal  $\Phi$ 's from the topmost and lowest XPs whereas candidate *a* favors

<sup>19</sup>When there is no winning candidate, as in Tableau 3, the smilingface is used to indicate the candidate that should win and the sad face to represent the one that should lose.

lower syntactic levels. To ensure the outcome in candidate *a*, I propose that the  $\Phi$  in IA maximally contains two  $\omega$ 's. This requirement is formulated as the markedness constraint in (87) below.

(87) \*BINMAX $\Phi$ : a  $\Phi$  maximally consists of two  $\omega$ 's.

In the following tableau, candidates *a* and *c* violate MATCHPHRASE once; however, candidate *a*, the actual prosodic pattern in IA, wins over candidate *c* which violates \*BINMAX $\Phi$  by having three  $\omega$ 's in a  $\Phi$ .

**Tableau 4: BINREC >> \*BINMAX $\Phi$ , MATCHPHRASE, MATCH $\Phi$ .**

**Recursive XP: *wazi:r min xaʃab ʔiʃfar* ‘A queen made of a yellow wood’.**

NP2[NP1[wazi:r] PP2[PP1[min xaʃab] AP[ʔiʃfar]]]	BIN REC	*BINMAX $\Phi$	MATCH PHRASE	MATCH $\Phi$
a. (wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$			*	
b. ((wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$ ) $\Phi$	*!	*		
c. ((wazi:r) $\Phi$ (min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ ) $\Phi$		*!	*	
d. (wazi:r) $\Phi$ (min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$			**!	
e. (wazi:rmin xaʃabʔiʃfar) $\Phi$		*	**!***	

The constraints that allow us to capture the formation of  $\Phi$ 's in IA are therefore:

(88) BINREC>>\*BINMAX $\Phi$ , MATCHPHRASE, MATCH $\Phi$ .

It is worth noting that ranking  $\text{BINMAX}\Phi$  or  $\text{MATCH}\Phi$  below  $\text{MATCHPHRASE}$  will not change the winning candidate, candidate *a*:

**Tableau 5:  $\text{BINREC} \gg \text{MATCHPHRASE} \gg * \text{BINMAX}\Phi, \text{MATCH}\Phi$ .**

**Recursive XP: *wazi:r min xaʃab ʔiʃfar* ‘A queen made of a yellow wood’.**

$\text{NP}_2[\text{NP}_1[\text{wazi:r}] \text{PP}_2[\text{PP}_1[\text{min xaʃab}] \text{AP}[\text{ʔiʃfar}]]]$	<b>BINREC</b>	<b>MATCH PHRASE</b>	<b>*BINMAX<math>\Phi</math></b>	<b>MATCH <math>\Phi</math></b>
a. $(\text{wazi:r})_\Phi((\text{min xaʃab})_\Phi(\text{ʔiʃfar})_\Phi)_\Phi$		*		
b. $((\text{wazi:r})_\Phi((\text{min xaʃab})_\Phi(\text{ʔiʃfar})_\Phi)_\Phi)_\Phi$	*!		*	
c. $((\text{wazi:r})_\Phi(\text{min xaʃab})_\Phi(\text{ʔiʃfar})_\Phi)_\Phi$		*	*!	
d. $(\text{wazi:r})_\Phi(\text{min xaʃab})_\Phi(\text{ʔiʃfar})_\Phi$		**!		
e. $(\text{wazi:rmin xaʃabʔiʃfar})_\Phi$		***!*	*	

Since no candidate could satisfy  $\text{BINREC}$  and  $\text{MATCHPHRASE}$  and incur a violation of  $\text{BINMAX}\Phi$  or  $\text{MATCH}\Phi$  in Tableau 4, I choose to rank them low. Note that the opposite (ranking them high) would also be an option.

At first sight,  $\text{BINREC}$  seems a bit ad hoc, but in the following subsections, I will show that it also plays a role in limiting prosodic recursion in  $\omega$ 's and in  $\iota$ 's.

### §6.2.2 The Intonational Phrase

My initial hypothesis in § 5.3 is that right-branching and left-branching sentences should cause the formation of recursive  $\iota$ 's. Once again, this was expected to derive directly from the basic constraints that rule  $\iota$ -formation in Match Theory (Selkirk 2011). These are given in (89).

(89) a. MATCH<sub>CLAUSE</sub>: a clause in the syntactic structure must be matched by a corresponding  $\iota$  in the prosodic representation.

b. MATCH <sub>$\iota$</sub> : an  $\iota$  in the prosodic representation must be matched by a corresponding clause in the syntactic structure.

Right-branching sentences that have iterative relative clauses tested here were expected to project two-layer recursive  $\iota$ 's since they only have two syntactic layers: simple CPs and complex CPs. As shown in (90a), the simple CPs (i.e. CP1 and CP2) and the complex CP (the maximal projection of the entire sentence) should match a minimal and maximal  $\iota$ , respectively. On the other hand, left-branching sentences with recursive relative clauses have three syntactic layers in (90b): (simple CP (CP1), complex CP (CP2) and extra-complex CP (the maximal projection of the sentence)) and should in theory project three levels of  $\iota$ : a minimal, non-minimal and maximal  $\iota$ .

(90) a. The expected prosodic representation of sentences with iterative relative clauses:

$$\{[\text{NP1}]_{\Phi} (\text{CP1})_{\text{min}} (\text{CP2})_{\text{min}} [\text{VP}]_{\Phi}\}_{\text{max}}$$

b. The expected prosodic representation of sentences with recursive relative clauses:

$$\{[\text{NP3}]_{\Phi} \{\text{CP2} \dots (\text{CP1})_{\text{min}}\}_{\text{non-min}} [\text{VP}]_{\Phi}\}_{\text{max}}$$

I have hypothesized that  $\iota$ -recursion should mainly be cued by different degrees of pre-boundary syllable lengthening. Specifically, the higher the prosodic domain is the larger the amount of pre-boundary syllable lengthening.

Unexpectedly, the results of Chapter 5 show that the prosodic representations of both types of sentences are identical: nested CPs/relative clauses are parsed into one minimal  $\iota$  that is marked by pre-boundary lengthening and a continuative high boundary tone, and external elements (i.e. the external antecedent and VP) form minimal  $\iota$ 's that are also marked by the same intonational and temporal cues, while the entire sentence projects a maximal  $\iota$  and cued by the greatest amount of lengthening and a low boundary tone that indicates final lowering.

Since the  $\iota$  structure for sentences with iterative and recursive relative clauses is again limited to two recursive layers, BINREC seems required here too. In addition, the results of the experiment in § 5.3 show that external antecedents and verbs form their own minimal  $\iota$ 's. This prosodic pattern seems to violate MATCH $\iota$  due to the fact that these syntactic constituents are XPs rather than CPs. However, what apparently motivates the formation of  $\iota$  around antecedents and verbs does not seem to be their syntactic constituency, but a requirement that  $\iota$ -parsing should be exhaustive. This mechanism has long been formalized by Selkirk (1996):

(91) EXHAUSTIVITY: no  $C_i$  immediately dominates a constituent  $C_j, j < i-1$ . (Selkirk 1996:6)



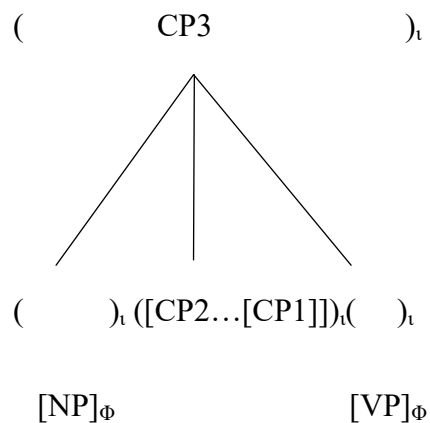
Originally, EXHAUSTIVITY was proposed as one of the constraints making up the Strict Layer Hypothesis (Nespor & Vogel 1986, Selkirk 1986). In the case at stake, it prevents the  $\Phi$ 's of the VPs and antecedents NPs from linking directly to the maximal  $\iota$  of CP3 in (92) below: they should be parsed in minimal  $\iota$ 's. This constraint has the following form in IA:

(92) EXHAUST $\iota$ : No  $\iota_{\max}$  immediately dominates a  $\Phi$ .

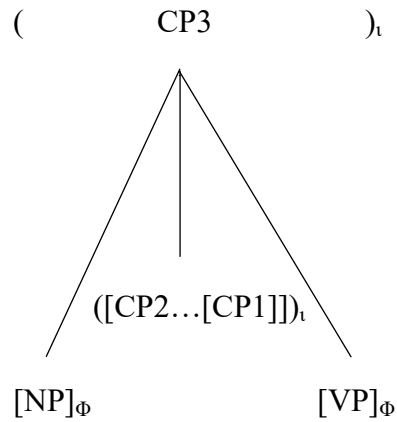
Based on this constraint, the exhaustive prosodic pattern in (93a) represents the desired phrasing pattern in IA, but the non-exhaustive prosodic pattern in (93b) is excluded.

(93) Recursive sentence:

a. Exhaustive minimal  $\iota$  level:



\*b. Non-exhaustive minimal  $\iota$  level:



In the following tableau, EXHAUST<sub>ι</sub> and BINREC are ranked higher than Match constraints to let Candidate *a*, the actual prosodic phrasing in IA, win. Candidate *a* wins over candidate *b* since it incurs fewer violations of the low-ranking constraints, MATCH<sub>ι</sub>: the first part of CP2 in candidate *b* should not form its own  $\iota$ . Candidate *c*, *d* and *e* already lost since they incur violations of high-ranking constraints. In candidate *d*, the  $\Phi$ 's corresponding to the NP and VP are directly dominated by the maximal  $\iota$ , and this maximal  $\iota$  is of three layers, similar to the maximal  $\iota$  in candidate *c*. In candidate *e*, the first part of CP2 is parsed in a  $\Phi$  and directly linked to the maximal  $\iota$ .

**Tableau 6: EXHAUST<sub>t</sub>, BINREC >> MATCH<sub>t</sub>, MATCH CLAUSE.**

**Recursive relative clauses:**

CP <sub>3</sub> [NP[ ]CP <sub>2</sub> [ ... CP <sub>1</sub> [ ]]]VP[ ]	EXHAUST <sub>t</sub>	BINREC	MATCH <sub>t</sub>	MATCH CLAUSE
a. (([NP] <sub>Φ</sub> ) <sub>t</sub> ([CP <sub>2</sub> ] <sub>Φ</sub> [CP <sub>1</sub> ] <sub>Φ</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>			**	*
b. (([NP] <sub>Φ</sub> ) <sub>t</sub> (CP <sub>2</sub> ) <sub>t</sub> (CP <sub>1</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>			***!	*
c. (([NP] <sub>Φ</sub> ) <sub>t</sub> ((CP <sub>2</sub> ) <sub>t</sub> (CP <sub>1</sub> ) <sub>t</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>		*!	***	
d. ([NP] <sub>Φ</sub> ([CP <sub>2</sub> ] <sub>Φ</sub> (CP <sub>1</sub> ) <sub>t</sub> ) <sub>t</sub> [VP] <sub>Φ</sub> ) <sub>t</sub>	**!	*		
e. (([NP] <sub>Φ</sub> ) <sub>t</sub> [CP <sub>2</sub> ] <sub>Φ</sub> (CP <sub>1</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>	*!		**	*

This provides further evidence that EXHAUST<sub>t</sub> and BINREC are high-ranking constraints in IA and that they should outrank MATCH<sub>t</sub>. However, there is no evidence for a high or a low ranking of MATCH CLAUSE and no logically possible candidates would allow us to rank it. I choose leave it low-ranked, but again one could do things the other way around and assume that it is high-ranking.

(94) EXHAUST<sub>t</sub>, BINREC >>MATCHCLAUSE, MATCH<sub>t</sub>, \*BINMAXΦ, MATCHPHRASE, MATCHΦ.

Let us now turn to sentences with iterative relative clauses. It has been shown in Chapter 5 that they share the same prosodic representation as recursive sentences, and I have proposed that this may be the outcome of a rhythmic restructuring aiming to minimize the number of minimal t's. Our current constraint ranking, in (95), predicts a prosodic representation in which each CP forms its own minimal t and the external elements, the antecedent and VP, are parsed in minimal

t's. In Tableau 7, in which the interactions of constraints let the actual prosodic phrasing in IA win in sentences with iterative relative clauses, candidate *b* is eliminated by incurring violations of the high-ranking EXHAUST<sub>t</sub>: it has two  $\Phi$ 's that are directly dominated by a maximal  $\iota$ . Candidate *c* violates BINREC by having a three-layer recursive  $\iota$ . Candidate *a* wins since it satisfies BINREC and EXHAUST<sub>t</sub> and incurs fewer violations of low-ranking constraints than candidate *d*: each CP in candidate *a*, unlike the CPs in candidate *d*, is parsed into a minimal  $\iota$ .

**Tableau 7: EXHAUST<sub>t</sub>, BINREC >> MATCH  $\iota$ , MATCH CLAUSE.**

**Iterative relative clauses:**

CP <sub>3</sub> [NP[ ] CP <sub>1</sub> [ ] CP <sub>2</sub> [ ] VP[ ]]	EXHAUST <sub>t</sub>	BINREC	MATCH <sub>t</sub>	MATCH CLAUSE
a. (([NP] <sub>Φ</sub> ) <sub>t</sub> (CP <sub>1</sub> ) <sub>t</sub> (CP <sub>2</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>			**	
b. ([NP] <sub>Φ</sub> (CP <sub>1</sub> ) <sub>t</sub> (CP <sub>2</sub> ) <sub>t</sub> [VP] <sub>Φ</sub> ) <sub>t</sub>	**!			
c. (([NP] <sub>Φ</sub> ) <sub>t</sub> ((CP <sub>1</sub> ) <sub>t</sub> (CP <sub>2</sub> ) <sub>t</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>		*!	***	
d. (([NP] <sub>Φ</sub> ) <sub>t</sub> (CP <sub>1</sub> CP <sub>2</sub> ) <sub>t</sub> ([VP] <sub>Φ</sub> ) <sub>t</sub> ) <sub>t</sub>			***!	**

At the  $\Phi$  level, restructuring normally takes place between the prosodic domains that contain a head and its complement, as proposed in Nespor & Vogel (1986): between a head noun and its non-branching adjectival modifier on its recursive side and between a verb and its non-branching direct object (Selkirk 2011). In IA, a rhythmic markedness constraint could prevent the emergence of an iterative structure with a minimal  $\iota$  for each CP, as in (95), but rather force the formation of a single minimal  $\iota$  including the two relatives, as in (96). In OT, this would happen

in parallel with all other  $\iota$  formation processes, but it is nonetheless akin with the restructuring described in earlier models.

(95) \*([ ] $\Phi$ )([ ] $\Phi$ [ ] $\Phi$ ) $\iota$  ([ ] $\Phi$ ) $\iota$ ([ ] $\Phi$ ) $\iota$ <sub>max</sub>  
 CP3[NP3[NP2[NP1[il-dʒundi]CP1 [illi lu:n-u abjað<sup>s</sup>]] CP2[illi min xaʃab]] VP[tharrak]]

il-dʒundi illi lu:n-u abjað<sup>s</sup> illi min xaʃab tharrak

DEF-pawn that color-3SGM.REF white that from DEF-wood move.3SGM.PST

‘The pawn that is white and made of wood was moved.’

(96) (([ ] $\Phi$ )([ ] $\Phi$ [ ] $\Phi$ [ ] $\Phi$ ) $\iota$ ([ ] $\Phi$ ) $\iota$ ) $\iota$ <sub>max</sub>

The nature of this rhythmic markedness constraint is not obvious at this point, but as I speculate in Chapter 5, what seems to happen is that the two relative clauses in the data are produced as a kind of parenthetical that forms its own  $\iota$ . It is a little as if they were saying in English:

(97) a. The pawn, that is made of wood and is yellow, was moved.

Since I only have limited data for the moment, I will not try to propose a formal account of this parenthetical restructuring. However, it is worth thinking about what would happen if we had more complex sentences (with more than two iterative relatives). There are two potential scenarios: the first is that all nested relative clauses would be contained in a single  $\iota$ . The other

scenario is that they would be parsed into several minimal t's. Although this is not tested empirically, my native intuitions suggest that the latter scenario is the correct one. This suggests a complex interaction of pragmatic restructuring and prosodic weight.

In the following section, I attempt to account for the formation of the  $\omega$  and highlight the importance of BINREC at this level.

### **§6.2.3 The Prosodic Word**

#### **§6.2.3.1 Lexical and Function Word**

In IA, lexical words project  $\omega$ 's and receive stress. In Match Theory (Selkirk 2011), two constraints capture this basic pattern, by which grammatical words should be parsed in  $\omega$ 's and  $\omega$ 's match grammatical words. These constraints are given in (98).

(98) a. MATCHWORD: A word in the syntactic structure must be matched by a corresponding  $\omega$  in the prosodic representation.

b. MATCH $\omega$ : A  $\omega$  in the prosodic representation must be matched by a corresponding word in the syntactic structure.

The prosodic structure of function words is slightly more complicated. In § 3.2, I have proposed, following Selkirk (1996)'s typology, that a minimally bimoraic function word projects a  $\omega$  and receives stress, thus conforming to the same pattern as lexical words. However, when a function word does not satisfy bimoraicity, it is a free clitic, which means that it is directly dominated by a  $\Phi$ . This level skipping violates early versions of the Strict Layer Hypothesis (Nespor & Vogel 1986, Selkirk 1986) in which prosodic levels should be exhaustive:  $\Phi$ 's should directly dominate  $\omega$ 's, but not feet or syllables. This derives from a prosodic markedness constraint that bans monomoraic  $\omega$ 's: BINMIN (Selkirk 2011). In IA, BINMIN would have the following form:

(99) BINMIN $\omega$ : A  $\omega$  is minimally bimoraic.

In the following tableaux, the constraints used for  $\Phi$  and  $\iota$  formation are omitted as they do not affect the selection of the optimal candidate. Let us first start with a basic case including a prosodically heavy function word and a lexical word. In Tableau 6, there are five candidates: candidate *a* has two  $\omega$ 's for the function word-lexical word sequence (note I am dealing with the function word *ka:n* as a serial verb), while candidate *b* is maximally recursive. In the last three candidates, the function word corresponds to affixal, internal, and free clitics, respectively. Candidate *d* violates MATCH $\omega$  since its  $\omega$  does not match a grammatical word. It also violates MATCHWORD twice: each word has to match a  $\omega$ . Candidate *c* incurs fewer violations of MATCHWORD by parsing the lexical word into its own  $\omega$ . Parsing the sequence into a major  $\omega$  in candidate *b* and leaving the function word without a corresponding  $\omega$  in candidate *d* cause

violations of  $\text{MATCH}\omega$  and  $\text{MATCHWORD}$  respectively. The only candidate that satisfies all the constraints is candidate *a*, in which each word has a corresponding non-recursive  $\omega$ .

**Tableau 8:  $\text{BINMIN}\omega$ ,  $\text{MATCH}\omega$ ,  $\text{MATCHWORD}$ .**

*ka:n si.miʕ* ‘He could have heard.’

$\text{VP}_{\text{aux}} [\text{ka:n}]_{\text{V}} [\text{si.miʕ}]$	$\text{BINMIN}\omega$	$\text{MATCH}\omega$	$\text{MATCHWORD}$
ⒺP a. $(\text{ka:n})_{\omega} (\text{si.miʕ})_{\omega}$			
b. $((\text{ka:n})_{\omega} (\text{si.miʕ})_{\omega})_{\omega}$		*!	
c. $(\text{ka:n} (\text{si.miʕ})_{\omega})_{\omega}$		*	*!
d. $(\text{ka:n} \text{si.miʕ})_{\omega}$		*	**!
e. $(\text{ka:n} (\text{si.miʕ})_{\omega})_{\emptyset}$			*!

Note that at this point  $\text{BINMIN}\omega$ ,  $\text{MATCHWORD}$  and  $\text{MATCH}\omega$  do not have a specific ranking in Tableau 8. I show below that  $\text{BINMIN}\omega$  has to be ranked high in IA to account for the prosodic status of function words that do not satisfy the minimality condition on  $\omega$ -formation.

As discussed in § 3.2, a function word that is monomoraic after the exclusion of its extrametrical last mora is a free clitic. In order to capture this,  $\text{BINMIN}\omega$  has to be raised to dominate other constraints. In Tableau 9, candidates *b* and *e* are eliminated because they violate  $\text{BINMIN}\omega$  by forming a  $\omega$  around the monomoraic function word *kan*, which is the reduced form of *ka:n*. Candidates *c* and *d* are both eliminated because they incur more violations of Match constraints than candidate *a*. Candidate *a* thus wins, even if its function word is not parsed in a  $\omega$ .



**Tableau9: BINMIN $\omega$  >> MATCH $\omega$ , MATCHWORD.**

*ka:n si.miʕ* ‘He could have heard.’

VP <sub>[aux]</sub> [kan] V[si.miʕ]	BINMIN $\omega$	MATCH $\omega$	MATCHWORD
a. (kan ('si.miʕ) $\omega$ ) $\Phi$			*
b. ((kan) $\omega$ ('si.miʕ) $\omega$ ) $\omega$	*!	*	
c. (kan ('si.miʕ) $\omega$ ) $\omega$		*!	*
d. (kan 'si.miʕ) $\omega$		*!	**
e. (kan) $\omega$ ('si.miʕ) $\omega$	*!		*

Even if MATCH $\omega$  is ranked below MATCHWORD, as shown in Tableau 10, the winner remains candidate *a*.

**Tableau 10: BINMIN $\omega$  >> MATCHWORD >> MATCH $\omega$ .**

*ka:n si.miʕ* ‘He could have heard.’

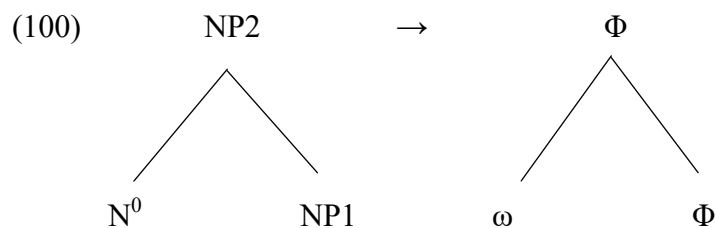
VP <sub>[aux]</sub> [kan] V[si.miʕ]	BINMIN $\omega$	MATCHWORD	MATCH $\omega$
a. (kan ('si.miʕ) $\omega$ ) $\Phi$		*	
b. ((kan) $\omega$ ('si.miʕ) $\omega$ ) $\omega$	*!		*
c. (kan ('si.miʕ) $\omega$ ) $\omega$		*	*!
d. (kan 'si.miʕ) $\omega$		**!	*
e. (kan) $\omega$ ('si.miʕ) $\omega$	*!	*	

Since I could not come up with a hypothetical candidate that incurs one violation of MATCH $\omega$  and satisfies the other constraints (except a candidate in which a  $\omega$  matches a part of a word, such as a syllable), there is no motivation for ranking MATCH $\omega$  and I therefore leave it in the last stratum with MATCHWORD.

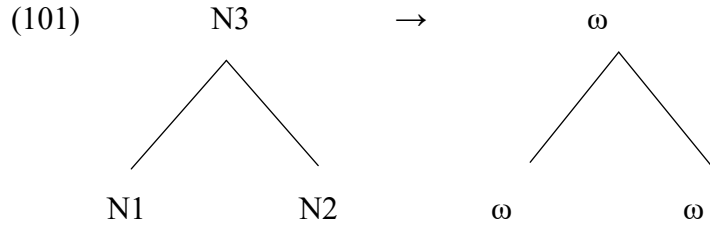
I show below that the ranking provided in Tableau 9 cannot straightforwardly predict the desired prosodic phrasing of IA genitive constructs and propose a solution.

### §6.2.3.2 Genitive Constructs

Theoretically, Match constraints require the prosodic structure of a genitive construct to directly reflect its syntactic structure and motivate  $\Phi$ -recursivity as shown in (100). As discussed in Chapter 3, Yasin (2012) suggested that a non-recursive  $\Phi$  is formed around the entire genitive construct, dominating its two  $\omega$ 's. However, I have shown in § 3.3 that a recursive  $\omega$  is necessary to account for the metrical structure of the genitive construct in IA: the recursive  $\omega$  is the domain of primary stress assignment and demotion of any other stress to secondary status. Therefore, the recursive representation in (101) must be adopted, which comes down to claiming that genitive constructs are a form of prosodic compound<sup>20</sup> consisting of two (or more) Ns. This entails that each embedded N must match a minimal  $\omega$  based on MATCHWORD and MATCH $\omega$ , and that the entire genitive construct must match a maximal  $\omega$ .



<sup>20</sup> The elements of a genitive construct are immediately adjacent (e.g. they do not allow word insertion in between) and therefore it behaves like a single lexical item or a one prosodic unit.



In the following tableau, no candidate violates high-ranking  $\text{BINMIN}_\omega$  (it has just been established that this constraint must be ranked high in IA to avoid parsing a monomoraic function word into its own  $\omega$ ). Therefore, the prosodic pattern that satisfies  $\text{MATCH}_\omega$  and  $\text{MATCHWORD}$  by perfectly mirroring the syntactic information provided in (101) wins. Candidate *a* wins over candidate *b* simply because all the available Ns have corresponding  $\omega$ 's and vice versa.

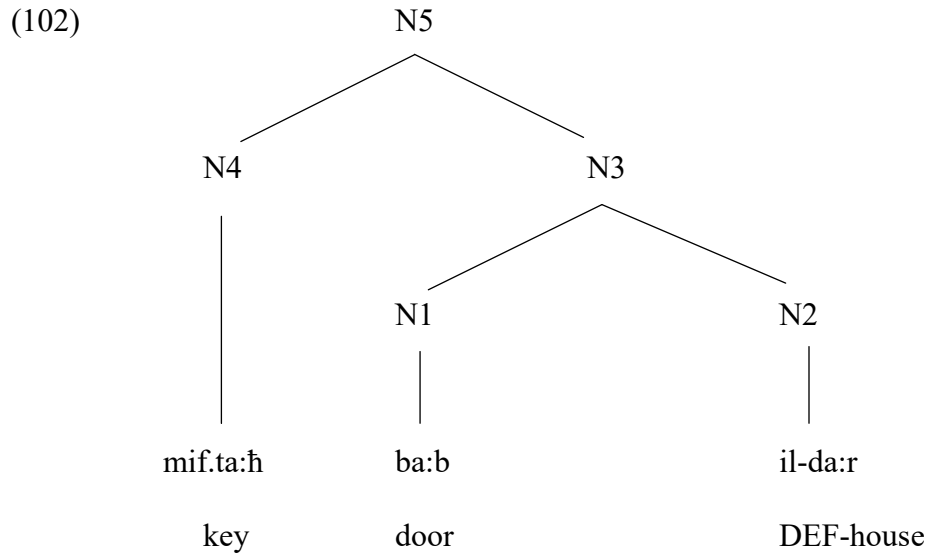
**Tableau 11:  $\text{BINMIN}_\omega \gg \text{MATCH}_\omega, \text{MATCHWORD}$ .**

*kta:b il-fi:z.ja* ‘The book of Physics’.

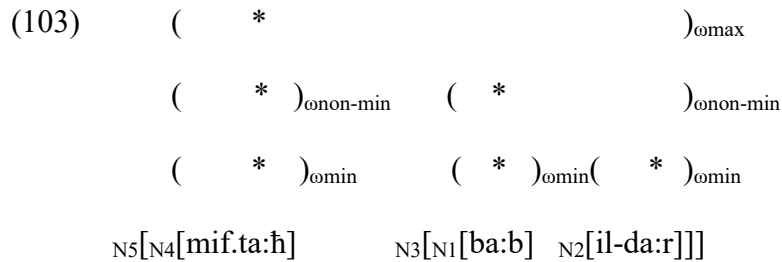
$\text{N}_3[\text{N}_1[\text{kta:b}] \text{N}_2[\text{il-fi:z.ja}]]$	$\text{BINMIN}_\omega$	$\text{MATCH}_\omega$	$\text{MATCH WORD}$
a. $((\text{kta:b})_\omega(\text{il-fi:z.ja})_\omega)_\omega$			
b. $(\text{kta:b})_\omega(\text{il-fi:z.ja})_\omega$			*!
c. $(\text{kta:b il-fi:z.ja})_\omega$			**

Interestingly,  $\text{BINREC}$  seems necessary to account for the prosodic representation of more complex genitive constructs, as exemplified in (102). I have shown in Chapter 3 that the first word in a genitive construct receives primary stress and that other stresses are demoted to secondary status. Since the genitive construct  $\text{N}_3 \textit{ba:b il-da:r}$  is embedded in  $\text{N}_5$  in (102), if  $\omega$

was fully recursive, each of the three words in this complex genitive construct should have a different metrical status, as in (103).



‘The key of the front door.’



These predictions do not precisely depict the metrical structure of complex genitive constructs in IA. Contrary to the expected representation in (103), *ba:b* and *il-da:r* bear prosodically identical secondary stresses. This means that, no matter the syntactic complexity of a genitive construct, its first element receives the primary stress and all the other stresses are demoted to secondary status, as shown in (104).

$$(104) \quad ( \quad * \quad )_{\omega_{\max}}$$

$$\quad ( \quad * \quad )_{\omega_{\min}} ( \quad * \quad )_{\omega_{\min}} ( \quad * \quad )_{\omega_{\min}}$$

$$N_5[N_4[\text{mif.ta:h}] \quad N_3[N_1[\text{ba:b}] \quad N_2[\text{il-da:r}]]]$$

Along these lines, it appears that BINREC, which was previously used for  $\iota$  and  $\Phi$ , must also be active as a constraint on the formation of the recursive prosodic domains, especially,  $\omega$ ,  $\Phi$  in IA: the maximum number of recursive layers in the  $\omega$  is two. In addition, another exhaustivity constraint is also required to avoid leaving any minimal  $\omega$  undominated by a maximal  $\omega$ :

(105) EXHAUST $\omega$ : A  $\omega_{\min}$  must be immediately dominated by a  $\omega_{\max}$ .

In the following tableau, EXHAUST $\omega$  is ranked high. Candidate *b*, *c* and *d* lose because they violate high-ranking constraints: in all these candidates, there are minimal  $\omega$ 's that are not immediately dominated by a maximal  $\omega$ . Candidate *a* wins over candidate *e* because it incurs fewer violations of the low-ranking MATCHWORD: there is only one word that lacks a corresponding  $\omega$  in candidate *a*.

**Tableau 12: EXHAUST $\omega$ , BINREC >> MATCHWORD, MATCH $\omega$ .**

*mif.ta:h ba:b il-da:r* ‘The key of the front door.’

$N_5[N_4[mif.ta:h] N_3[N_1[ba:b] N_2[il-da:r]]]$	EXHAUST $\omega$	BIN REC	MATCH WORD	MATCH $\omega$
a. $((mif.ta:h)_{\omega_{min}}(ba:b)_{\omega_{min}}(il-da:r)_{\omega_{min}})_{\omega_{max}}$			*	
b. $((mif.ta:h)_{\omega_{min}}((ba:b)_{\omega_{min}}(il-da:r)_{\omega_{non-min}})_{\omega_{max}})$	*!*	*		
c. $((mif.ta:h)_{\omega_{min}}(ba:b)_{\omega_{min}})_{\omega_{max}}(il-da:r)_{\omega_{min}}$	*!		**	*
d. $(mif.ta:h)_{\omega_{min}}((ba:b)_{\omega_{min}}(il-da:r)_{\omega_{min}})_{\omega_{max}}$	*!		*	
e. $(mif.ta:h)_{\omega}(ba:b)_{\omega}(il-da:r)_{\omega}$			***!	
f. $(mif.ta:h ba:b il-da:r)_{\omega}$			***!*	

NOREC has not been listed in all the previous tableaux. Listing NOREC results in the following clash: candidates *b* and *a* in Tableau 13 each incurs one violation of a single low-ranking constraint. Therefore, MATCHWORD has to be raised to the next highest stratum to let the recursive  $\omega$  (the actual phrasing pattern in IA) in candidate *a* be the winner.

**Tableau 13: EXHAUST $\omega$ , BINREC, MATCHWORD >> NOREC, MATCH $\omega$ .**

$N_3[N_1[ba:b] N_2[il-be:t]]$	EXHAUST $\omega$	BIN REC	MATCH WORD	NOREC	MATCH $\omega$
a. $((ba:b)_{\omega_{min}}('il-be:t)_{\omega_{min}})_{\omega_{max}}$				*	
b. $(ba:b)_{\omega}('il-be:t)_{\omega}$			*!		
c. $(ba:b 'il-be:t)_{\omega}$			*!*		

Before making any comparisons between the prosodic structures of IA and some other Arabic dialects, it is important to comment on the importance of the constraint BINREC in the grammar of IA. It has been suggested by a dissertation examiner that NOREC alone may be sufficient to

make the actual IA prosodic pattern win. However, none of the possible rankings of NOREC relative to Match constraints will yield the prosodic phrasing pattern attested in IA, a prosodic domain of maximally two recursive layers. At the  $\Phi$  level, for example, ranking NOREC below Match constraints (MATCHPHRASE, MATCH $\Phi$  >> NOREC) to account for the prosodic representation of a three-layer recursive XP leaves the three-layer recursive prosodic domain as the winning candidate. On the contrary, if NOREC is high-ranking (NOREC >> MATCHPHRASE, MATCH $\Phi$ ), candidates that have any prosodically recursive layer lose. Finally, ranking this constraint between Match constraints comes in two possible ways: MATCHPHRASE >> NOREC >> MATCH $\Phi$  and MATCH $\Phi$  >> NOREC >> MATCHPHRASE. If MATCHPHRASE is high-ranking, the winner will be the three-layer recursive  $\Phi$ , and if MATCH $\Phi$  is the highest constraint, a non-recursive prosodic pattern will be the winner.

### **§ 6.3. Prosodic domains in Arabic: Cross-dialectal Comparison**

As far as I know, prosodic recursion neither has been under examination in Arabic, nor has been reported, except in Hellmuth's (2011) work on EA. As I have mentioned in §4.1, Hellmuth has reported cues that vary in strength at XPs edges in EA. This possibly signals different prosodic subcategories: minimal and maximal  $\Phi$ 's. On the other hand, there are indications that recursion is absent at some prosodic levels. For example, the prosodic patterns that have been found in EA in Hellmuth's work indicate that the match between maximal XPs and  $\Phi$ 's is conditioned by a prosodic weight requirement: a light maximal XP is not expected to be marked by cues of  $\Phi$  boundaries, such as final lengthening and a phrase accent. Based on this finding, I assume that light minimal/embedded XPs in this dialect are less likely to project their own  $\Phi$ 's, and therefore the  $\Phi$  in this dialect should be non-recursive.

At the  $\omega$  level, Chahal and Hellmuth (2014), have suggested that the  $\omega$  is non-recursive in LA based on Abdul-Karim's (1980) argument that there is no secondary stress in this dialect. As for the  $\iota$ , further work on its formation is needed to examine prosodic recursion in these varieties.

In this section, I compare the construction of the  $\Phi$ ,  $\iota$  and  $\omega$  in IA and the above-mentioned dialects, as far as I can. My goal is to determine if differences between dialects can be captured by constraint re-rankings and minor changes to existing constraint templates, which would suggest that a Match-Theory account of IA prosody has some typological validity, or if dramatically different formal tools are needed, which would suggest that the current analysis is language-specific and too ad hoc.

### § 6.3.1 The Phonological Phrase

Based on my stipulation that EA  $\Phi$  is non-recursive, contrary to IA, the simple solution consisting in re-ranking BINREC as a low-ranking constraint and NONREC as a dominating constraint will not result in parsing a maximal XP into one prosodically heavy non-recursive  $\Phi$ . The winner will be the candidate in which each simple XP is parsed in its own  $\Phi$  which is prosodically light: (wazi:r) $_{\Phi}$ (min xaʃab) $_{\Phi}$ (ʔiʃfar) $_{\Phi}$ . This pattern satisfies Match constraints.

In fact, an XP projects a  $\Phi$  if it consists of at least three  $\omega$ 's in this dialect. I have based this claim on my understanding to Hellmuth's previous cumulative work on the construction of the  $\Phi$  in EA (2004, 2007, 2011). Therefore, I formulate this condition in EA as a markedness constraint:



(106) **TERMIN $\Phi$** : A  $\Phi$  minimally consists of three  $\omega$ 's.

In Tableau 14, which evaluates a maximal subject XP with two embedded  $\omega$ 's (along with a simple VP), this new constraint is ranked high to capture the prosodic phrasing of a maximal XP. The last three candidates lose by violating high-ranking **TERMIN $\Phi$** : each one has a  $\Phi$  that embeds less than three  $\omega$ . Therefore, the winning candidate is *a*, in which the maximal subject XP does not have a corresponding  $\Phi$ .

**Tableau 14: **TERMIN $\Phi$** >> **NONREC**, **MATCHPHRASE**, **MATCH $\Phi$** , **BINREC**.**

**Recursive XP: *wazi:r min xaʃab ʔisfar* ‘A queen made of yellow wood’.**

NP2[NP1[wazi:r] PP1[minxaʃab]]VP[tʰarrak]...	<b>TERMIN<math>\Phi</math></b>	<b>NON REC</b>	<b>MATCH PHRASE</b>	<b>BIN REC</b>	<b>MATCH<math>\Phi</math></b>
a. (wazi:rmin xaʃabtʰarrak) $\Phi$			****		*
b. (wazi:r) $\Phi$ (min xaʃab) $\Phi$ (tʰarrak) $\Phi$	***!		*		
c. (wazi:rmin xaʃab) $\Phi$ (tʰarrak) $\Phi$	**!		**		
d. ((wazi:r) $\Phi$ (min xaʃab) $\Phi$ ) $\Phi$ (tʰarrak) $\Phi$	****!	*			

In Tableau 15, which evaluates a maximal subject XP with three embedded  $\omega$ 's, candidate *a* (the actual prosodic phrasing) is the winner when **MATCHPHRASE** is also ranked high. In this candidate, the maximal subject XP and the simple VP project two non-recursive  $\Phi$ 's. Candidate *a* and candidate *d* incur the least number of violations of the high-ranking constraints, but candidate *a* wins by satisfying all the low-ranking constraints, unlike candidate *d*.

**Tableau 15: TERMIN $\Phi$ , MATCHPHRASE >> NONREC, MATCH $\Phi$ , BINREC.**

**Recursive XP: *wazi:r min xaʃab ʔiʃfar* ‘A queen made of yellow wood’.**

NP2[NP1[wazi:r] PP2[PP1[min xaʃab] AP[ʔiʃfar]]VP[tʰarrak]]	TERMIN $\Phi$	MATCH PHRASE	NON REC	BINREC	MATCH $\Phi$
a. (wazi:r min xaʃab ʔiʃfar) $\Phi$ (tʰarrak) $\Phi$	*	****			
b. (wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ (tʰarrak) $\Phi$ )	*****	*!	*		
c. (wazi:r) $\Phi$ (min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ (tʰarrak) $\Phi$	****	**!			
d. ((wazi:r) $\Phi$ ((min xaʃab) $\Phi$ (ʔiʃfar) $\Phi$ )(tʰarrak) $\Phi$ )	*****		*!*	*	
e. (wazi:r min xaʃab ʔiʃfar tʰarrak) $\Phi$		*****!			*

In Tableau 15, it seems that there is no motivation for the relative ranking of BINREC and MATCH $\Phi$ . Therefore, I leave it in the last stratum.

In AA, by contrast, any maximal XP, light or heavy, is parsed into a  $\Phi$  (Hellmuth 2016). This means that the correspondence between XPs and  $\Phi$ 's in AA is not regulated by TERMIN $\Phi$  and NOREC. In Tableau 16, candidate *a* is the desired prosodic pattern in AA, but it cannot win over candidate *b* and *d* unless MATCHPHRASE is ranked lower, and MATCH $\Phi$  higher than the other constraints.

**Tableau 16: MATCH $\Phi$ >>NONREC, BINREC, TERMIN $\Phi$ >> MATCHPHRASE.**

**Recursive XP: *wazi:r ʔiʃfar* ‘A yellow queen’.**

NP2[NP1[wazi:r] AP[ʔiʃfar]]VP[tharrak]	MATCH $\Phi$	NON REC	BIN REC	TER MIN $\Phi$	MATCH PHRASE
a. (wazi:rʔiʃfar) $\Phi$ (tharrak) $\Phi$				**	**
b. (wazi:r) $\Phi$ (ʔiʃfar) $\Phi$ (tharrak) $\Phi$				***!	*
c. ((wazi:r) $\Phi$ (ʔiʃfar) $\Phi$ (tharrak) $\Phi$ )		*		****!	
d. (wazi:rʔiʃfartharrak) $\Phi$	*!				****

The difference in  $\Phi$  construction between EA and AA can be captured by ranking TERMIN $\Phi$  and MATCHPHRASE high in EA and MATCHPHRASE low and MATCH $\Phi$  high in AA. As for the  $\Phi$  in LA, I assume, based on Chahal's (2001) dissertation, that the match of XPs to  $\Phi$ 's is conditioned by a prosodic weight requirement, similar to EA  $\Phi$ ; however, this requirement needs to be investigated further to determine the minimal weight of a  $\Phi$  in this dialect.

### § 6.3.2 The Intonational Phrase

The construction of the  $\iota$  has been studied in the same Arabic varieties as the  $\Phi$  and the  $\omega$ .  $\iota$ 's match clauses/CPs in EA (Hellmuth and Chahal 2014), LA (Chahal 2001) and AA (Yasin 2012). Following a non-recursive analysis, Chahal and Hellmuth (2014) proposed that an  $\iota$  in these dialects must dominate at least one  $\Phi$ . However, it seems that their account is not dramatically different from my account of IA, the main difference being that they do not consider gradient final lengthening as possible evidence for  $\iota$ -recursion. In addition,  $\iota$ 's restructuring, as far as I know, has not been previously reported in the studied Arabic varieties. More descriptive work is needed before  $\iota$  formation can be compared across Arabic dialects.

### § 6.3.3 The Prosodic Word

As in IA, function words that do not satisfy minimal bimoraicity are not involved in stress assignment in EA (Hellmuth 2006) and LA (Chahal and Hellmuth 2014) and can therefore be treated as free clitics. This can be generalized to regional varieties in Jordan. Overall, free clitics are less frequent in Jordanian Arabic and LA than in EA due to the tendency of Egyptian speakers to reduce and therefore de-stress several function words and some lexical words. Following this reasoning, the same analysis that has been presented for words in IA in § 6.2 can be extended to Jordanian and Lebanese dialects (i.e. BINMIN $\omega$  has to be ranked high in these dialects).

It has been shown in Chapter 3 that a recursive  $\omega$  is necessary to capture the secondary stress in IA genitive constructs. As explained in detail in § 3.3, simple genitive constructs are composed of two  $\omega$ 's that each has its own stress, but these  $\omega$ 's are embedded in a larger  $\omega$  in which the first stress is promoted to primary status while the second is demoted to secondary status. Recall that my analysis of genitive constructs is different from Yasin's (2012) in that he treats the two elements of the genitive construct in AA as non-recursive  $\omega$ 's dominated by a  $\Phi$ .

Yasin's analysis entails that each word in a genitive construct receives main stress, but this contradicts the empirical evidence provided by Al-Ani (1992) that is an uneven metrical structure in genitive constructs in Arabic. It seems that the genitive constructs are parsed into recursive  $\omega$ 's not only in IA, but in other Jordanian Arabic varieties, be them *Fallahi*, *Madani* or *Badawi* varieties (but I concede that this is an empirical question). However, if the genitive

constructs in AA are indeed prosodically different from their counterparts in IA and project two flat  $\omega$ 's, NONREC would have to be ranked high in AA, as shown in Tableau 17. Otherwise, it is MATCHWORD, which has to be ranked high (as in IA), so that candidate *c*, which contains a recursive  $\omega$ , can win.

**Tableau 17: BINMIN $\omega$ , NONREC >> MATCH $\omega$ , MATCHWORD, BINREC.**

*Ba:b il-bi:t* 'The house door'.

$N_3[N_1[ba :b] N_2[il-be :t]]$	<b>BINMIN <math>\omega</math></b>	<b>NON REC</b>	<b>MATCHWORD</b>	<b>MATCH<math>\omega</math></b>	<b>BINREC</b>
a. (ba:b 'il-be:t) $\omega$			**!		
<del>b.</del> (ba:b) $\omega$ ('il-be:t) $\omega$			*		
c. ((ba:b) $\omega$ ('il-be:t) $\omega$ ) $\omega$		*!			

In EA, it has been reported in Hellmuth's (2006) dissertation that in her collected dataset there are few tokens of genitive constructs in which the first word of this construction is de-accented, but the majority of the tokens show that both words are accented. Therefore, there are two possible scenarios for the metrical and prosodic representation in EA: EA speakers, similar to IA speakers, normally promote one stress to primary status and the other to secondary but sometimes they de-stress the first word, as shown in (107b). It is also possible that each word equally receives main stress, and in some cases the first word is de-stressed.

In (107a), the most prominent word is the genitive construct-initial *ba:b* in IA. On the contrary, when the first word is reduced in EA in (108b) and looks like a clitic, the genitive construct-final *il-be:t* in EA is the most prominent word.

(107) a. IA:

((ba:b)<sub>ω</sub> (,il-be:t)<sub>ω</sub>)<sub>ω</sub>

door DEF-house

‘The house door.’

b. EA:

(bab (‘il-be:t)<sub>ω</sub>)<sub>Φ</sub>

It has been shown above that TERMIN $\Phi$  and MATCHPHRASE are ranked high in order to parse a XP that contains three  $\omega$ 's into a  $\Phi$  in EA. NONREC and MATCHWORD are also ranked higher than TERMIN $\Phi$  to account for the prosodic representation of the genitive constructs in EA when the first word is de-stressed. In the following tableau, for example, there are five candidates: a  $\Phi$  that contains a free clitic in *a*, two non-recursive  $\omega$ 's in *b*, a recursive  $\omega$  which contains an affixal clitic in *c*, a recursive  $\omega$  that embeds two minor  $\omega$ 's in *d* and a non-recursive  $\omega$  in *e*. All of them incur at least one violation of high-ranking constraints, but candidate *a* wins because, unlike the other candidates, it incurs a single violation of a high-ranking constraint MATCHWORD: in this candidate, the function word does not project a  $\omega$ . On the other hand, this candidate satisfies BINMIN $\omega$  and NONREC: the light function word does not have a  $\omega$ , and recursion is not present in this pattern.

**Tableau 18: NONREC, BINMIN $\omega$ , MATCHWORD >> TERMIN $\Phi$  >> MATCH $\omega$ .**

***Ba:b il-be:t*** ‘The house door’.

$N_3[N_1[ba :b] N_2[il-be :t]]$	NON REC	BINMIN $\omega$	MATCH WORD	TERMIN $\Phi$	MATCH $\omega$
a. (bab ('il-be:t) $\omega$ ) $\Phi$			*	*	
b. (bab) $\omega$ ('il-be:t) $\omega$		*	*!		
c. (bab ('il-be:t) $\omega$ ) $\omega$	*		*!		
d. ((bab) $\omega$ ('il-be:t) $\omega$ ) $\omega$	*	*!			
e. (bab 'il-be:t) $\omega$			**!		

The prosodic representation of the genitive constructs in LA, as far as I know, has not been investigated yet. However, I assume that LA, like AA and IA, tends to avoid the reduction of the first lexical word of the genitive construct that exists in EA. I also assume that in these three dialects secondary stress is found in the genitive constructs and these constructions match recursive  $\omega$ 's. It is worth noting that empirical studies should be done on the metrical and prosodic structure of genitive constructs in various Arabic dialects in order to determine whether the prosodic representation of this syntactic structure varies across Arabic dialects.

## § 6.4 Conclusion

In § 6.2, I have presented an OT analysis for IA prosodic patterns. This analysis highlights a few important results of this dissertation. There seems to be a fairly close match between syntactic structure and prosody in IA. This is realized by the important role of the Match constraints and the low ranking of NOREC. However, there are limits to this mirroring of syntax by prosody.

First, prosodic recursion seems to be limited to two levels per prosodic constituents. Therefore,

this dissertation can be added to the previous work supporting the existence of recursion in the prosodic structure of various languages (Truckenbrodt 1999, Wagner 2005, 2010, Elfner 2012, Itô & Mester 2012, 2013 among others), but it is to my knowledge the first piece of work that suggests that there may be a binary maximum to prosodic recursivity. Second, the language seems to require an exhaustive parsing of some prosodic constituents:  $\omega$ 's and  $\iota$ 's.

In § 6.3, I have shown that IA is special in some respects, but that minor rerankings of faithfulness constraints (i.e. syntactic-prosodic and prosodic-syntactic correspondence constraints) and markedness constraints can capture dialectal differences. The fact that similar formal tools can be used to generate the prosodic parsing of the various dialects at stake would tend to suggest that a Match-Theory account of IA prosody has some typological validity.



## §7 Conclusion

### §7.1 Overview of the results

This dissertation has provided an empirical and theoretical analysis of the prosodic structure of Jordanian Arabic as spoken in the rural areas of Irbid (IA). I have presented empirical evidence for the  $\omega$ ,  $\Phi$  and  $\iota$  in IA and their formation. No evidence for any other prosodic level has been found. Furthermore, results suggest that these prosodic domains are recursive, and that their recursion is motivated by syntactic embedding. These results have been framed in a Match-Theory account (Selkirk 2009, 2011). They suggest that prosodic domains match their syntactic counterparts and largely mirror syntactic recursion, but also need to be constrained by markedness constraints that result in prosodic patterns that are not completely isomorphic with their syntactic counterparts (e.g. each prosodic level has maximally two recursive layers). Along these lines, the prosodic domains that have syntactic grounds in IA are: maximal  $\iota$  >> minimal  $\iota$  >> maximal  $\Phi$  >> minimal  $\Phi$  >> maximal  $\omega$  >> minimal  $\omega$  >> foot >> syllable.

Cross-dialectal comparisons have also shown that this account can predict the prosodic differences among the studied Arabic dialects mainly by proposing a few markedness constraints and making minimal re-rankings (see § 6.4). This contribution supports the typological validity of a Match-Theory account of IA prosody. One theoretical contribution of this dissertation, based on empirical evidence, is to propose a constraint that defines the maximum number of recursive layers of a prosodic level (i.e. BINREC). I summarize below the results of each empirical chapter.

In Chapter 3, I have provided phonological evidence for the  $\omega$  and explored its syntactic grounding. In § 3.2, I have investigated the status of grammatical words: minimally bimoraic words form their own  $\omega$ 's whereas the syllables or feet of monomoraic words directly link to  $\Phi$ 's. In § 3.3, several types of evidence for  $\omega$ -recursion have been provided. First, while maximal  $\omega$  is the domain of primary stress, other words in genitive constructs receive secondary stress, supporting the existence of minimal  $\omega$ 's. This uneven metrical structure confirms the empirical results of Al-Ani (1992) and goes against Yasin (2012), who claimed that each  $\omega$  in a genitive construct receives main stress. The realization of the feminine suffix  $-t$  in genitive construct-internal position was argued to further suggest that IA genitive constructs form recursive  $\omega$ 's. The final piece of evidence in favor of  $\omega$ -recursion comes from the coarticulation of pharyngealization in genitive constructs. However, my results are a bit more complicated than expected as they indicate that this type of coarticulation does not simply apply within  $\omega$ 's, but is rather blocked by the boundaries of two adjacent  $\omega$ 's.

In Chapter 4, I have provided intonational and temporal evidence regarding the  $\Phi$  and its recursive nature. The empirical results indicate that minimal  $\Phi$ 's in IA match simple XPs while maximal  $\Phi$ 's match complex XPs ( i.e. XPs at the immediately higher syntactic level) for both right and left branching extra-complex XPs:

(108)

a. A right-branching XP:

((            ) $\Phi_{\min}$ ((            ) $\Phi_{\min}$ ) $\Phi_{\max}$ (            ) $\Phi_{\min}$ )

CP<sub>[NP3[NP2[NP1[il-ḍʒundi]</sub> AP[il-iswad]] PP[min xaʃab]]

DEF-soldier DEF-black            from wood

‘The black wooden pawn’.

b. A left-branching XP:

(            ) $\Phi_{\min}$  ((            ) $\Phi_{\min}$ (            ) $\Phi_{\min}$ ) $\Phi_{\max}$

CP<sub>[NP3[NP1[ḍʒundi]</sub> PP2[PP1[min xaʃab] AP[iswad]]]

soldier            from wood            black

‘A pawn made of black wood’.

The right boundaries of minimal  $\Phi$ 's are cued by pre-boundary syllable lengthening and (L-) boundary tones. Maximal  $\Phi$ 's are marked by further pre-boundary lengthening. This entails that the syntactic complexity of XPs motivates  $\Phi$ -recursion but just to a certain extent: only the lowest and the immediately higher syntactic levels impact the formation the  $\Phi$  level. These results are different from previous studies on Arabic vernaculars in which  $\Phi$ -recursion was not reported (Yasin 2012, Chahal and Hellmuth 2014, Hellmuth 2015).

In Chapter 5, I have addressed  $\iota$  formation. I have shown that  $\iota$ 's match clauses and provided two types of evidence to  $\iota$  boundaries: segmental and suprasegmental. I have shown that vowel deletion, a strategy to avoid vowel hiatus, is sensitive to  $\iota$  boundaries, but not in a categorical

manner: vowels usually, but not always, resist reduction at clause edges. The suprasegmental evidence supports the syntactic grounding of the  $\iota$  and  $\iota$ -recursion: a maximal  $\iota$  corresponds to the topmost CP of a complex sentence and minimal  $\iota$ 's match CPs immediately embedded in it. Again, only two levels of recursion are allowed: lower CPs, like the CP1 embedded in CP2 in (109b) do not have a corresponding  $\iota$ . The data also point to some phonologically-conditioned departures from syntax: for instance, any  $\Phi$  that is not included in a minimal  $\iota$  for syntactic reasons must nonetheless be parsed in a minimal  $\iota$  to ensure that this prosodic layer is exhaustive:

(109) a. A sentence with iterative relative clauses and prosodic representation:

$$(([\quad]_{\Phi})_{\min}([\quad]_{\Phi}[\quad]_{\Phi}[\quad]_{\Phi})_{\min}([\quad]_{\Phi})_{\min})_{\max}$$

$$CP3[NP3[ NP2[ NP1[il-\widehat{d}\zeta\text{undi}]] CP1[illi lu:n-u abja\delta^s]] CP2[illi min xa[ab]] VP[t\harrak]]$$

il- $\widehat{d}\zeta\text{undi}$  illi lu:n-u abja $\delta^s$  illi min xa[ab] t\harrak

DEF-pawn that color-3SGM.REF white that from DEF-wood move.3SGM.PST

‘The pawn that is white and made of wood was moved.’

b. A sentence with recursive relative clauses and prosodic representation:

$$(([\quad]_{\Phi})_{\min}([\quad]_{\Phi}[\quad]_{\Phi}[\quad]_{\Phi})_{\min}([\quad]_{\Phi})_{\min})_{\max}$$

$$CP3[NP4[NP3[il-\widehat{d}\zeta\text{undi}]] CP2[illi min NP2[NP1[xa[ab]] CP1[lu:n-u aswad]]] VP[t\harrak]]$$

il- $\widehat{d}\zeta\text{undi}$  illi min xa[ab] lu:n-u aswad t\harrak

DEF-pawn that from wood color-3SGM.REF black move-3SGM.PST

The right boundaries of minimal  $\iota$ 's are marked by pre-boundary lengthening and continuative H% tones. As for the right boundaries of maximal  $\iota$ 's, they are cued by further lengthening and sentence-final boundary tones (which are all L% in my data, but can have other tonal specifications). Unexpectedly, the results of Chapter 5 show that the CPs of iterative relative clauses have to be grouped into one minimal  $\iota$ . Factors that may explain this parsing include the nature of the speech task, speech rate and prosodic weight requirements.

In Chapter 6, as mentioned above, I have accounted for the possible prosodic phrasing patterns of IA and some dialectal differences among four Arabic vernaculars: IA, Egyptian Arabic (EA), Lebanese Arabic (LA) and Jordanian Arabic as spoken in Amman (AA) in a Match-Theory (Selkirk 2011) framework. These dialectal differences are mainly based on my understanding to previous work on the prosody of these dialects. The standard MATCH constraints proposed in Match Theory (Selkirk 2011), and a few markedness constraints that are mostly borrowed from previous work (NONREC, BINMIN $\omega$ , EXHAUST) could capture most IA prosodic patterns and pave the way to account for dialectal prosodic differences and to have more empirical studies that focus on the prosodic structures of Arabic vernaculars. The main innovations proposed here are: 1) the constraint BINREC, which limits prosodic recursion to two levels in IA, a markedness requirement that has to my knowledge never been found in other languages, and 2) the postulation of the TERMIN constraint template to account for the weight-conditioned prosodic restructuring attested in other dialects.

More generally, a non-negligible contribution of this dissertation is to bring out new evidence about the prosodic structure of a vernacular Arabic dialect and new parameters of variation.

## **§7.2 Limitations and directions for future research**

The nature of the collected datasets is the main limitation of this study. Since the target of the experiment were specific syntactic structures that may not be easily found in spontaneous speech (i.e. grammatical words, maximal XPs that embed three low level XPs, simple genitive constructs and sentences that embed two CPs), the datasets are a mixture of non-spontaneous and semi-spontaneous speech that were collected using reading and game-based tasks. A related limitation is that the dataset could not possibly explore all known types of syntactic structures: as this is the first study of IA prosody, it was necessary to begin with a relatively small set of simple sentences. As such, my results open the door to further investigation of structures that did not behave as expected and of more complex sentences that could support or infirm the analyses proposed here.

Since the collected data are at best semi-spontaneous, running another game-based task (e.g. tangram task (Clark & Shober 1992) or toy-moving task (Snedecker and Trueswell 2003)) could help in confirming my empirical results and determining whether the participants were influenced by the surrounding recording conditions or the training sessions too much or not. Another experiment that can complement my dissertation is a perception experiment to see how natural the resulting prosodic patterns to other native speakers.

Further work could also be conducted to investigate, for example, the prosodic representations of focused, topicalized and clefted constituents in IA. Such empirical investigations will be complementary to my dissertation in which I have focused on the correspondence between syntactic and prosodic domains and on cues to prosodic boundaries. Actually, I expect that these constituents will form their  $\iota$ 's and their boundaries are marked by the same cues that have been found in my dissertation: final lengthening and high continuative boundary tones in sentence-non-final position. Furthermore, collecting and analyzing complex genitive constructs will be useful to make sure that there are no more than two types of stress in IA: primary and secondary.

In addition to the limitations on the collected datasets, one of the points that need to be highlighted and may need further empirical investigation is why iterative relative clauses were lumped together into a single  $\iota$  in Chapter 5. Whether this is due to their weight, to pragmatic factors or to experimental effects is something that remains to be determined for certain.

It would be interesting to see whether the three main unexpected results of this dissertation (maximally binary recursion, exhaustivity of the  $\iota$  and the uneven structure of genitive constructs) can be extended to other Arabic vernaculars or if they are specific to IA. For instance, one could try to determine which dialects deal with the genitive constructs as single non-recursive  $\omega$ 's and which treat them as recursive  $\omega$ 's. A better picture of the prosodic diversity of Arabic varieties could open the door further typological generalizations and even open the door to a diachronic study of Arabic prosody.

Finally, it is worth repeating that the cues to prosodic boundaries at the left edges of syntactic constituents, such as F0 reset and the suspension of downstep, were hard to investigate not only because IA participants did not constantly use these cues, but also because the domain of application of downstepping in the recorded tokens seems to vary across participants. This will need to be further investigated with experimental materials specifically designed to control for the various factors involved.



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## §9 Appendices

### A. Appendix 1: (Pharyngealization coarticulation)

Sequences of function and lexical words with a pharyngeal consonant:

(1) kaam      ʔa:lib

How-many    student

‘How many students?’

(2) iða        ʔalab

If            ask.SG3M

‘‘If he asks’’.

(3) lamma    ʔaab

When        healed-SG3M

‘When he is healed’.

(4) bass      ʂaʕub

but        hard

‘But it is hard’.

Sequences of function and lexical words with no pharyngeal consonant:

(5) kaam      ʔaajib

How-many repentant

‘How many repentant?’

(6) iða ʔeʕib

If get tired.SG3M

‘‘If he gets tired’’.

(7) lamma    taab

When        repent.3SGM.PST

‘When he repented’.

(8) bas sahil

But easy

‘It is easy.’

Construct states with a pharyngeal consonant:

(15) tuul axuu-ha

Length brother-3SGFPOSS.

‘The length of her brother’.

(16) nuṣ saʕah

Half hour

‘Half an hour’.

(17) aḥsan ṭaalib

Better student

‘The best student’.

(18) aḥla ḏaw

Higher light

‘The brightest light’.

(19) akbar ṭulum

Biggest injustice

‘Unbearable injustice’.

(20) tuul abuu-ha

Length father-3SGFPOSS.

‘The length of her father’.



## B. Appendix 2: (Vowel hiatus by vowel deletion)

### i. Vowel in hiatus at XPs edges:

(1) NP<sub>N</sub>[sajjaart-u]    AP[il-d̄ʒadi:de]    VP[V[in-sarga-t]

DEF-Mazda    DEF-new    CAUS-steal.F.

‘His new Mazda was stolen.’

(2) NP<sub>N</sub>[ʃantitha]    AP[il-iswada]    VP[V[in-sarga-t]

Bag-REF.SG3M    DEF-black.F.    CAUS-steal-F.

‘Her black bag was stolen.’

(3) NP<sub>N</sub>[gamiş-u]    AP[il-guṭuni]    VP[V[in-gasal]

Shirt-REF.SG3M    DEF-cotton    CAUS-washed

‘His shirts from original cotton was washed.’

(4) NP<sub>N</sub>[sajja:rt-u]    AP[il-zarga]    AP[il-d̄ʒadi:de]    VP[V[ax̄ða-t]    NP[ðarbah]]

Key-REF.SG3M    DEF-blue    DEF-new    take-F.3SG.PST    hit

‘His new blue car got hit.’

(5) NP<sub>N</sub>[sajja:rit-ha]    VP[V[in-ðarba-t]

car-REF.SG3M    CAUS-hit-F.3SG.PST.

‘His car got hit.’

(6) NP<sub>N</sub>[gamiş-u]    VP[V[in-gasal]

Shirt-REF.SG3M    CAUS-washed

‘His shirt was washed.’

### ii. Vowels in hiatus at clauses edges:

Conditionals:

(1) ʔiða aḍʒu    imfu

If    come.3SGM-PST    walk.2PLM

‘When they come, you can go.’

(2) iða id̄ʒa, imfi  
If come.3SGM.PST walk.2SG

‘When he comes, you can go.’

(3) lamma txallşi, ihki  
When finish.2SGM talk.2SGM

‘When you finish, tell me.’

(4) lamma itxallşu, iħk-u  
When finish.2PLM talk.2SGM

‘When you finish, tell me.’

(5) btigdar-u timf-u, iða ad̄ʒ-u  
Can-2PLM walk-2PLM if come-3PLM.PST

‘You can go when they come.’

(6) btigdar timfi, iða ad̄ʒa  
Can.2SGM walk if come.3SGM.PST

‘You can go when he comes.’

Parentheticals:

(1) il-raadju ismafi iştayal  
DEF-radio listen work.3SGM.PST

‘Listen! The radio has started working again.’

(2) ĵirkit-ki, akiid, raħ tinkasir  
Company-2SGF.REF definitely will break.3SGF

‘Definitely, your company will break down.’

(3) nokja, aħsan talafoon, ingaťaŋ min ilsuug  
Nokia better telephone cut from Def-market

‘Nokia mobile phone, which is the best, is no longer sold.’

(4) talifoon-i, akiid, insarag  
 Phone-1SG.REF definitely steal.3SGM.CAUS

‘Definitely, my mobile phone has been stolen.’

(5) firkit-ki, ihtimaal, raḥ tinkasir  
 Company-2SGF.REF possibly will break.3SGF

‘Your company may break down.’

(6) ?il-raadju, ismaʕ-i, iftayaal  
 DEF-radio listen-2SGF work.3SGM.PST

‘Listen! The radio is working.’

(7) talifoon-i, ihtimaal insarag  
 Phone-1SG.REF possibly steal.3SGM.CAUS

‘My phone may be stolen.’

### C. Appendix 3 (Right-branching and left-branching extra-complex XPs):

#### Left-branching stimuli:

1. NP2[NP1[iḷ-ḍʒundi] PP2[PP1[*min* xaʃab] AP[iswad]]] VP[tharrak]  
 DEF-soldier from wood black move.PST step

‘The pawn made of black wood was moved.’

2. NP2[NP1[iḷ-ḍʒundi] PP2[PP1[*min* xaʃab] AP[abjad]]] VP[tharrak]  
 DEF-soldier from wood white move.PST step

‘The pawn made of white wood was moved.’

3. NP2[NP1[iḷ-ḍʒundi] PP2[PP1[*min* blastek] AP[iswad]]] VP[tharrak]  
 DEF-soldier from plastic black move.PST step

‘The pawn made of black plastic was moved.’

4. NP2[NP1[iḷ-ḍʒundi] PP2[PP1[*min* balstek] AP[abjad]]] VP[tharrak]  
 DEF-soldier from plastic white move.PST step

‘The pawn made of white plastic was moved.’

5. NP2[NP1[iḷ-fi:l] PP2[PP1[*min* xaʃab] AP[iswad]]] VP[tharrak]  
 DEF-elephant from wood black move.PST step

‘The bishop made of black wood was moved.’

6. NP2[NP1[iḷ-fi:l] PP2[PP1[*min* xaʃab] AP[abjad]]] VP[tharrak]  
 DEF-elephant from wood white move.PST step

'The bishop made of white wood was moved.'

7.NP2[NP1[il-fi:l] PP2[PP1[min balstek] AP[iswad]]] VP[tharrak]  
DEF-elephant from plasticblack move.PST step

'The bishop made of black plastic was moved.'

8.NP2[NP1[il-fi:l] PP2[PP1[min balstek] AP[abjad]]] VP[tharrak]  
DEF-elephant from plastic white move.PST step

'The bishop made of white pastic was moved.'

9.NP2[NP1[il-Has:n] PP2[PP1[min xaʃab] AP[iswad]]] VP[tharrak]  
DEF-housefrom wood black move.PST step

'The knight made of black wood was moved.'

10.NP2[NP1[il-Has:n] PP2[PP1[min xaʃab] AP[abjad]]] VP[tharrak]  
DEF-house from wood white move.PST step

'The knight made of white wood was moved.'

11.NP2[NP1[il-Has:n] PP2[PP1[min balstek] AP[iswad]]] VP[tharrak]  
DEF-house from plastic black move.PST step

'The knight made of black plastic was moved.'

12.NP2[NP1[il-Has:n] PP2[PP1[min balstek] AP[abjad]]] VP[tharrak]  
DEF-house from plasticwhite move.PST step

'The knight made of whiteplastic was moved.'

13.NP2[NP1[il-gal'a] PP2[PP1[min xaʃab] AP[iswad]]] VP[tharraka-t]  
DEF-castlefrom wood black move.PST step-F.

'The rock made of black wood was moved.'

14.NP2[NP1[il-gal'a] PP2[PP1[min xaʃab] AP[abjad]]] VP[tharraka-t]  
DEF-castle from wood white move.PST step-F.

'The rock made of white wood was moved.'

15.NP2[NP1[il-gal'a] PP2[PP1[min bastek] AP[iswad]]] VP[tharraka-t]  
DEF-castle from plastic black move.PST step-F.

'The rock made of black plastic was moved.'

16.NP2[NP1[il-gal'a] PP2[PP1[min balstek] AP[abjad]]] VP[tharraka-t]  
DEF-castle from wood white move.PST step-F.

'The rock made of white plastic was moved.'

17.NP2[NP1[il-wazi:r] PP2[PP1[min xaʃab] AP[iswad]]] VP[tharrak]  
DEF-ministerfrom wood black move.PST step

'The queen made of black wood was moved.'

18.<sub>NP2</sub>[<sub>NP1</sub>[il-wazi:r] <sub>PP2</sub>[<sub>PP1</sub>[min xaʃab] <sub>AP</sub>[abjad]]] <sub>VP</sub>[tharrak]  
DEF-minister from wood white move.PST step

'The queen made of white wood was moved.'

19.<sub>NP2</sub>[<sub>NP1</sub>[il-wazi:r] <sub>PP2</sub>[<sub>PP1</sub>[min bastek] <sub>AP</sub>[iswad]]] <sub>VP</sub>[tharrak]  
DEF-minister from wood black move.PST step

'The queen made of black plastic was moved.'

20.<sub>NP2</sub>[<sub>NP1</sub>[il-wazi:r] <sub>PP2</sub>[<sub>PP1</sub>[min bastek] <sub>AP</sub>[abjad]]] <sub>VP</sub>[tharrak]  
DEF-minister from wood white move.PST step

'The queen made of white palstic was moved.'

21.<sub>NP2</sub>[<sub>NP1</sub>[il-malik] <sub>PP2</sub>[<sub>PP1</sub>[min xaʃab] <sub>AP</sub>[iswad]]] <sub>VP</sub>[tharrak]  
DEF-kingfrom wood black move.PST step

'The king made of black wood was moved.'

22.<sub>NP2</sub>[<sub>NP1</sub>[il-malik] <sub>PP2</sub>[<sub>PP1</sub>[min xaʃab] <sub>AP</sub>[abjad]]] <sub>VP</sub>[tharrak]  
DEF-king from wood black move.PST step

'The king made of abjad wood was moved.'

23.<sub>NP2</sub>[<sub>NP1</sub>[il-malik] <sub>PP2</sub>[<sub>PP1</sub>[min blastek] <sub>AP</sub>[iswad]]] <sub>VP</sub>[tharrak]  
DEF-king from plastic black move.PST step

'The king made of black plastic was moved.'

24.<sub>NP2</sub>[<sub>NP1</sub>[il-malik] <sub>PP2</sub>[<sub>PP1</sub>[min balstek] <sub>AP</sub>[abjad]]] <sub>VP</sub>[tharrak]  
DEF-king from plastic black move.PST step

'The king made of abjad plastic was moved.'

### Right-branching stimuli:

1. <sub>NP3</sub>[<sub>NP2</sub>[<sub>NP1</sub>[il-dʒundi] <sub>AP</sub>[il-iswad]] <sub>PP</sub>[min xaʃab]] <sub>VP</sub>[tharrak]  
DEF-Soldier DEF-black from wood move.PST

'The black wooden pawn moved.'

2. NP3[NP2[NP1[il-dʒundi]AP[il-abjad]] PP[min xaʃab]] VP[ʰarrak]  
 DEF-Soldier DEF-white from wood move.PST

'The white wooden pawn moved.'

3. NP3[NP2[NP1[il-dʒundi] AP[il-iswad]] PP[min blastek]] VP[ʰarrak]  
 DEF-Soldier DEF-black from plastic move.PST

'The black plastic pawn moved.'

4. NP3[NP2[NP1[il-dʒundi] AP[il-abjad]] PP[min balstic]] VP[ʰarrak]  
 DEF-Soldier DEF-white from plastic move.PST

'The white plastic pawn moved.'

5. NP3[NP2[NP1[il-fi:l] AP[il-iswad]] PP[min xaʃab]] VP[ʰarrak]  
 DEF-Elephant DEF-black from wood move.PST

'The black wooden bishop moved.'

6. NP3[NP2[NP1[il-fi:l] AP[il-abjad]] PP[min xaʃab]] VP[ʰarrak]  
 DEF-elephant DEF-white from wood move.PST

'The white wooden bishop moved.'

7. NP3[NP2[NP1[il-fi:l] AP[il-iswad]] PP[min blastek]] VP[ʰarrak]  
 DEF-elephant DEF-black from plastic move.PST

'The black plastic pawn moved.'

8. NP3[NP2[NP1[il-fi:l] AP[il-abjad]] PP[min balstic]] VP[ʰarrak]  
 DEF-elephant DEF-white from plastic move.PST

'The white plastic bishop moved.'

9. NP3[NP2[NP1[il-Hsa:n] AP[il-iswad]] PP[min xaʃab]] VP[ʰarrak]  
 DEF-horse DEF-black from wood move.PST

'The black wooden knight moved.'

10. NP3[NP2[NP1[il-Has:n] AP[il-abjad]] PP[min xaʃab]] VP[ʰarrak]  
 DEF-horse DEF-white from wood move.PST

'The white wooden knight moved.'

11. NP3[NP2[NP1[il-Has:n] AP[il-iswad]] PP[min blastek]] VP[tharrak]  
DEF-horse DEF-black from plastic move.PST

'The black plastic knight moved.'

12. NP3[NP2[NP1[il-Has:n] AP[il-abjad]] PP[min balstic]] VP[tharrak]  
DEF-horse DEF-white from plastic move.PST

'The white plastic knight moved.'

13. NP3[NP2[NP1[il-gal'a] AP[il-iswad]] PP[min xaʃab]] VP[tharrak]  
DEF-castle DEF-black from wood move.PST

'The black wooden rock moved.'

14. NP3[NP2[NP1[il-gal'a] AP[il-abjad]] PP[min xaʃab]] VP[tharrak]  
DEF-castle DEF-white from wood move.PST

'The white wooden rock moved.'

15. NP3[NP2[NP1[il-gal'a] AP[il-iswad]] PP[min blastek]] VP[tharrak]  
DEF-castleDEF-black from plastic move.PST

'The black plastic rock moved.'

16. NP3[NP2[NP1[il-gal'a] AP[il-abjad]] PP[min balstic]] VP[tharrak]  
DEF-castleDEF-white from plastic move.PST

'The white plastic rock moved.'

17. NP3[NP2[NP1[il-wazi:r] AP[il-iswad]] PP[min xaʃab]] VP[tharrak]  
DEF-minister DEF-black from wood move.PST

'The black wooden queen moved.'

18. NP3[NP2[NP1[il-wazi:r] AP[il-abjad]] PP[min xaʃab]] VP[tharrak]  
DEF-minister DEF-white from wood move.PST

'The white wooden queen moved.'

19. NP3[NP2[NP1[il-wazi:r] AP[il-iswad]] PP[min blastek]] VP[tharrak]  
DEF-minister DEF-black from plastic move.PST

'The black plastic queen moved.'

20. NP3[NP2[NP1[il-wazi:r] AP[il-abjad]] PP[min balstic]] VP[tharrak]  
DEF-minister DEF-white from plastic move.PST

'The white plastic queen moved.'

21. NP3[NP2[NP1[il-malik] AP[il-iswad]] PP[min xaʃab]] VP[tharrak]  
DEF-king DEF-black from wood move.PST

'The black wooden king moved.'

22. NP3[NP2[NP1[il-malik] AP[il-abjad]] PP[min xaʃab]] VP[tharrak]  
DEF-king DEF-white from wood move.PST

'The white wooden king moved.'

23. NP3[NP2[NP1[il-wazi:r] AP[il-iswad]] PP[min blastek]] VP[tharrak]  
DEF-minister DEF-black from plastic move.PST

'The black plastic queen moved.'

24. NP3[NP2[NP1[il-wazi:r] AP[il-abjad]] PP[min balstic]] VP[tharrak]  
DEF-minister DEF-white from plastic move.PST

'The white plastic queen moved.'



#### D. Appendix 4: Left-branching stimuli:

1. il-ḍʒundi illi min xaʃab lu:n-u iswad tharrak  
DEF-soldier that from wood color-3SM.POSS black move.PST  
'The pawn which is made of black wood was moved.'

2. il-ḍʒundi illi min xaʃab lu:n-u abjad tharrak  
DEF-soldier that from wood color-3SM.POSS white move.PST  
'The pawn which is made of white wood was moved.'

3. il-ḍʒundi illi min balstic lu:n-u iswad tharrak  
DEF-soldier that from plastic color-3SM.POSS black move.PST  
'The pawn which is made of black plastic was moved.'

4. il-ḍʒundi illi min balstic lu:n-u abjad tharrak  
DEF-soldier that from plastic color-3SM.POSS white move.PST  
'The pawn which is made of white plastic was moved.'

5. il-fi:l illi min xaʃab lu:n-u iswad tharrak  
DEF-elephant that from wood color-3SM.POSS black move.PST  
'The bishop which is made of black wood was moved.'

6. il-fi:l illi min xaʃab lu:n-u abjad tharrak  
DEF-elephant that from wood color-3SM.POSS white move.PST  
'The bishop which is made of white wood was moved.'

7. il-fi:l illi min balstic lu:n-u iswad tharrak  
DEF-elephant that from plastic color-3SM.POSS black move.PST  
'The bishop which is made of black plastic was moved.'

8. il-fi:l illi min balstic lu:n-u abjad tharrak

DEF-elephant that from plastic color-3SM.POSS white move.PST

'The bishopwhich is made of white plastic was moved.'

9. il-Hisa:n illi min xafab lu:n-u iswad tharrak

DEF-horse that from wood color-3SM.POSS black move.PST

'The knightwhich is made of black wood was moved.'

10. il-Hisa:n illi min xafab lu:n-u abjad tharrak

DEF-horse that from wood color-3SM.POSS white move.PST

'The knightwhich is made of white wood was moved.'

11. il-Hisa:n illi min balstic lu:n-u iswad tharrak

DEF-horse that from plastic color-3SM.POSS black move.PST

'The knightwhich is made of black plastic was moved.'

12. il-Hisa:n illi min balstic lu:n-u abjad tharrak

DEF-horse that from plastic color-3SM.POSS white move.PST

'The knightwhich is made of white plastic was moved.'

13. il-qal'ah illi min xafab lu:n-ha iswad tharrak-at

DEF-palace that from wood color-3SF.POSS black move-F.PST

'The rockwhich is made of black wood was moved.'

14. il-qal'ah illi min xafab lu:n-ha abjad tharrak-at

DEF-palace that from wood color-3SF.POSS white move-F.PST

'The rockwhich is made of white wood was moved.'

15. il-qal'ah illi min balstic lu:n-ha iswad tharrak-at  
DEF-palace that from plastic color-3SF.POSS black move-F.PST

'The rockwhich is made of black plastic was moved.'

16. il-qal'ah illi min balstic lu:n-ha abjad tharrak-at  
DEF-palace that from plastic color-3SF.POSS white move-F.PST

'The rockwhich is made of white plastic was moved.'

17. il-wazi:r illi min xafab lu:n-u iswad tharrak  
DEF-minister that from wood color-3SM.POSS black move.PST

'The queenwhich is made of black wood was moved.'

18. il-wazi:r illi min xafab lu:n-u abjad tharrak  
DEF-minister that from wood color-3SM.POSS white move.PST

'The queenwhich is made of white wood was moved.'

19. il-wazi:r illi min balstic lu:n-u iswad tharrak  
DEF-mister that from plastic color-3SM.POSS black move.PST

'The queenwhich is made of black plastic was moved.'

20. il-wazi:r illi min balstic lu:n-u abjad tharrak  
DEF-minister that from plastic color-3SM.POSS white move.PST

'The queenwhich is made of white plastic was moved.'

21. il-malik illi min xafab lu:n-u iswad tharrak  
DEF-king that from wood color-3SM.POSS black move.PST

'The kingwhich is made of black wood was moved.'

22. il-malik illi min xafab lu:n-u abjad tharrak

DEF-king that from wood color-3SM.POSS white move.PST

'The king which is made of white wood was moved.'

23. il-malik illi min balstic lu:n-u iswad tharrak

DEF-king that from plastic color-3SM.POSS black move.PST

'The king which is made of black plastic was moved.'

24. il-malik illi min balstic lu:n-u abjad tharrak

DEF-king that from plastic color-3SM.POSS white move.PST

'The king which is made of white plastic was moved.'

### **Right-branching stimuli:**

1. il-dʒundi illi lu:n-u iswad illi min xafabtharrak

DEF-Soldier that color-3SMPOSS black that from wood move.PST

'The pawn that is black and is made of wood moved.'

2. il-dʒundi illi lu:n-u abjad illi min xafabtharrak

DEF-Soldier that color-3SMPOSS white that from wood move.PST

'The pawn that is white and is made of wood moved.'

3. il-dʒundi illi lu:n-u iswad illi min blasticttharrak

DEF-Soldier that color-3SMPOSS black that from plastic move.PST

'The pawn that is black and is made of plastic moved.'

4. il-dʒundi illi lu:n-u abjad illi min blasticttharrak

DEF-Soldier that color-3SMPOSS white that from plastic move.PST

'The pawn that is white and is made of plastic moved.'

5. il-malik illi lu:n-u iswad illi min xafabtharrak

DEF-king that color-3SMPOSS black that from wood move.PST

'The kingthat is black and is made of wood moved.'

6. il-malik illi lu:n-u abjad illi min xafabtharrak

DEF-king that color-3SMPOSS white that from wood move.PST

'The kingthat is whiteand is made of wood moved.'

7. il-malik illi lu:n-u iswad illi min blastictharrak

DEF-king that color-3SMPOSS black that from plastic move.PST

'The pawn that is black and is made of plastic moved.'

8. il-malik illi lu:n-u abjad illi min blastictharrak

DEF-king that color-3SMPOSS white that from plastic move.PST

'The kingthat is whiteand is made of plastic moved.'

9. il-wazi:r illi lu:n-u iswad illi min xafabtharrak

DEF-minister that color-3SMPOSS black that from wood move.PST

'The queenthat is black and is made of wood moved.'

10. il-wazi:r illi lu:n-u abjad illi min xafabtharrak

DEF-minister that color-3SMPOSS white that from wood move.PST

'The queenthat is whiteand is made of wood moved.'

11. il-wazi:r illi lu:n-u iswad illi min blastictharrak

DEF-minister that color-3SMPOSS black that from plastic move.PST

'The queenthat is black and is made of plastic moved.'

12. il-wazi:r illi lu:n-u abjad illi min blastictharrak  
DEF-minister that color-3SMPOSS white that from plastic move.PST

'The queen that is white and is made of plastic moved.'

13. il-fi:l illi lu:n-u iswad illi min xafabtharrak  
DEF-elephant that color-3SMPOSS black that from wood move.PST

'The bishop that is black and is made of wood moved.'

14. il-fi:l illi lu:n-u abjad illi min xafabtharrak  
DEF- that color-3SMPOSS white that from wood move.PST

'The bishop that is white and is made of wood moved.'

15. il-fi:l illi lu:n-u iswad illi min blastictharrak  
DEF-elephant that color-3SMPOSS black that from plastic move.PST

'The bishop that is black and is made of plastic moved.'

16. il-fi:l illi lu:n-u abjad illi min blastictharrak  
DEF-elephant that color-3SMPOSS white that from plastic move.PST

'The bishop that is white and is made of plastic moved.'

17. il-Hisa:n illi lu:n-u iswad illi min xafabtharrak  
DEF-horse that color-3SMPOSS black that from wood move.PST

'The knight that is black and is made of wood moved.'

18. il-Hisa:n illi lu:n-u abjad illi min xafabtharrak  
DEF-horse that color-3SMPOSS white that from wood move.PST

'The knight that is white and is made of wood moved.'

19. il-Hisa:n illi lu:n-u iswad illi min blastictharrak  
DEF-horse that color-3SMPOSS black that from plastic move.PST

'The knightthat is black and is made of plastic moved.'

20. il-Hisa:n illi lu:n-u abjad illi min blastictharrak  
DEF-horse that color-3SMPOSS white that from plastic move.PST

'The knightthat is whiteand is made of plastic moved.'

21. il-qal'ah illi lu:n-ha iswad illi min xafabtharrak-at  
DEF-palace that color-3SFPOSS black that from wood move-F.PST

'The rockthat is black and is made of wood moved.'

22. il-qal'ah illi lu:n-ha abjad illi min xafabtharrak-at  
DEF-palace that color-3SFPOSS white that from wood move-F..PST

'The rockthat is whiteand is made of wood moved.'

23. il-qal'ah illi lu:n-ha iswad illi min blastictharrak-at  
DEF-rock that color-3SFPOSS black that from plastic move-F.PST

'The rockthat is black and is made of plastic moved.'

24. il-qal'ah illi lu:n-ha abjad illi min blastictharrak-at  
DEF-rock that color-3SFPOSS white that from plastic move-F.PST

'The rockthat is whiteand is made of plastic moved.'