An Optimality-Theoretic Account of Allomorphy in Moroccan Arabic Subject Pronoun Affixes

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Abstract
This paper provides a unified Optimality-Theoretic analysis of Moroccan Arabic subject personal pronoun affixes. It focuses on their allomorphic alternations affecting their featural quality. The target allomorphic alternations are due to glide formation, glide vocalization, or assimilation. They respectively target final weak verbs, middle weak verbs, and finally initial or final alveolar verbs. The analysis rests on the fact that their predictability requires either simplex constraints or simplex

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and complex constraints, namely (local) implicational constraints. Simplex constraints are at play when the allomorphic alternations result from either glide formation or glide vocalization, including assimilation in the context of initial alveolar verbs. Simplex and complex constraints are at play when the allomorphic alternations are due to assimilation in the context of final alveolar verbs.

**Keywords:** Moroccan Arabic, Personal pronouns, Affixes, Allomorphy, Optimality Theory

0. Introduction

M(oroccan) A(rabic) subject personal pronoun affixes show interesting allomorphic alternations resulting in glide formation, vocalization and assimilation. Glide formation occurs in verbs ending in a vowel (e.g. 3Sg.Fem.Imperf. [(t)əqraʃ] of /t+qra+i/ “you (sg.fem.) read” or 3Pl.Perf. [qraw] of /qra+ul/ “they read”). Glide vocalization targets middle weak verbs (e.g. 3Sg.Imperf. [(ʔ)ʃuf] of /ʃ+uf/ “he sees”. Finally, assimilation targets initial or final alveolar verbs (e.g. 1Sg.Imperf. [Ilum] of /n+Ilum/ “I blame” or 1Sg.Perf. [srətt] of /sr+d+t/ “I became wet”).

Recent studies on morpho-phonology of MA subject personal pronoun affixes adopt two approaches, both of which suffer from limitations: The prosodic approach focuses on verb morphology (El Himer, 1991; Bernouss, 1994), and the constraint-based approach focuses on their allomorphy, including object and genitive ones (Hachoumi, 2016). While the prosodic approach is not devoted to MA (subject) personal pronoun affixes, Hachoumi’s treatment leaves certain details unaccounted for such as verb stems that end in /t/ (e.g. [rbətf] “to tie”).

The paper proposes a unified Optimality-Theoretic analysis (Prince and Smolensky, 1993/2004; McCarthy and Prince, 1993a, 1995) claiming that their allomorphic alternations affecting their featural quality are due to local phonotactics and their predictability requires simplex constraints or simplex and complex constraints. Our analysis explains these allomorphic alternations using simplex constraints when they are a result of either glide formation or glide vocalization, including assimilation in the context of initial alveolar verbs, and simplex and complex (local) implicational constraints when it is a result of assimilation in the context of final alveolar verbs, without reference to Lombardi’s (1999) specific constraints.
The paper is organized as follows. Section 2 provides the relevant issues and previous accounts. Section 3 gives a brief overview of the adopted theoretical framework. Section 4 provides a unified Optimality-Theoretic analysis of the phonological processes that play a major role in their featural allomorphic alterations. Subsection 4.1 deals with glide formation, subsection 4.2 deals with glide vocalization, and finally subsection 4.3 deals with assimilation.

1. Data and Previous Accounts

MA subject personal pronoun affixes exhibit allomorphic alternations affecting their position and featural quality. First, they appear as prefixes or apparent circumfixes in the perfective and as suffixes in the perfective and imperative as shown in (1):²

(1)

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<tr>
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<tbody>
<tr>
<td>Sg.</td>
<td>1</td>
<td>n+...</td>
<td>...+t</td>
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</tr>
<tr>
<td></td>
<td>2Masc.</td>
<td>t+...</td>
<td>...+t</td>
<td>...+ø</td>
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<tr>
<td></td>
<td>2Fem.</td>
<td>t+...+i</td>
<td>...+i</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>3Masc.</td>
<td>j+...</td>
<td>...+ø</td>
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<tr>
<td></td>
<td>3Fem.</td>
<td>t+...</td>
<td>...+t</td>
<td>----</td>
</tr>
<tr>
<td>Pl.</td>
<td>1</td>
<td>n+...+u</td>
<td>...+na</td>
<td>----</td>
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<tr>
<td></td>
<td>2</td>
<td>t+...+u</td>
<td>...+tu</td>
<td>...+u</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>j+...+u</td>
<td>...+u</td>
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Second, their featural allomorphic alternations are due to (i) glide vocalization, (ii) glide formation, and (iii) assimilation. Glide formation targets V-final verbs in the contexts given in (2):

(2) Contexts of gliding:

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<tbody>
<tr>
<td>Sg.</td>
<td>2Fem.</td>
<td>t+...+i</td>
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<td>...+i</td>
</tr>
<tr>
<td>Pl.</td>
<td>1</td>
<td>n+...+u</td>
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<tr>
<td></td>
<td>2</td>
<td>t+...+u</td>
<td></td>
<td>...+u</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>j+...+u</td>
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² The abbreviations used are: 1=first person, 2=second person, 3=third person, Fem.=feminine, Gen.=gender, Imper.=imperative, Imperf.=imperfective, Masc.=masculine, Num.=number, Perf.=perfective, Pers.=person, Pl.=plural, Sg.=singular.
In these cases, the suffixes \( {+i} \) and \( {+u} \) are respectively realized as the glides \([j]\) and \([w]\) when they are attached to V-final verbs. By way of illustration, let us consider the 2Sg.Fem.Imperf. and the 3Pl.Perf. as given in (3) and (4). Note that gliding is only one strategy of eliminating vocalic hiatus.\(^3\)

(3) 2Sg.Fem.Imperf.

a.  
\[  /t+xaf+i/ \quad txafi \quad "you (fem.sg.) get afraid" \]
\[  /t+bi\dot{s}+i/ \quad tbi\dot{s}i \quad "you (fem.sg.) sell" \]
\[  /t+gul+i/ \quad tguli \quad "you (fem.sg.) say" \]

b.  
\[  /t+qra+i/ \quad t\partial qraj \quad "you (fem.sg.) read" \]
\[  /t+\dot{f}ri+i/ \quad t\partial f\dot{ri} \quad "you (fem.sg.) buy" \]
\[  /t+\dot{h}bu+i/ \quad t\partial h\dot{bu} \quad "you (fem.sg.) crawl" \]

(4) 3Pl.Perf.

a.  
\[  /xaf+u/ \quad xafu \quad "they got afraid" \]
\[  /bi\dot{s}+u/ \quad ba\dot{s}u \quad "they sold" \]
\[  /gul+u/ \quad galu \quad "they said" \]

b.  
\[  /qra+u/ \quad q\partial rau \quad "they read" \]
\[  /\dot{f}ri+u/ \quad f\partial rau \quad "they bought" \]
\[  /\dot{h}bu+u/ \quad h\dot{b}au \quad "they crawled" \]

This featural allomorphic alternation has been seen differently in the literature on MA as (i) abstract segments (El Himer, 1991), (ii) archiphonemes (Bernouss, 1994), and (iii) allomorphs (Hachoumi, 2016).

In El Himer’s (1991) analysis, the suffixes \( {+i} \) and \( {+u} \) are treated as abstract segments and realized as glides since they are vocoid segments, while in Bernouss’s (1994) one they are analysed as archiphonemes and realized as glides to correlate with extraprosodic syllables. In Hachoumi’s (2016) treatment, they emerge as glides to avoid vocalic hiatus. In this paper, they are analysed as allomorphs within the constraint-based approach as in Hachoumi (2016), in which glide formation plays a major role.

Glide vocalization targets middle weak verbs in the contexts given in (5):

(5) Contexts of vocalizing:

<table>
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<tbody>
<tr>
<td>Sg.</td>
<td>3Masc.</td>
<td>( j+)</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Pl.</td>
<td>3</td>
<td>( j+u )</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

\(^3\) Deletion is also at play when V-final verbs end in \([i]\) or \([u]\), especially in the 2 Sg.Fem.Imperf./Imper. This issue is not tackled here due to the space limitation.
In these two cases, the prefix \( \{j+\} \) is realized as the high vowel [\( i \)] when it is prefixed to middle weak verb stems. The data in (6) illustrates this fact, where we use the 3Sg. as an example.

(6) 3Sg. Imperf.

\[
\begin{align*}
    \text{a. } & /j+gul/ & igul & "\text{he says}" \\
    & /j+bis/ & ibis & "\text{he sells}" \\
    & /j+fuf/ & ifuf & "\text{he sees}" \\
    \text{b. } & /j+klb/ & jəktəb & "\text{he writes}" \\
    & /j+qlb/ & jəqləb & "\text{he turns}" \\
    & /j+frb/ & jəfəb & "\text{he drinks}" \\
    \text{c. } & /j+kri/ & jəkri & "\text{he rents}" \\
    & /j+bəra/ & jəbra & "\text{he gets healthy}" \\
\end{align*}
\]

In El Himer (1991) and Bernouss (1994), this featural allomorphic alternation is due to glide formation. The prefix \( \{i+\} \) emerges as the glide [\( j \)] because it is respectively seen as a vocoid segment and an archiphoneme. In Hachoumi (2016), by contrast, it is due to glide vocalization since forms like *[\( jə.gul \)], *[\( jə.bis \)], and *[\( jə.fuf \)] are not permissible in MA.\(^4\) Herein, it is seen, following Hachoumi (2016), as vocalizing the underlying glide within the constraint-based approach.

Finally, assimilation targets initial or final alveolar verbs in the contexts of the imperfective and perfective. These contexts are given in (7):

(7) Contexts of assimilation:

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<tbody>
<tr>
<td>Sg.</td>
<td>1</td>
<td>n+…</td>
<td>...+t</td>
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<tr>
<td></td>
<td>2Masc.</td>
<td></td>
<td>...+t</td>
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<tr>
<td></td>
<td>2Fem.</td>
<td></td>
<td>...+ti</td>
<td></td>
</tr>
<tr>
<td>Pl.</td>
<td>1</td>
<td>n+…+u</td>
<td></td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td>...+tu</td>
<td></td>
</tr>
</tbody>
</table>

In the imperfective, assimilation takes place when the 1Sg. and 1Pl. are affixed to verb stems that begin with the coronal liquids [\( r \)] or [\( l \)]. The prefix \( \{n+\} \) loses its [nasal] feature in the target environment. Let us take the 1Sg. as an example, as shown in (8).

\(^4\) We refer the reader to Hachoumi (2016, in preparation) for arguments.
(8) 1Sg.Imp.

a. /n+llum/  llum  "I blame"
    /n+lsaq/  llsaq  "I stick"
    /n+lʃb/  lʃəb  "I play"

b. /n+rab/  rrabəb  "I win"
    /n+rəh/  rəh  "I go"
    /n+rəb/  rrəb  "I get on"

Assimilation also takes place in the 2Sg.Masc./Fem., 3Sg.Fem., and 2Pl. when the initial segment of verb stems is one of the following coronal alveolar stops: [t], [d] or [ʈ]. That is, the prefix {t+} gets assimilated when it is followed by the segment under study. By way of illustration, consider the data in (9) in which we use the 2Sg.Masc. as an example.

(9) 2Sg.Masc.Imp.

a. /t+dlk/  ddlək  "you rub"
    /t+dir/  ddir  "you do"
    /t+dəb/  dəb  "you melt"

b. /t+daijaʃ/  ɖdaijaʃ  "you lose"
    /t+dər/  dər  "you circle"
    /t+dəb/  dəb  "you hit"

c. /t+twwl/  ʈəwwəl  "you lengthen"
    /t+tir/  tər  "you fly"
    /t+tajjib/  ʈəjjəb  "you cook"

In the perfective, assimilation occurs when the target subject personal pronoun affixes are attached to verb stems that end with one of the following radicals: [t], [d] or [ʈ]. Consider the 1Sg. given in (10) as an example.

(10) 1Sg.Perf.

a. /srə+t/  srətt  "I wetted"
    /krə+t/  krətt  "I learned by heart"
    /brə+t/  brətt  "I became cold"

b. /rə+t/  rətt  "I tried"
    /ʂə+t/  şətt  "I swallowed"
    /frə+t/  frətt  "I threw"

c. /nə+t/  nətt  "I stood"
    /ʂə+t/  şətt  "I invited"
    /frə+t/  frətt  "I imposed"
The literature on MA assimilation can be traced back to the beginning of 1980’s. It is treated by Benkaddour (1982), El Himer (1991), Bennis (1992), and Hachoumi (2016). At the level of subject personal pronoun affixes, it could be traced back to the beginning of the 1990’s (El Himer, 1991). However, the focus is oriented to El Himer and Hachoumi’s treatments because of their connection to our study.

El Himer’s (1991) analysis treats the assimilated segments as (phonological) germination. In accordance with the prosodic approach, he assumes that such a process takes place after tier conflation. Hachoumi’s (2016) analysis treats them as (total) assimilation within the constraint-based approach. He makes use of (i) the general constraints as developed by Prince and Smolensky (1993/2004) and McCarthy and Prince (1993a, b) and (ii) specific constraints as developed by Lombardi’s (1999) to account for voicing assimilation in obstruent clusters. Herein, we analyse them as (total) assimilation without reference to Lombardi’s (1999) specific constraints since they cannot explain the nature of allomorphy in certain environments. Instead, we use (local) implicational constraints.

2. Optimality Theory

O(optimality) T(heory) is a general framework of linguistic analysis (Prince and Smolensky, 1993/2004; McCarthy and Prince, 1993a, b). Within OT, the interaction of violable universal constraints determines the well-formedness of output forms. The constraints are ranked on a language-particular basis when they are in conflict, and they are unranked when they are in non-conflict (Prince & Smolensky, 1993/2004; McCarthy & Prince, 1993b).

OT’s constraints fall into two main categories: simplex and complex constraints. The former are provided by Universal Grammar, while the latter are derived from at least two individual simplex constraints (Crowhurst and Hewitt, 1997). Complex constraints are associated mainly with conjunction and peripherally with implication constructions built on simplex ones. In local conjunction or implication, two or more simplex constraints are coordinated to form a single complex high ranked constraint on the basis of logical disjunction or implication. They are proposed by Smolensky (1993, 1995) and implemented in a number of

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5 We refer the reader to El Himer (1991) for more details and references.
works such as Crowhurst and Hewitt (1997), Balari, Marín, and Vallverdú (2000), and Bensoukas (2001).

Smolensky’s (1993, 1995) complex constraints appear under the name of local conjunction constraints. The coordinated constraint \([A \land B]\) (i.e. \([A \text{ and } B]\)) is violated iff both constraints are not satisfied. Generally, conjunction is equated to logical disjunction, i.e. disjunction \([A \lor B]\) (i.e. \([A \text{ or } B]\)) is false iff both propositions are false, not with logical conjunction, i.e. the conjunction \([A \land B]\) is true if both propositions are true (Crowhurst & Hewitt, 1997). In other words, the former is evaluated as true when either of its disjuncts is true, or both of the disjuncts are true; the latter is evaluated as false if either of the conjoined propositions is false or both.

Still, it might be identical to local conjunction if it is defined with respect to falsehood or failure, i.e. the conjunction \([A \land B]\) is false iff both propositions are false. This interpretation, then, forces logical conjunction to appear in a form of logical disjunction (Crowhurst and Hewitt, 1997). They are also built on implication (Crowhurst and Hewitt, 1997; Balari, Marín, and Vallverdú, 2000), called implicational constraints. Crowhurst and Hewitt (1997) assume that the truth value of implication proposition \([A > B]\) (i.e. \([\text{if } A, \text{ then } B]\)) is true iff both propositions are true, while Balari, Marín, and Vallverdú (2000) assume that material implication is false only when the antecedent is true and the consequent is false.

OT grammar is presented in tableaux containing an input form and its set of possible generated candidates along with a set of constraints. The input is given at the top-left-hand column and its set of candidates appear underneath it. The constraints are given on the top-row. The constraints on the left are higher in ranking than the one(s) to their right if they are separated by solid lines. Otherwise, they are unranked and, therefore, separated by dotted lines. The remaining cells are devoted to evaluate the well-formedness of candidates. Violation of constraints is indicated by “*” when the violation is not fatal and by “!*” when it is fatal. The optimal candidate is indicated by “= optimal”.

OT’s conception is developed into C(orrrespondence) T(heory) (McCarthy and Prince, 1995, 1999). In CT, the focus has been given to correspondence as defined in (11):
Correspondence (McCarthy and Prince, 1995: 14):

Given two strings $S_1$ and $S_2$, correspondence is a relation $\mathcal{R}$ from the elements of $S_1$ to those of $S_2$. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as correspondents of one another when $\alpha \mathcal{R} \beta$.

Correspondence relates two structures or two strings. Their correspondence is not only limited to B(ase)-R(eduplicant) identity (ibid.) but also to I(nput)-O(utput) faithfulness (ibid., 1999), and O(utput)-O(utput) correspondence (McCarthy, 1995; Benua, 1997).

Another aspect of OT that plays an essential role in our analysis is the theory of P(ositional) F(aitfulness) (McCarthy and Prince, 1994, 1995; Beckman, 1998; Lombardi, 1999). Under PF, prominent positions, e.g. roots, exhibit a privileged behaviour and trigger the non-prominent, e.g. affixes, to undergo processes in that positional faithfulness effects are exhibited by prominent positions. Thus, positional constraints that regulate privileged positions must dominate positional constraints that regulate non-privileged positions as for positional privileged ranking, root (Beckman, 1998: 194), schematized in (12).

(12) $\text{IDENT-ROOT}(F) >> \text{C(onstraint)} >> \text{IDENT}(F)$

The ranking of IDENT-ROOT over some markedness C(s) favours affixal alternation and ensures a faithful realization of the root.

Beckman’s (1998) schema can be equated to McCarthy and Prince's (1994) one. They disperse the faithfulness constraints into root and non-root constraints (McCarthy and Prince, 1994, 1995) as given in (13).

(13) $\text{Root-Faith} >> \text{Affix-Faith}$

The ranking of Root-Faith over Affix-Faith ensures a faithful realization of the root.

3. Allomorphy in MA Subject Personal Pronoun Affixes

This section provides a unified analysis of featural allomorphic alternations in MA subject pronoun affixes within the framework of OT. It is shown that their affixation in certain environment affects their featural quality, which is due to three phonological processes, namely glide formation, glide vocalization, and assimilation.
3.1. The role of glide formation

In OT, the alternation between the underlying vowels and glides is a result of the interaction of constraints as set out by Prince and Smolensky (1993/2004).

Research shows that there are several hiatus resolution strategies, e.g. glide formation, vowel elision, and epenthesis. These strategies are not arbitrary. They are universally determined in the sense that they are subject to certain restrictions. They usually target the non-privileged positions such as affixes, word-final positions, and root-final syllables. In other words, the privileged positions such as roots, word-initial positions, and root-initial syllables are more resistant to gliding, loss, or epenthesis, etc., and they are regulated by position-sensitivity faithfulness constraints. These types of constraints explain vocalic hiatus. In some contexts, the choice seems to be locally motivated.

Suffixing either of the attested MA subject personal pronoun affixes to V-final verb stems results in glide formation as illustrated in (3) and (4). This process yields two allomorphic alternations between the high vowels and glides: the suffixes \{+u\} and \{+i\} are realized as [w] and [j] when they are affixes to V-final verb stems and [u] and [i] elsewhere. These allomorphic alternations are manifestations of hiatus resolution since MA does not allow a sequence of two vowels. According to Rosenthall (1994), the difference between the high vowels [i] and [u] and glides [j] and [w] is that of affiliation within the syllable. The high vowels fill the position of nucleus, whereas glides occupy the position of onset and coda.

To account for gliding, we need both markedness and faithfulness constraints. These constraints are given in (14):

(14) a. **ONSET**: Syllables must have an onset (Prince & Smolensky, 1993/2004)
   b. **NO-CODA**: Syllables must not have a coda (ibid.)
   c. **MAX**\textsubscript{10}: No phonological deletion (McCarthy & Prince, 1995)
   d. **DEP**\textsubscript{10}: No phonological epenthesis (ibid.)
   e. **IDENT**\textsubscript{10}(F): Correspondent segments are identical in feature (ibid.)

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7 If we assume the realization of the target suffixes as high vowels, we find no empirical arguments in favor of glide vocalization. The latter is a process where glides turn into vowels.
These constraints interact with each other to yield the optimal forms. With the exception of the markedness constraint NO-CODA (14b), the markedness constraint ONSET (14a) enters the grammar as a dominant constraint since MA does not permit onsetless syllables. Concerning faithfulness constraints, they are dominated with the exception of the constraint MAX$_{IO}$ (14c), which must be unranked with the dominant markedness constraint to satisfy the structure in MA by banning segment deletion. The constraint NO-CODA (14b) must be ranked below the constraints DEP$_{IO}$ (14d) and ID$_{IO}(F)$ (14e). This ranking is justified by the fact that MA resorts to schwa epenthesis and changing feature quality. Finally, the constraint DEP$_{IO}$ (14d) must dominate the constraint IDENT$_{IO}(F)$ (14e) to ensure the optimization of the candidate that undergoes a certain featural change. This ranking is given in (15).

(15) ONSET, MAX$_{IO}$ >> DEP$_{IO}$ >> IDENT$_{IO}(F)$ >> NO-CODA

The analysis runs as follows: Any form violating one of the constraints *μ/ə, ONSET and MAX$_{IO}$ must be ruled out. Tableau (16) below shows the interaction of these constraints and others, in which the markedness and faithfulness constraints are either dominant or dominated for the input /{t}+bda+{i}/.

(16) ONSET, MAX$_{IO}$ >> DEP$_{IO}$ >> IDENT$_{IO}(F)$ >> NO-CODA

<table>
<thead>
<tr>
<th>/{t}+bda+{i}/</th>
<th>ONSET</th>
<th>MAX$_{IO}$</th>
<th>DEP$_{IO}$</th>
<th>IDENT(F)</th>
<th>NO-CODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. təb.daj</td>
<td>**</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. təb.da.i</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. təb.da</td>
<td>*!</td>
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</table>

Candidates (16b, c) are ruled out because they violate the higher-ranked constraints by allowing onsetless syllable (16b) and deleting an affixal segment (16c). Each of these incurs a violation of ONSET, MAX$_{IO}$, respectively. We are left with candidate (16a), which is the optimal candidate, although it violates IDENT$_{IO}(F)$, DEP$_{IO}$, and NO-CODA since they are not top-ranked.

Other candidates that deserve special consideration are *[təb.da.ʔi] and *[təb.da.i]. The first candidate involves an epenthetic segment [ʔ] and violates none of the top-ranked constraints. Even more, it does not violate IDENT$_{IO}(F)$. This new candidate is ruled out because it doubly violates DEP$_{IO}$. The second candidate also falls beyond the established
ranking. The candidate *[təb.dai] is ruled out by the constraint NO-DIPHTHONGS. This constraint is given (17).

(17) **NO-DIPHTHONGS**: Two moras of a diphthong must be linked to two separate vocalic root nodes (Rosenthal, 1994)

This constraint is dominant and unranked with the top-ranked constraints given in (16). Its domination is due to the absence of diphthongs in MA. Tableau (18) below shows how the constraint NO-DIPHTHONGS interacts with the constraints ONSET, MAXIO, DEPIO, and IDENTIO(F) and how *[təb.daj] is chosen over *[təb.daʔi] and *[təb.dai]. The constraint NO-CODA is not invoked because of its subsidiary role.

(18) **NO-DIPHTHONGS, ONSET, MAXIO >> DEPIO >> IDENTIO(F)**

<table>
<thead>
<tr>
<th>/(t)+bda+{i}/</th>
<th>NO-DIPHTHONGS</th>
<th>ONSET</th>
<th>MAXIO</th>
<th>DEPIO</th>
<th>IDENTIO(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td> a. təb.daj</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
</tr>
<tr>
<td>b. təb.daʔi</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
</tr>
<tr>
<td>c. təb.dai</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
<td>no violation</td>
</tr>
</tbody>
</table>

Candidate (18a) is optimal since it incurs only one violation mark of DEPIO by epenthesisizing schwa. Candidate (18b) is suboptimal because it incurs two violation marks of DEPIO by epenthesisizing schwa and the glottal stop. Candidate (18c) is suboptimal because of violating NO-DIPHTHONGS, a higher-ranking constraint.

The analysis of the 3Sg.Fem.Imperf. could be extended to the other cases, i.e. the 1Pl.Imperf., 2Pl.Imperf., 3Pl.Imperf., 3Pl.Perf., 2Sg.Fem.Imperf., and 2Pl.Imper. In other words, they can be obtained in the same fashion as the 3Sg.Fem.Imperf.

3.2. **The role of glide vocalization**

As has been noted earlier, the allomorphic alternation between the high vowels and glides is due the interaction of the phonological constraints and faithfulness constraints (Prince and Smolensky, 1993/2004; Rosenthal, 1994).

Prefixing either the 3Sg.Masc.Imperf. affix or the 3Pl.Imperf. affixes to middle weak verb stems results in glide vocalization as shown in (6) above. The prefix, which is represented by the glide [j], alternates with the high vowel [i]. To simplify a bit, the prefix {j+} is realized as [i] when it is prefixed to middle weak verb stems, and [j] elsewhere.
To account for the phonological process of glide vocalization, we need to rank the faithfulness constraint $\text{MAX}_{10}$ over the markedness constraints $\text{ONSET}$ and NO-CODA as well as the faithfulness constraint $\text{IDENT}_{10}(F)$. Positing the constraint $\text{MAX}_{10}$ as a dominant constraint is justified by maintaining the structure of the input. These constraints must be unraked with each other since their ranking makes no difference in yielding the desired result. The constraints $\text{IDENT}_{10}(F)$ and NO-CODA are outranked by the constraint $\text{MAX}_{10}$ to optimize candidates with different featural quality and syllables with codas. The constraint NO-CODA never outranks the constraint $\text{IDENT}_{10}(F)$ so as not to ban candidates containing codas in their syllables. This domination is given in tableau (19) for the input $/\{j\}+\text{gul}/$. The constraint ONSET is posited as a dominated constraint just to allow candidates with onsetless syllables because here we are assuming that MA allows them.

(19) $\text{MAX}_{10} >> \text{ONSET} >> \text{IDENT}_{10}(F) >> \text{NO-CODA}$

<table>
<thead>
<tr>
<th>$/{j}+\text{gul}/$</th>
<th>$\text{MAX}_{10}$</th>
<th>$\text{ONSET}$</th>
<th>$\text{IDENT}_{10}(F)$</th>
<th>NO-CODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varnothing$ a. i.gul</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. gul</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In (19), each candidate incurs a certain violation; however, a violation mark of the lower-ranked constraints, i.e. ONSET, $\text{IDENT}_{10}(F)$, and NO-CODA, is allowed to secure the higher-ranked constraint, i.e. $\text{MAX}_{10}$. It follows that the optimal candidate is $[\text{i}gul]$\(^8\). To put it differently, the optimal candidate is (19a) although it incurs violation marks of ONSET, $\text{IDENT}_{10}(F)$, and NO-CODA, three lower-ranking constraints. Candidate (19b) incurs a fatal violation mark of $\text{MAX}_{10}$ by deleting the glide $/j/$. However, this analysis remains inadequate for at least two reasons. First, MA does not allow onsetless syllables.\(^9\) Second, positing the structural constraint ONSET as a dominated constraint is not in line with the established ranking given in (16) and (18). One possible way to obtain onsetless outputs is restricted to rank the constraint ONSET above the constraint $\text{IDENT}_{10}(F)$ and invoking the constraint $\text{DEP}_{10}$ which must be lower than the constraint ONSET in order to rule out onsetless syllables.

---

\(^8\) This analysis can be accepted under what is termed the emergence of the unmarked (McCarthy and Prince, 1994) in MA whereby the 3Sg.Masc. of the imperfective is realized as $[i]$ in the output $[\text{igul}]$.

\(^9\) We refer the reader to El Himer (1991) and Boudal (2001) for details.
as established in (16) and (18). The latter are solved by epenthesizing the glottal stop. This domination is given in the tableau below.

(20) \( \text{ONSET} >> \text{DEP}_{10} >> \text{IDENT}_{10}(F) >> \text{NO-CODA} \)

<table>
<thead>
<tr>
<th>/j\gul/</th>
<th>ONSET</th>
<th>DEP (_{10})</th>
<th>IDENT (_{10}(F))</th>
<th>NO-CODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.  i\gul</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>\textit{b.  ?i\gul}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

If we reverse the ranking of ONSET and DEP\(_{10}\), the optimal candidate will be an item with an onsetless syllable *[i\gul]*, not *[\?i\gul]*.

According to this alternative analysis, the (potential actual) outputs in (6a) can be realized with the glottal stops [?] as follows:

(21) 3Sg.Masc.Imperf.

\[
\begin{align*}
\text{\lj+\gul} & \quad \text{\?i\gul} & \quad \text{"he says"} \\
\text{\lj+bi\?\?} & \quad \text{\?ibi\?} & \quad \text{"he sells"} \\
\text{\lj+fu\?\?} & \quad \text{\?ifu\?} & \quad \text{"he sees"}
\end{align*}
\]

The tableaux above do not involve two other possible candidates, namely *[i\j\gul]* and *[j\gul]*. None of the invoked constraints in both tableaux above can rule out these candidates. The former is ruled out by the constraint *[\mu/\sigma]*, i.e. schwa must not be associated with a mora (Bensoukas and Boudlal, 2012). The latter is ruled out by the constraint *[Minor-\sigma]*, i.e. minor syllables are prohibited (Boudlal, 2001; Bensoukas and Boudlal, 2012). The constraint *[\mu/\sigma]* is top-ranked since MA does not permit schwa in open syllables, while the constraint *[Minor-\sigma]* outranks the faithfulness constraints IDENT\(_{10}\) and DEP\(_{10}\) to allow candidates with epenthetic segment and/or different featural quality.

### 3.3. The role of assimilation

Within OT, assimilation is regarded as violation of IDENT\(_{10}(F)\). It is a result of the interaction of either the general constraints (Prince and Smolensky, 1993/2004; McCarthy and Prince, 1993, 1995), including positional faithfulness constraint (Beckman, 1998) or the specific constraints (Lombardi, 1999).

In Lombardi (1999), for example, voicing assimilation is always regressive unless there are certain circumstances. According to which, progressive assimilation is explained via the interaction of the general voicing assimilation constraints with other morphological or
phonological constraints which have the effect of reversing the direction of assimilation. Regressive assimilation is explained by specific constraints: A markedness constraint and three faithfulness constraints. These constraints are given in (22):

(22) a. **AGREE**: Obstruent clusters should agree in voicing
    b. **ID(ent) Ons(et) Lar(yngeal)**: Onsets should be faithful to underlying laryngeal specification
    c. **ID(ent) Lar(yngeal)**: Consonants should be faithful to underlying laryngeal specification
    d. **Lar(yngeal)**: No Laryngeal features

The constraint AGREE (22a) requires sequences of obstruents to have the same value for voicing. It applies only to obstruent clusters. The constraint IDOnsLar (22b) takes into consideration the privileged status of onsets with respect to the voicing contrast. The constraint IDLar (22c) ensures that the input and output segments agree in voicing, and finally the constraint *Lar (22d) is violated by voiced consonants, not by voiceless ones because voicing is privative. Their normal ranking is given in (23).

(23)  \[ \text{AGREE} \gg \text{IDOnsLar} \gg \text{IDLar} \gg \ast \text{Lar} \]

In the context of MA subject personal pronoun affixes, however, certain cases fall beyond the general constraints (Prince and Smolensky, 1993/2004; McCarthy and Prince, 1993, 1995), positional faithfulness constraints (Beckman, 1998) or specific constraints (Lombardi, 1999), especially when the verbs end in voiceless alveolar sounds. The shortcomings of Lombardi’s (1999) specific constraints can be handled through (local) implicational constraints, which imply material implication as proposed by Balari, Marín, and Vallverdú (2000).

### 3.3.1. Initial alveolar verbs and the imperfective affixes

As has been shown in (8) above, affixing the 1Sg. or 1Pl. to verb stems that start with \([l]\) and \([r]\) results in assimilation. The prefix \(\{n+\}\) loses the feature of nasality. More precisely, the assimilatory process is triggered by the privileged position, i.e. root. In both cases, the change is a violation mark of the constraint IDENT\(_{10}(F)\).

The other case of regressive assimilation takes place in the contexts of the 2Sg.Masc./Fem., 3Sg.Fem., and 2Pl. when they are attached verb stems that start with \([t]\), \([d]\) or \([q]\) as illustrated in (9). It is shown that the subject personal pronoun affix \(\{t+\}\) gets assimilated in either of the
environments. It becomes voiced (9a), voiced and pharyngealized (9b), and pharyngealized (9c). In the three sets, the change is regarded as a violation mark of the constraint IDENT_{IO}(F).

This kind of assimilation can be derived by the schemas given in (12) and (13) along with the markedness constraint AGREE given in (24). It is different from Lombardi’s (1999) one in that it is more general.

(24) AGREE: Adjacent segments should agree in featural quality

The interaction of these constraints may appear in two different rankings as given in (24).

(25) a. ID(ENT)-R(OO)T >> AGR(EE) >> ID(ENT)-V(OI)C(E)
b. AGR(EE) >> ID(ENT)-R(OO)T >> ID(ENT)-AF(FIX)

Tableaux (26) and (27) show how these constraints interact to yield the actual output, in which we use the input /{n}+lsaq/ as an example.

(26) ID-RT >> AGR >> ID-VC

<table>
<thead>
<tr>
<th>/{n}+lsaq/</th>
<th>ID-RT</th>
<th>AGR</th>
<th>ID-VC</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nl.saq</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. ll.saq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. nn.saq</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

(27) AGR >> ID-RT >> ID-AF

<table>
<thead>
<tr>
<th>/{t}+dlk/</th>
<th>AGR</th>
<th>ID-RT</th>
<th>ID-AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nl.saq</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ll.saq</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. nn.saq</td>
<td></td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>

Candidates (26a, c) and (27a, c) are excluded because of incurring a fatal violation mark of either AGR (26a) and (27a) or ID-RT (26c) and (27c), two higher-ranking constraints. Candidates (26b) and (27b) are optimal because of satisfying the two top-ranked constraints.

3.3.2. Verbs final alveolar and the perfective affixes

Unlike the cases of the imperfective forms where the 1Sg. affix \{n+\} and the 2 Sg. affix \{t+\} get assimilated when they are respectively prefixed to verbs that start with the coronal liquids or coronal alveolar stops, the cases of the perfective forms show the opposite by not being influenced when they are suffixed to verbs that end with the coronal alveolar stops [t], [d] or [ḍ]. As illustrated in (10), the 1Sg. affix \{+t\} influences the final segment of verb stems when it is one of the coronal alveolar stops.
by making them lose some of their featural quality to become identical to the segment which comes close to it. In this case, the general constraints of OT fail to predict the desired results. Let us take the 1Sg. as an example, where we take the input /srəd+{t}/ as an example. This can be shown in (28).

(28) AGR >> ID-RT >> ID-AF

<table>
<thead>
<tr>
<th>/srəd+{t}/</th>
<th>AGR</th>
<th>ID-RT</th>
<th>ID-AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. srədt</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. srədd</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. srətt</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

The ranking arguments in (28) wrongly predict the optimal candidate (28b). This candidate satisfies the higher-ranked constraints AGR and ID-RT. Although candidate (28b) satisfies both constraints, it should be excluded on the ground that is not an actual output in MA. Notice that ID-RT cannot be dominated by ID-AF because their ranking is universally established (Beckman, 1998).

To account for d-assimilation, we need to make use of the specific constraints which account for regressive voicing assimilation in obstruent clusters. This means that any candidate violating the highest ranked constraint AGR is ruled out. The normal ranking of such specific constraints is given in (29) for the input /srəd+{t}/.

(29) AGR >> IDOnsLar >> IDLar >> *Lar

<table>
<thead>
<tr>
<th>/srəd+{t}/</th>
<th>AGR</th>
<th>IDOnsLar</th>
<th>IDLar</th>
<th>*Lar</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. srədt</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. srədd</td>
<td></td>
<td></td>
<td>*</td>
<td>*!</td>
</tr>
<tr>
<td>c. srətt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Candidate (29a) is suboptimal because the sequence of obstruent cluster [dt] does not agree in voicing, thus fatally violating AGR. Candidate (29b) is suboptimal since it (doubly) violates *Lar by having a sequence of two voiced obstruents [dd]. Candidate (29d) is the optimal candidate because the decision is passed to the lower-ranked constraint *Lar which rules out candidate (29b).

The analysis of d-assimilation can be extended to ḍ-assimilation, but not to ṭ-assimilation because it falls beyond the constraint *Lar, i.e. ruling out voiced consonants. Tableau (30) shows that.
In (30), the invoked constraints fail to predict the optimal candidate (30c) and, therefore, we end up with two optimal candidates (30b, c). Candidate (30a) is excluded since it does not satisfy AGR, a higher-ranked constraint.

To predict the optimal candidate, we need to invoke a (local) implicational constraint in accordance with Balari, Marín, and Vallverdú’s (2000) proposal, in which they assume that material implication is false only when the antecedent is true and the consequent is false. It is formulated in (31).

(31) \([\text{ID(ENT)}-\text{R(OO)}T > \text{ID(ENT)}-\text{AF(FIX)}]: \text{Violated}\ \iff \text{the antecedent is satisfied and the consequent is violated}\)

This constraint is made up of two simple universal constraints, namely the constraints IDT-RT and ID-AF. It enters the grammar as a dominant constraint outranking both simplex constraints. Tableau (32) shows how this constraint interacts with the constraints AGR, ID-RT and ID-AF to predict \(\text{frətt}\).

(32) AGR \(\gg\) [ID-RT \(\gg\) ID-AF] \(\gg\) ID-RT \(\gg\) ID-AF

<table>
<thead>
<tr>
<th>/frt+{t}/</th>
<th>AGR</th>
<th>[ID-RT (\gg) ID-AF]</th>
<th>ID-RT</th>
<th>ID-AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. frətt</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. frətt</td>
<td>*!</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. fətt</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Candidates (32a, b) are ruled out since each of them incurs a fatal violation of one of the dominant constraints. Candidate (32a) violates the simplex constraint AGR, while candidate (32b) violates the complex constraint [ID-RT \(\gg\) ID-AF]. The remaining candidate is optimized as optimal since it satisfies the higher-ranking constraints, AGR and [ID-RT \(\gg\) ID-AF].

This analysis can be extended to final voiced alveolar verb stems. If we take the input /srd+{t}/ given in (29). Candidate (29b), i.e. *\(\text{srədd}\), can ruled out by [ID-RT \(\gg\) ID-AF].
In this section, we have provided a unified OT account of allomorphy in MA subject personal pronoun affixes. We have shown that their allomorphic alternations which affect their featural quality are due to glide formation, glide vocalization, or assimilation. More precisely, we have shown that simplex constraints regulate the allomorphic alternations which emerge as a result of glide formation, glide vocalization, or assimilation in the case of initial alveolar verbs, and finally, we have shown that simplex and complex constraints regulate the allomorphic alternations which emerge as a result of assimilation in the case of final alveolar verbs.

4. Conclusion

In this paper, we have provided a morpho-phonological analysis of MA subject personal pronoun affixes within OT. We have shown that glide formation, glide vocalization, and assimilation play a major role in their allomorphic alternations affecting their featural quality. Their predictability is governed by the interaction of either simplex constraints or simplex and complex constraints. The interaction of simplex constraints predicts the allomorphic alternations that result from glide formation and glide vocalization as well as assimilation in the case of initial alveolar verbs. The allomorphic alternations that result merely from assimilation in the case final alveolar verbs require the interaction of simplex constraints as well as complex constraints.

Significantly, the analysis can be extended to the other personal pronoun affixes, namely accusatives and genitives even if their allomorphic alternations are not in line with the type of allomorphy in subject personal pronoun affixes. They differ in that their allomorphic alternations are not derived from a single underlying form since there is no regular phonological process that relates their realizations. Thus, they must be listed in the lexicon as independent allomorphs, each of which appears in a certain environment (after McCarthy, 2002; Mascaró, 2004). These types of allomorphs fall within the category of external allomorphy; by contrast, the ones that are derived from a single underlying form fall within the category of internal allomorphy (ibid.).

On a wider level, further research is needed to address the external allomorphic alternations of MA accusative and genitive personal pronoun affixes to complete the picture. Herein, they are not considered for reasons of space. To further our research, we intend to analyse this issue
elsewhere (Hachoumi, in preparation). The prospect of treating the issue of external allomorphy in the context of MA personal pronoun affixes serves as a continuous incentive for future research.

References

Balari, S., Marín, R., & Vallverdú, T. (2000). Implicational constraints, defaults, and markedness. GGT Report de Recerca GGT 00-8, Universitat Autònoma de Barcelona. [ROA#396].


