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An Optimality-Theoretic Analysis of Word-stress: Evidence from Moroccan-English Interlanguage

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Abstract

This paper intends to provide an Optimality-theoretic analysis of word-stress learnability among Moroccan learners of English. Language acquisition, from an Optimality Theory perspective, is a process of reordering the constraints from an initial state of the grammar to the language-specific ranking of the target grammar. To account for stress development, this paper makes use of Constraint Demotion Algorithm (Tesar & Smolensky, 1996; 2000) which learners adopt to infer the correct hierarchy of constraints. Starting with a default hierarchy supplied by Universal Grammar, learners proceed with recursive demotion of higher-ranked constraints until the correct ranking is reached. The algorithm, starting by initializing the hierarchy, assumes that constraints are unranked, and thus hosted in the same stratum. Sixty Moroccan learners, who have some basic background in linguistics, participated in the study. The informants are third-year students at university. They were administered an oral multiple-choice test that elicited their intuition about English stress pattern. The overall findings of the study reveal that learners' prior (L1) ranking (ALIGNHD-R >> WSP >>NONFIN >> FT-TYPE$_{IAMB}$>>Ft-BIN>> PARSE-σ >> Ft-TYPE$_{TROC}$) influences their learnability of English stress. That is, Moroccan learners misplace stress in English words due to the initial state of their grammar. What follows shows the constraints demotion learners go through to reach the optimized stress pattern of English:

Initial stratum = {Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {NONFIN}
>>
Stratum 2 = {WSP}
>>
Stratum 3 = {FT-BIN, ALIGNHD-R}
>>
Stratum 4 = {PARSE-σ}
>>
Stratum 5 = {FT-TYPE$_{IAMB}$}

Keywords: English stress, Optimality Theory, Constraint Demotion Algorithm, Stress assignment, Moroccan Arabic.

Introduction

The acquisition of phonology has recently received a fast-growing essence. This area of research lies at the heart of the modern study of language. Research on second language (L2)[1]

[1] In line with the North-American tradition, L2 is used to refer to any language that is acquired after L1.

phonology has thrived as this field has intrigued linguists, practitioners, and educators. This growing interest in L2 phonology stems from the belief that correct pronunciation is influential in the development of language (see Eckman, 2004). Lately, phonological acquisition has witnessed an ever-increasing revival of interest. The emergence of constraint-based models, in particular Prince and Smolensky's (1993) Optimality Theory (henceforth, OT) has played a central role in this revival.

In spite of the interest in the acquisition of L2 phonology, the published literature remains scarce in the Moroccan context. The present study, thus, endeavors to enrich the existing body of research at the level of L2 sounds acquisition. By investigating a suprasegmental feature (word-stress) acquisition, this study attempts to fill the gap of focusing solely on studying the acquisition of segments. This study is an extension of the analysis presented in Smirkou with the aim to explore the relevance of learners' pre-existing knowledge to the acquisition of this aspect. Exploring the interaction of English and Moroccan Arabic (MA) on Moroccan learners' interlanguage (hereafter, IL) could yield considerable findings on the role of Universal Grammar (henceforth, UG) on language acquisition and the different stages of L2 phonological acquisition.

The analysis of how prosodic properties of typologically distant languages can affect each other requires a model of phonological acquisition that can abstract away from the surface differences between their stress patterns. The model adopted for this purpose is Optimality Theory. OT explains linguistic grammar as a set of universal violable constraints. From an OT perspective, the difference of two languages lies in the different ordering of the same universal constraints. For example, while stress assignment in both English and MA is subjected to universal constraints, they differ in how they rank these shared constraints. Under this view, L2 acquisition is regarded as a process of re-ranking the constraints from the L1 state towards the L2 state. Assuming that the stress pattern of MA and English is interpreted by the same constraints, the researcher can predict the stress development among Moroccan learners of English.

The overall aim of this study is to account for the learnability of English word-stress among Moroccan learners of English. To achieve this aim, the analysis adopts the Constraint Demotion Algorithm (hereafter, CDA) (Tesar & Smolensky 2000). The analysis looks into how learners handle the conflict between the constraints that determine stress location in moving from initial state to final state. Section (5) furthers this algorithm.

The organization of this paper can be seen along the following lines. Section 2 introduces the theoretical background necessary in undertaking the analysis of stress learnability. This section reviews the development of L2 acquisition approaches. Additionally, it introduces the framework adopted in this study and the algorithm used in stress learnability à la OT. It also provides some comparative generalizations about stress in MA and English. Section 3 presents the methodology employed in this study. It spotlights the research problem investigated, the research questions enquired, the participants under study, and the instrument employed in this paper. While section 4 provides a presentation of the data, section 5 offers an analysis and a discussion of the results in the light of CDA. Section 6 concludes the paper by providing succinct pedagogical implications of the findings.

2. Literature review

2.1. Approaches to the acquisition of second language phonology

The field of phonology acquisition is very interdisciplinary, and approaches differ drastically. In the last decades, several different theoretical frameworks have been employed in studies on acquisition of phonology. Research in L2 phonology has been approached differently, starting from Contrastive Analysis (Fries, 1945; Lado, 1957) to the most recent framework OT (Archibald, 1997a, 1997b; Broselow, et al., 1998; Escuerdo & Boersma, 2001, 2004; Broselow, 2004). Whereas some have investigated the acquisition of segments (Best, 1995; Flege, 1995; Amrous, 2012), others have studied prosodic aspects of interlanguage (Archibald, 1997a, 1997b) with the assumptions that UG is heavily involved in L2. It follows that learners' L1 has some influences on the accuracy achieved in L2 sounds and that the initial state of learners' interlanguage is actually the grammar of their L1.

The learnability of L2 phonology is conducted at least within four theoretical frameworks. Contrastive Analysis (CA) (Lado, 1957) was the first model that has endeavoured to explore how the comparison of L1 and L2 systems can predict and describe the patterns which cause difficulty in learning. Some linguists (e.g., Flege, 1995; Best & Tyler, 2007; Faris, et al., 2018) consider that this influence lies in similarities between L1 and L2, while others (e.g. Lado, 1957; Eckman, 1977; Major, 1987, 2001; Brown, 1998) ascribe the errors to dissimilarities between L1 and L2 grammar. While the similarities of phonological features between L1 and L2 facilitate learning, the

dissimilarities of phonological features pose difficulty in acquiring the features that are not shared in their L1 (Lado, 1957).

Unlike CA, Flege (1991) proposes Speech Learning Model (SLM) to account for the acquisition of L2 phonology. SLM assumes that phonological errors are not induced due to dissimilar sounds between L1 and L2 but are traceable to similar sounds. As summed up in Amrous (2012), the argument is that similar sounds are stored and articulated relying on the already existing sounds in L1 without creating a new L2 phonetic category. On the other hand, the acquisition of dissimilar sounds mandates creating a new sound with specific phonetic properties. For instance, a Moroccan Arabic speaker would be more likely to establish a phonetic category for English /æ/ or /ɔ/ than for English /i/ (which differs only slightly from MA /i/) because only three underlying vowels /a, i, u/ and epenthetic schwa are attested in MA (Benhallam, 1989/1990; Boudlal, 2006/2007/ 2011; Bensoukas & Boudlal, 2012).

A different perspective on the acquisition of L2 phonology is given in Eckman's (1997) Markedness Differential Hypothesis (MDH) framework. The assumption that underlies the notion of markedness is that some linguistic features are universal and shared in all natural languages. L2 phonology difficulties are predicted on the basis of UG markedness relation. It follows that learning marked segments (less frequent) are more difficult than the corresponding unmarked segments (frequent). The assumption is that unmarked structures are acquired before marked ones.

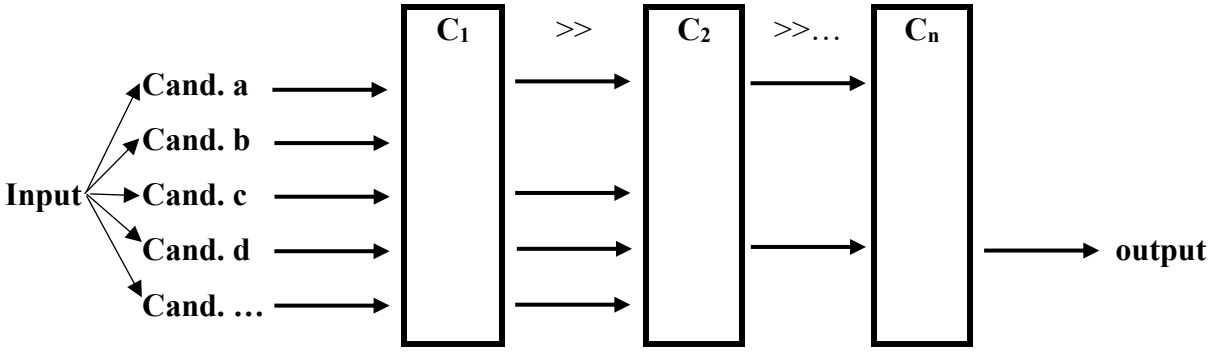
The most recent model adopted in accounting for L2 acquisition is OT. Research that espouses OT makes use of constraints interaction (Archibald, 1997a, 1997b, 2003; Broselow, et al., 1998; Hancin-Bhatt, 2000; Escuerdo & Boersma, 2001; Amrous, 2012; Broselow & Xu, 2004; Broselow, 2018). Besides being a model for grammar explanation, OT can provide an adequate analysis of language acquisition. Employing learning algorithms, learners, if need be, reorder constraints on the input until they reach the correct (optimal) output. The following section discusses OT as the framework that is adopted in this study.

2.2. Optimality theory

The developments in phonological theory were crucial to the emergence of OT (McCarthy & Prince, 1993, 1995, 1999; Prince & Smolensky, 1993/2004 and related works). OT proposes that the observed language forms arise from the interaction of conflicts between competing constraints rather than on rule derivation. In OT, the optimal/harmonic output is the form that

results from the minimal violation of strictly ordered constraints. It follows that a candidate may violate some constraints, but it can still surface as optimal in case the constraint(s) it satisfies is high ranked. To map an input to output, OT operates as follows:

(1) Mapping of input to output in OT grammar (Kager, 1999, p. 8)



The set of candidate forms, generated by means of Gen(erator), are evaluated using Eval to determine the optimal candidate (actual output). As in (1), the evaluation uses a set of hierarchically ranked constraints C_1>>C_2>>…. C_n (where >> denotes that the domination relation 'higher than'). This evaluation process is made by means of constraint tableau. A given input appears at the top of the left of the constraints, below the input are the set of candidates, one of which is optimal. The top row displays the constraints in hierarchy from left to right. A solid line represents the hierarchy order. The remaining cells exhibit the evaluation, where the asterisk (*) marks the violation. A fatal violation is marked by an exclamation mark (*!) or shaded cells for the lower-ranked constraints. A pointing-hand (☞) designates the optimal candidate. Consider tableau (2).

(2) Table 1

Input	C_1	C_2	C_3
☞ Cand.a	*	*	***
Cand.b	*	**!	

In (2), the optimal candidate is *Cand.a* because it fares better on the highest-ranking constraint. While *Cand.a* incurs fewer violation of C_2, *Cand.b* fatally violates the same constraint. The ordering is strictly respected in evaluating the candidates. *Cand.a* incurs more violation to C_3 than its competitor, but it is ranked below the decisive one. *Cand.a* is optimal as it incurs fewer violation of C_2 which dominates C_3.

2.3. Learnability in OT: Constraint Demotion Algorithm

Prior to OT is the principle of constraint strict ranking. Difference between languages lies in the ordering of the universal constraints in their language-specific dominance hierarchies (Tesar & Smolensky, 1996). Under the assumption of innateness of the universal constraints, L2 acquisition is primarily "to learn the language-specific ranking of the universal constraints" Tesar and Smolensky (1996, p.1). From an OT perspective, learnability is a process of reranking these constraints from an initial state of the grammar to the language-specific ranking of the target grammar.

Constraint Demotion Algorithm (CDA) (Tesar, 1998, 1999, 2000; Tesar & Smolensky, 2000), one of the prominent learning algorithms within OT, defines L2 acquisition as a process of reordering the existing constraints. According to CDA, learners first start by establishing an initial hierarchy at initial state. Since constraints are universal, the initial state of L2 acquisition is believed to correspond to the final state of L1. In the next stage, learners, by means of the Robust Interpretive Parsing (RIP), map the overt form they perceive to a full structural description. The third stage, Grammar Learning, learners deduce the constraint hierarchy of the L2 based on negative and positive evidence from constraint violation (Kager, 1999). To achieve this aim, learners use Constraint Demotion which mandates demoting every winner-favouring constraint below some loser-favouring constraint until all winner-favouring constraints are dominated.

The constraints violated by the optimal candidate must be demoted steps below those violated by its competitors. In OT literature, this is also explained by the notion of *stratum*. While constraints within a stratum are non-conflicting, strata are ranked in respect to other strata. A hierarchy containing strata is termed a *stratified hierarchy*. Constraints are demoted only when necessary; suppose that, at a stage, constraints 1 and 2 among others are housed in the same stratum as in (3a) where C1 is violated by the optimal form and C2 by the suboptimal forms. This entails that constraint C2 dominates C1, C1 consequently demotes below C2 to the immediate stratum as in (3b):

(3) a. Stratum 1 {C3, C1, C2, C6}
>>
Stratum 2 {C4, C5}

b. Stratum 1 {C3, C2, C6}
>>
Stratum 2 {C4, C5, C1}

Learners continue to demote constraints until no negative evidence arises for further demotion to take place.

2.4. Stress in English and MA

2.4.1. Stress in MA

Studies on stress in MA remain scarce. Following Benhallam's (1990) taxonomy, works on MA stress are either **impressionistic** (Abdelmassih, 1973; Benkaddour, 1982; Fares, 1993; El Hadri, 1993; Benhallam, 1990b) or **instrumental** (Benkirane, 1982; Hammoumi, 1988; Nejmi, 1993, 1995; Boudlal, 2001; kably, 2001). MA can have both iambic and trochaic feet depending on whether or not the word is in context or in isolation (Boudlal, 2001). Stress location is triggered by two factors: syllable position and syllable weight. What follows draws the generalizations of stress in MA from these works.

i. MA is quantity sensitive language (Abdelmassih, 1973; Benkaddour, 1982; El Hadri, 1993; Benhallam, 1990b; Hammoumi, 1988; Nejmi, 1993, 1995; Boudlal, 2001; Bohas, et al., 1989, Bouziri 1991, Kably 2001); stress is sensitive to syllable weight.
ii. Stress is restrictively located on one of the last two syllables of a word (Boudlal, 2001).
iii. Stress falls on the ultimate syllable if it is heavy ([lawjín] 'wilted, pl.'); otherwise on the penultimate ([láwja] 'wiled, fem. Sg.') (Boudlal, 2001; Benkirane, 1982, Benhallam, 1990b).
iv. If the penultimate syllable is an object clitic, stress falls on the preceding syllable: kərkbíhalhum "roll (2 fem.sg.) it for them" (Benhallam, 1990b).
v. When the word has a closed syllable with schwa as a nucleus; it is considered light syllable. Hence, it never attracts stress if there is a syllable with a full vowel as in [májəl] or [wáʕdək] (Boudlal, 2001).
vi. Stress assignment is postlexical; it applies after all morphological and phonological rules have applied (Fares, 1993).
vii. The interaction of the prosodic parameters (fundamental of frequency, intensity, duration) is a determining factor in stress placement (Boudlal, 2001).

The OT account has shown that stress in MA is governed by the following constraints ranking (Boudlal, 2001):

ALIGNHD-R >> WSP >>NONFIN >> FT-TYPE$_{IAMB}$>>Ft-BIN>> PARSE-σ >> Ft-TYPE$_{TROC}$

Stress in words, in context, shows that MA is an iambic foot type[2] and that FTTYPE$_{IAMB}$ (which is right-headed) is ranked above FTTYPE$_{TROC}$ (which is left-headed). Boudlal (2001)

[2] Recall that, according to Boudlal (2001), there are two possible analyses in terms of foot structure in MA: (i) **trochaic foot** that is attested in words in isolation; and (ii) **iambic foot** which is observed in words in context. This paper adopts the view that FTTYPE$_{IAMB}$ outranks FTTYPE$_{TROC}$. OT allows both iambs and trochees in the same language; and it is the interaction with other higher ranked constraints what decides which one to appear. Further support of this fact is found

assumes that the basic stress pattern of MA is iambic and that trochaic feet exist in the language under certain conditions. Weight-to-Stress Principle (WSP) (Prince and Smolensky 1993) which requires a heavy syllable to be stressed in foot structure has to be ranked above NON-FIN to ensure stress on the final heavy syllable in words such as [limun] "orange". Stress in MA is restrictively located in one of the last two. In OT terms, this is regulated by Alignment Theory, namely the constraint ALIGNHD-R wherein the right edge of the prominent foot (Ft′) must be aligned with the right edge of the PWd. ALIGNHD-R has to outrank WSP thus dominates NON-FIN by transitivity to exclude forms such as [*(Sán)(Da.la)]. The coming discussion will exemplify and further the conflict relation between the constraints.

2.4.2. Stress in English

Stress in English is regulated by the following constraint ranking (Hammond, 1999).

Ft-TYPE$_{TROC}$ >> NONFIN>>WSP >> Ft-BIN, ALIGNHD-R >> PARSE-σ >> FT-TYPE$_{IAMB}$

While this hierarchy does not account for every token in English, it provides the overall generalizations of stress pattern in English, particularly in monomorphemic words. These generalizations include:

i. ALIGNHD-R and Ft-TYPE$_{TROC}$ are undominated in English.
   a) Ft-TYPE$_{TROC}$ must dominate Ft-TYPE$_{IAMB}$, so that feet can be left-headed; stress falls on the left edge of the foot. *A(**me**ri)ca* is more harmonic than *A(me**ri**)ca*.

ii. The remaining constraints are dominated. They are also in conflict with each other, and hence some of them are ranked relative to each other:
   a) WSP should outrank NONFIN, so that words ending in a heavy syllable can carry stress; *a(**gree**)* and *a(**larm**)* is more harmonic than*(**a**)gree* and *(**a**)larm*.
   b) NONFIN must outrank Ft-BIN, *A(meri)ca* is a more harmonic parse than *(Ame)(rica)*.
   c) WSP must dominate Ft-BIN, so that a heavy syllable can be stressed; *a(gen)da* is a better parse than *(agen)da*.
   d) Ft-BIN must dominate PARSE-σ. The parse *A(meri)ca* is more harmonic than *(A)(meri)ca* or *(Ame)(ri)ca*.

in McCarthy and Prince (1993a:150) who show that the stress pattern of Axininca Campa, an Arawakan language of Peru, is both iambic and trochaic.

Recall that these constraints are universal; shared in all languages. In stress learnability, learners are supposed to learn the above constraints hierarchy, i.e., they have to rerank the constraints making use of CDA.

2.4.3. English Stress versus MA Stress: Additional Remarks

Stress patterns of MA and English share some similarities in terms of position. Stress is not fixed to a certain position within a word, but realized within three final syllables: final stress position (e.g., MA li'mun "orange"; English prɪ'zent), penultimate syllable (e.g., San'DaLa "sandal"; ə'dʒendə), and antepenultimate syllable (e.g., 'mænɪdʒmənt; 'fʕajəlkum "your (pl.) deeds"). Stress assignment in English invokes three types of information: (i) syntactic information (whether the word is a noun, an adjective, a verb, etc., e.g., 'increase (N) vs. in'crease (V)), morphological structure (whether the word is mono- or polymorphemic, e.g., límit vs. limitátion), and phonological information (e.g., whether a syllable is light or heavy).

MA and English stress systems share some regularities, i.e., the morphological structure of the constituents, their rhythmic organization, intrinsic prominence of the syllable (weight), and number and position of the syllables in a word. However, they differ in terms of stress function, stress position, stress degrees, and vowel reduction. As for the function of stress, whereas stress is phonetic (i.e., predictable) in MA, it is phonemic in English. In English, stress distinguishes compound nouns from adjectives followed by nouns (**black**board vs. black **board**)[3], alternates meaning (**con**tent vs. con**tent**), and differentiates word class (e.g., **pre**sent vs. pre**sent**). As opposed to MA, where there is only one level of stress, English distinguishes four degrees of stress: primary (1ry), secondary (2ry), tertiary (3ry) and zero (0) stress (unstressed). As for vowel reduction, in English, the vowels that occupy the nucleus of unstressed syllables are reduced to a schwa. In MA, on the other hand, unstressed vowels are always realized in full forms.

3. Methodology

3.1. Research problem

This study attempts to address the problem of word-stress errors among Moroccan Learners of English. There is a common consensus among some educators that Moroccan learners' speech

[3] Bold indicates the stressed syllable.

is Moroccan Arabic-like. Since stress placement can alter meaning as instantiated earlier, stress errors can precipitate false recognition which can yield communication breakdown. Since "pronunciation is the most challenging aspect of mastering a foreign language" (Alaoui et, al., 2004/2019), making errors calls for further research at this area. Therefore, a study that investigates this type of errors, traces back the learning stages within the framework of OT, and provides some pedagogical implementation is in order.

3.2. Research questions

The present study enquires the following research questions:

1. How does learners' L1 constraint ranking affect their acquisition of English word-stress?
2. How do Moroccan learners employing CDA acquire English word-stress?

3.3. Participants

A total of sixty students at university participated in this study. The subjects under investigation are Third-Year University (TYU). To ensure the homogeneity of the samples under investigation, the participants filled in a personal information section in the test that assured that they all have the same linguistic background. Thus, all participants speak MA as their mother tongue and similar formal exposure to the English language. To ensure that the participants have similar proficiency of English stress, they were also administered an oral multiple-choice test that elicited their intuition about English stress pattern.

3.4. Instrument and procedure

To answer the research questions, a corpus of relevant data needs to be collected through relevant instruments. This paper used an MCQ test to select homogeneous participants and to generate data about stress development. The rationale behind this particular test lies in fostering the authenticity of the data. This instrument can generate more spontaneous production of the targeted item (word-stress) as participants' focus is on the meaning of the words rather than the accurate pronunciation, yielding more random data. The test consists of two sections: the first section is concerned with personal information, while the second section generates students' intuition about English stress pattern. The test includes a corpus of 24 items. At first, seventy-three participants set for the test. Forty participants whose score was between 8 and 11 out of 20 were

selected. The test was administered orally; learners read loudly their answers while being recorded for later analysis.

4. Data presentation

The table below presents the words presented to the participants along with the percentage of stress errors labeled into the position of the syllable: antepenultimate, penultimate, or ultimate. They are classified to the number of syllables: disyllabic, trisyllabic, and polysyllabic. Some of these words will be further explained in reference to CDA in due course.

(4) Table 2

	Disyllabic	**Trisyllabic**	**Polysyllabic**
Antepenultimate		ˈAgenda (13%) ˈOctober (39%)	ˈAcademic (46%)
Penultimate	ˈGarage (11%) ˈCommence (10%) ˈJuly (70) ˈDirect (43%)	ciˈgarette (67%) OˈrigIn (43%) MiˈnIster (61%) InˈfluEnce (46%)	AmeˈrIca (52%) CereˈmOny (56%) NeceˈssAry (68%) ElectriˈcIty (49%)
Ultimate	CoˈffEe (47%) AttˈIc (52%) ObˈjEct (61%) CliˈmAte (44%)	SatelˈlIte (63%) AniˈmAl (41%) DeterˈmIne (38%) FantasˈtIc (46%)	AmeriˈcA (16%) ExcommuniˈcAte (71%)

In the words in (4), 3 out of 24 receive antepenultimate stress, i.e., about 4%, 12 out of 24 receive penultimate stress, i.e. 50%, and 10 out of 24 receive ultimate stress, i.e. about 46%. It is evident that most of stress errors are restrictively located to the last two syllables, a state of affairs which can be explained by the participants L1 stress pattern that locates stress on the ultimate syllable if it is heavy, otherwise on penultimate. One remark that could be made about the results in the table above is that the participants did not hesitate in stressing the heavy syllable. This fact can be attributed to L1 transfer wherein heavy syllable triggers stress.

5. Analysis and discussion

The aim of this section is to develop an optimality-theoretic account for the results presented in the section above. Making use of the CDA, it attempts to track down the developmental stages of learning process of word-stress. The problem that Moroccan learners

encounter when learning the English stress system is foot typology. Recall that, unlike English, FTTYPE$_{IAMB}$ outranks FTTYPE$_{TROC}$, in words in context. Consider the example in tableau (5):

Ft-TYPE$_{IAMB}$: Align the head-syllable with its foot, on the right edge (right-headed foot).
Ft-TYPE$_{TROC}$: Align the head-syllable with its foot, on the left edge (left-headed foot).

(5) Table 3: FTTYPE$_{IAMB}$ and FTTYPE$_{TROC}$ conflict in MA: /ʒaʒa/ (glass)

/ʒaʒa/	FTTYPE$_{IAMB}$	FTTYPE$_{TROC}$
a. ('ʒa.ʒa)	*!	
☞ b. (ʒa.'ʒa)		*

This tableau, which shows that *candidate b* is optimal as it satisfies the higher-ranking constraint, exhibits the domination relation of FTTYPE$_{IAMB}$ >> FTTYPE$_{TROC}$. It is established in the OT literature that the initial state of L2 acquisition matches to the final state of L1. In simpler terms, learners when learning L2 start by establishing a random ranking that is exempt from the existing ranking (that of L1).

At the initial stage of acquisition, Moroccan learners fail to correctly place stress. By way of illustration, disyllabic words as *attic*, *climate*, *object*, and *coffee* were mispronounced with stress on the ultimate syllable. By placing stress on the final syllable, learners try to satisfy FTTYPE$_{IAMB}$ which dominates FTTYPE$_{IAMB}$ in their L1. Thus, learners transferred the incorrect ranking into their IL.

As an initial stage, applying the L1 ranking (in tableau 5) to the target language (TL, henceforth) word *coffee*, for example, yields the wrong output with ultimate stress. The results of L1 transferred hierarchy is illustrated in tableau (6) below:

(6) Table 4: Learners' initial state (IL): Transferred L1 hierarchy

/kɑːfi/	FT-TYPE$_{IAMB}$	FT-TYPE$_{TROC}$
a. (ˈkɑː.fi)	*!	
💣 b. (kɑː.ˈfi)		*

The MA hierarchy favors the sub-optimal candidate (b) that is ruled out by the ranking of the TL. Candidate (a) surfaces as the (wrong) optimal output in the learners' IL as it satisfies FT-TYPE$_{IAMB}$. In the learners' IL, candidate (a) loses the competition due to the fatal violation of FT-TYPE$_{IAMB}$. Tableau (6) exemplifies how Moroccan learners transfer the wrong hierarchy of the L1, at the initial stages of acquisition.

Later, Moroccan learners, as language develops, show signs of optimizing their IL and hence corresponding to TL norms. Having negative evidence, the subsequent stage was to demote FT-TYPE$_{IAMB}$ step below FT-TYPE$_{TROC}$ by means of CDA as shown in (7). FT-TYPE$_{TROC}$ is undominated in English unlike in MA.

(7) Table 5: Constraint (FT-TYPE$_{IAMB}$) demotion

/kɑːfi/	FT-TYPE$_{IAMB}$	FT-TYPE$_{TROC}$
a. (ˈkɑː.fi)	*!	
b. (kɑː.ˈfi)		*

The result of learners' demotion of the dominated constraint (the constraint violated by the optimal form) is illustrated in tableau (8):

(8) Table 6 : Learners' convergence into the English system

/kɑːfi/	FT-TYPE$_{TROC}$	FT-TYPE$_{IAMB}$
☞ a. (ˈkɑː.fi)		*
b. (kɑː.ˈfi)	*!	

The demotion of FT-TYPE$_{IAMB}$ below FT-TYPE$_{TROC}$ optimizes candidate (a) instead of candidate (b). Tableau (8) indicates that learners converge their IL into the English stress pattern; i.e., moving towards a constraint ordering that corresponds to the English hierarchy of word-stress location.

Now we turn to explain this state of affairs using stratified hierarchy. As noted earlier, the language learners start with a priori assumption that at the initial stage constraints are unranked relative to each other. Hence, constraints can be established in any order. However, with the principle of UG in mind, we modify this assumption and claim that the constraints, at the first stage, appear in the L1 hierarchy (ALIGNHD-R >> WSP >>NONFIN >> FT-TYPE$_{IAMB}$>>Ft-BIN>> PARSE-σ >> Ft-TYPE$_{TROC}$). Hence, the initial state of learning a language is the final state of the L1 as shown below:

(9)

Initial Stratum= {ALIGNHD-R, WSP, NONFIN, FT-TYPE$_{IAMB}$, Ft-BIN, PARSE-σ, Ft-TYPE$_{TROC}$}

The next step is to find out what dominates what relative to the target grammar so as to optimize their IL. We assume that learners' developmental stages are explained by trail-and-error

process, in which they form hypotheses, err to prove them, and make corrections to optimize their grammar. By way of analogy, in OT terms, these processes are reflected in applying the L1 ranking, yielding the wrong output form, and demoting constraints to reach the most harmonic (correct) form.

The constraints violated by the optimal output are dominated by those violated by the suboptimal output; therefore, they have to be demoted to a lower stratum. Consider (10) where learners demote FT-TYPE$_{IAMB}$ to a lower stratum that is dominated by the initial stratum, the unavailability of a lower stratum results in creating a stratum to house the demoted constraint.

(10)

Initial Stratum = {ALIGNHD-R, WSP, NONFIN, Ft-BIN, PARSE-σ, Ft-TYPE$_{TROC}$}

>>

Stratum 1 = {FT-TYPE$_{IAMB}$}

The domination relation in (10) is still not the final hierarchy. Different word structure compels learners to proceed further demotion to improve the existing domination hierarchy. A constraint which is operative in stress location is WSP which is in conflict with NONFIN(ALITY). Consider tableau (12) which draws the domination hierarchy in learners' L1.

(11)

NON-FIN: No prosodic head is final in PrWd.

Weight-to-Stress Principle (WSP): A heavy syllable is stressed in foot structure.

(12) Table 7: WSP and NONFIN conflict in MA: 'limun' (orange 'fruit")

/limun/	WSP	NONFIN
a. (ˈli.mun)	*!	
☞ b. (li.ˈmun)		*

Tableau (12) indicates that candidate (b) is the winner as it satisfies the higher ranked constraint (WSP) that mandates stress to fall on the heavy syllable. Candidate (a), on the other hand, is ruled out because it incurs a fatal violation of WSP. The ranking of these two constraints in learners' L1 is WSP>> NONFIN, while the opposite holds true for English (i.e., NONFIN dominates WSP). Hence, transferring the L1 hierarchy into the TL stress pattern yields the wrong output form. The tableau (13) below illustrates the IL after L1 transfer.

(13) Table 8: IL: Transferred L1 hierarchy

/sætəlaɪt/	FT-TYPE$_{TROC}$	WSP	NONFIN
a. sæ.(ˈtə.laɪt)		*!	*
b. (ˈsæ.tə) laɪt		*!	
c. (sæ)(tə.ˈlaɪt)	*!		*
💣 d. (sæ.tə)(ˈlaɪt)			*

The transferred ranking in this tableau favors the suboptimal candidate (d) (which is ruled out by the TL hierarchy) as it fares well in the higher ranked constraint. While candidates (a) and (b) are ruled out due to the violation of WSP, candidate (c) loses the competition because it fatally violates the high ranked constraint FT-TYPE$_{TROC}$.

At this stage, candidate (d) is considered optimal in learners' IL. Subsequently, learners come to realize that the transferred ranking fails to optimize the correct output form in English. This newly evidence impels a demotion of WSP below NONFIN to match the TL ranking, as shown in tableau (14).

(14) Table 9: Constraint (FT-TYPE$_{IAMB}$) demotion

/sætəlaɪt/	FT-TYPE$_{TROC}$	WSP	NONFIN
a. sæ.(ˈtə.laɪt)		*!	*
b. (ˈsæ.tə) laɪt		*!	
c. (sæ)(tə.ˈlaɪt)	*!		*
💣 d. (sæ.tə)(ˈlaɪt)			*

Tableau (14) above illustrates the process of the demotion of WSP because the accessed evidence showed that this constraint is dominated by NONFIN in English. The result of learners' demotion is illustrated in tableau (15):

(15) Table 10: Learners' convergence into the English system

/sætəlaɪt/	FT-TYPE$_{TROC}$	NONFIN	WSP
a. sæ.(ˈtə.laɪt)		*!	*
☞ b. (ˈsæ.tə) laɪt			*
c. (sæ)(tə.ˈlaɪt)	*!	*	
d. (sæ.tə)(ˈlaɪt)		*!	

This tableau shows the convergence from IL into the English stress system by means of CDA. Candidate (b) is the optimal output because it best satisfies the high ranked constraints and it only causes one minimal violation of WSP. Candidates (a) and (d) are similarly ruled out due to their violation of NONFIN. Candidate (c) loses the competition as it incurs a violation of the highest ranked constraint FT-TYPE$_{TROC}$. Indeed, the demotion of WSP optimizes the actual output in English. To illustrate this demotion in a stratified hearing, the constraint WSP has to be demoted to a lower stratum, as shown below:

(16)

Initial Stratum = {ALIGNHD-R, NONFIN, Ft-BIN, PARSE-σ, Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {FT-TYPE$_{IAMB}$, WSP}

According to the stratified hierarchy in (16), while the constraint FT-TYPE$_{IAMB}$ and WSP are unranked with respect to each other (i.e., there is no domination relation between them), they are dominated by the initial stratum and all the constraints it houses. However, at this stage, this ranking needs further modification. It is well established that Ft-TYPE$_{TROC}$ does outrank FT-TYPE$_{IAMB}$ in English, unlike in MA. To ensure this ranking, learners have to house, by means of demotion, FT-TYPE$_{IAMB}$ in a stratum below WSP. Also, tableau (15) implies that NONFIN is dominated by t-TYPE$_{TROC}$; therefore, it should be demoted to a lower stratum that is dominated by the initial stratum. The constraints domination ranking in (16) is reformulated as (17) below:

(17)

Initial Stratum = {ALIGNHD-R, Ft-BIN, PARSE-σ, Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {NONFIN}
>>
Stratum 2 = {WSP}
>>
Stratum 3 = {FT-TYPE$_{IAMB}$}

The above stratified hierarchy reads as the initial stratum (and all the constraints housed in it) dominates stratum 1 and stratum 2 and 3 by transitivity.

It is noteworthy that the interaction of WSP and NONFIN in stress assignment in English verbs was found not to incur any difficulties for most of the participants. This state of affairs is explained by the fact that the constraints in question are similarly ranked in the learners' L1. Consider tableau (18).

(18) Table 11: The interaction of WSP and NONFIN in English verbs: (e.g., commence)

/kə mens /	FT-TYPE$_{TROC}$	WSP	NON-FIN	ALIGNH-R	FTBIN-μ	PARSE-σ	FT-TYPE$_{IAMB}$
a. ☞ * μ (μμ) kəmens			*			*	*
b. * (μ μ)μ kəme ns		*!		*		*	*
c. * (μ μμ) kəmens		*!	*		*		*
d. * (μ μ) kəmens		*!	*				*
e. * (μ μ) kəmens	*!		*				

Similar to MA, in English verbs WSP outranks NONFIN. Therefore, as was predicted by CDA, learners did not need to go through this stage of demoting WSP below NONFIN to reach the optimal form. Had they demoted WSP below NONFIN, they would have optimized the wrong output.

The domination relation in (17) is still not the final hierarchy. The data available to learners falsify the ranking in (17). Learners come to realize that further demotion is in order to improve the existing domination hierarchy. Another determining constraint to stress placement is ALIGNHD-R which is in conflict with WSP. Consider tableau (19) which captures the conflict between these two constraints in stress pattern of learners' L1.

(19) Table 12: The interaction of ALIGNHD-R and WSP in learners' L1: 'SanDaLa' (sandal)

/SanDaLa/	ALIGNHD-R	WSP
a. ˈSan.Da.La	**!	
☞ b. San.ˈDa.La		*

Candidate (a) is ruled out due to stress location on the absolute left edge of the word; therefore, incurring a fatal violation of ALIGNHD-R. Candidate (b), on the other hand, is the most harmonic as it satisfies the higher ranked constraint.

When learning English, Moroccan learners hypothesized that ALIGNHD-R >> WSP. Tableau (20) illustrates learners' transfer of the L1 constraint ranking into English stress pattern.

(20) Table 13: IL: a transferred constraint hierarchy from MA

/serɪməni/	FT-TYPE$_{TROC}$	ALIGNHD-R	WSP
a. (ˈser.ɪ)mə.ni		**!	
💣 b. (ser.ɪ)(ˈmə.ni)			*
c. ser(ɪ.ˈmə)ni	*!	*	*
d. ser(ˈɪ.mə)ni		*!	*

The transferred ranking favors the suboptimal candidate (b) (that is ruled out by the English hierarchy) for it best satisfies the higher ranked constraint. Candidates (a), (c), and (d) lose the competition due to their violation of ALIGNHD-R, candidate (c) also violates the high ranked constraint FT-TYPE$_{TROC}$. The consequence of the L1 transferred hierarchy is the optimization of the wrong system in the learners' IL.

English data contains evidence as to disconfirm the ranking of ALIGNHD-R>>WSP that Moroccan learners have already acquired as part of their L1 grammar. The next stage, as learners are exposed to data, brings evidence for demotion of ALIGNHD-R into a lower position. This demotion is illustrated below:

(21) Table 14: The demotion of ALIGNHD-R below WSP

/serɪməni/	FT-TYPE$_{TROC}$	ALIGNHD-R	WSP
a. (ˈser.ɪ)mə.ni		**!	
💣 b. (ser.ɪ)(ˈmə.ni)			*
c. ser(ɪ.ˈmə)ni	*!	*	*
d. ser(ˈɪ.mə)ni		*!	*

Tableau (21) above illustrates the process of the demotion of ALIGNHD-R because the newly accessed evidence showed that this constraint is dominated by WSP. The result of learners' demotion is represented in tableau (22):

(22) Table 15: Optimization of stress assignment in the English system

/serɪməni/	FT-TYPE$_{TROC}$	WSP	ALIGNHD-R
☞ a. (ˈser.ɪ)mə.ni			**
b. (ser.ɪ)(ˈmə.ni)		*!	
c. ser(ɪ.ˈmə)ni	*!	*	*
d. ser(ˈɪ.mə)ni		*!	*

Tableau (22) demonstrates the convergence from learners' IL into the English stress pattern ranking employing CDA. The result of this demotion is a hierarchy identical to the English hierarchy in that it secures that a heavy syllable receives stress regardless of the position of the syllable. In the word *ceremony*, as an instance, stress is attracted to the heavy syllable although stress is placed on the absolute left edge of the word. The opposite holds true in learners' L1 (cf. the example in tableau (19)).

In tableau (22), candidate (a) is the optimal output thanks to its satisfaction of the high ranked constraints. Candidates (b) and (d) are ruled out for they fatally violate WSP by placing stress on a light syllable. Candidate (c) loses the competition due to its violation of the constraints. By demoting ALIGNHD-R, learners correctly optimize the actual output in English. (23) captures another stage in the learning process of English stress that is characterized by demoting ALIGNHD-R to a lower stratum.

(23)

Initial Stratum = {ALIGNHD-R, Ft-BIN, PARSE-σ, Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {NONFIN}
>>
Stratum 2 = {WSP}
>>
Stratum 3 = {ALIGNHD-R}
>>
Stratum 4 = {FT-TYPE$_{IAMB}$}

This stratified hierarchy indicates the optimized ranking in tableau (22) wherein WSP dominates ALIGNHD-R.

Another relevant constraint to our analysis of stress learnability is Ft-BIN which is in conflict with WSP. Consider the account of stress location in the word *agenda* below:

(24)

Ft-BIN (FOOT-BINARITY): Feet are binary at some level of analysis (μ, σ).

(25) Table 16

/ədʒendə/	WSP	Ft-BIN
☞ a. ə(ˈdʒen)də		*
b. (ˈə.dʒen)də	*!	

Candidate (a) is the optimal output as it satisfies WSP even though the foot is not binary at the level of syllabic analysis. Candidate (b), on the other hand, is ruled out because stress does not fall on the heavy syllable although it satisfies Ft-BIN.

As was predicted by CDA, Moroccan learners of English do not encounter difficulties relative to the interaction of WSP and Ft-BIN. This state of affairs recourses to positive evidence which is a result of similar ranking, as promised by CDA. Positive evidence lies in the winning candidate that learners optimize, which shows that the established hierarchy is correct as in tableau (25).

Notice that learners, at this stage, could not generate a candidate as (gəˈrɑːʒ). We believe that at this stage of acquisition learners have already established a ranking where FT-TYPE$_{IAMB}$ is not attested in English. Hence, such candidates are excluded due to the fatal violation of FT-TYPE$_{TROC}$.

While Ft-BIN does not cause any difficulty for learners as it similarly interacts with WSP in MA; hence, they optimize a structure in conformity with TL grammar. Learners needed to house it (Ft-BIN) in a stratum below. (23) is reproduced in (26) below to secure the ranking WSP>> Ft-BIN:

(26)

Initial Stratum = {PARSE-σ, Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {NONFIN}
>>
Stratum 2 = {WSP}
>>
Stratum 3 = {ALIGNHD-R, Ft-BIN}
>>
Stratum 4 = {FT-TYPE$_{IAMB}$}

This stratified hierarchy reads as while Ft-BIN is unranked relative to ALIGNHD-R, they are both dominated by WSP and all above strata (1 and initial). They, on the other hand, dominate stratum 4.

Ft-BIN is also in conflict with PARSE-σ that bans unfooted syllables. In English grammar, it is well established that Ft-BIN dominates PARSE-σ. Consider tableau (28) which illustrates the interaction of these two constraints along with other decisive constraints in stress account.

(27)

PARSE-σ: Syllables are parsed by feet.

(28) Table 17: The interaction of Ft-BIN and PARSE-σ

/əmerɪkə/	FT-TYPE$_{TROC}$	NONFIN	WSP	ALIGNHD-R	Ft-BIN	PARSE-σ
a. ə.(ˈmer)ɪ.kə					*!	***
b. (ˈə.mer)ɪ.kə			*!			**
c. (ə.mer)(ˈɪ.kə)		*!	*			
d. (ə.ˈmer)(ɪ)kə	*!		*		*	*
☞ e. ə(ˈmer.ɪ)kə						**

This tableau indicates the ranking that Ft-BIN dominates PARSE-σ; hence, *A(meri)ca* (candidate e) is more harmonic than its competitors. As principled in CDA, this hierarchy does not

cause difficulties for Moroccan learners as it is equally ranked in their L1 grammar. This is another example of positive evidence. At this stage, all what learners were required to do is to place PARSE-σ in a stratum below Ft-BIN. This ranking is illustrated in the following stratified hierarchy.

(29)

Initial Stratum = {Ft-TYPE$_{TROC}$}
>>
Stratum 1 = {NONFIN}
>>
Stratum 2 = {WSP}
>>
Stratum 3 = {ALIGNHD-R, Ft-BIN}
>>
Stratum 4 = {PARSE-σ}
>>
Stratum 5 = {FT-TYPE$_{IAMB}$}

The stratified hierarchy represents the stages of learning process that learners went through to reach the optimized stress pattern. In the absence of further negative evidence, Moroccan learners adopt the hierarchy in (29) for it optimizes solely the correct output in the target language.

6. Conclusion and Implications

The aim of this research paper has been to offer an OT analysis of English word-stress learnability. Adopting the framework of Constraint Demotion Algorithm (Tesar and Smolensky, 2000/2006) to account for this process, this study has attempted to enquire the effect of L1 ranking on stress acquisition and to test if OT can predict the stages of learning process. It decomposes word-stress learnability problem and shows how learners, by means of CDA, can deduce the constraint ranking particular to a target language. Given the structural descriptions of negative evidence (data), demoting constraints allows efficient convergence to a correct grammar.

We conclude that most errors are traceable to the unconformity between the constraint hierarchy of English and MA. One can also conclude that learners' L1 constraint ranking affects their acquisition of English word-stress. Leaners' IL is a fluctuation between the hierarchy of their mother tongue and the target language. However, as language develops and with sufficient adequate exposure to the input, Moroccan learners optimize the hierarchy of the target language and succeed in avoiding fossilization in this area.

Given its deeper linguistic explanation, OT can successfully predict learning stages using CDA (Tesar & Smolensky, 2000). It is established that CDA is relevant to language learnability. First, CDA is an algorithm that was straightforwardly adopted to account for L2 acquisition problems. Second, the algorithm has succeeded to predict the stages in L2 acquisition process. As predicted by CDA, every phase a constraint is demoted to a lower stratum, a new hierarchy is established and housed in a particular stratum (the absence of a lower stratum results in creating a new one). When more constraints are demoted, a number of strata are created to house the established hierarchy. Each stratum (a hierarchy) represents a stage in language learning process, as shown in the stratified hierarchy in (29) wherein each stratum implies a learning stage.

As for the teaching approach of word-stress, there are tangible arguments in favour of inductive approach (rule-discovery) over deductive approach (learners being given a rule: rule-driven). Although there are benefits to both approaches, a number of researchers and practitioners have recommended implicit teaching. For instance, Krashen (1982; 1985) and Krashen and Terrel (1983) recommended that teachers provide comprehensible input instead of presenting an item (say word-stress pattern in this case) explicitly. Nevertheless, while we believe that deductive and inductive teaching should not look at as competing approach, but rather as two approaches that complete each other, the adoption of each depends on a number of factors (e.g., the nature of the target item, learners' age, and the preferences of the teacher and learners). By way of illustration, inductive teaching of English stress pattern is often seen advantageous in high school classrooms. Conversely, university learners (adults) favour deductive teaching because they like to analyze the grammar pattern.

We also recommend the application of computer-assisted pronunciation training (CAPT) to visually and instrumentally teach pronunciation. A CAPT program that was proposed as a pedagogical tool to effectively teach word-stress is Praat (open-source acoustic analysis software) in Smirkou's study. In his experimental study, Smirkou has attempted to assess the effectiveness of Praat incorporation in teaching word-stress. The result obtained from the Independent Samples t-test shows that Sig. (2-tailed) score was 0.004, smaller than the significance value 0.05. Thus, the use of Praat has a positive effect on EFL learners' pronunciation. By opening up an analysis to the visual medium and visual measurement of acoustic properties, Moroccan learners succeeded to improve word-stress pronunciation. Praat also helps learners self-identify their pronunciation

problems, self-correct them by comparing their speech with that of native speaker, and self-pace their learning.

The present paper has attempted to contribute to L2 phonology in the Moroccan context, an area of research which is scare. Using CDA, it has studied the role of crosslinguistic influence on the acquisition of L2 phonology, particularly of the acquisition of English word-stress among Moroccan learners. The overall findings of the present study can be captured as follows:

- Learners' prior (L1) ranking (ALIGNHD-R >> WSP >>NONFIN >> Ft-TYPE$_{IAMB}$>>Ft-BIN >> PARSE-σ >> Ft-TYPE$_{TROC}$) influences their learnability of English stress.
- Moroccan learners misplace stress in English words due to the initial state of their native grammar.
- The relevance of Constraint Demotion Algorithm to L2 acquisition is evident. Each demotion captures a hierarchy, and each hierarchy represents a stage in learning process.
- As predicted by CDA, the interaction of WSP and Ft-BIN and that of Ft-BIN and PARSE-σ do not cause any difficulty for learners as they are similarly ranked in their L1. Learners also do not encounter difficulty in stress location in verbs (WSP and NONFIN similarly interacts in their L1).
- Making use of CDA, learners can optimize the hierarchy of the target language (stress pattern), as represented in (29).

References

Abdelmassih, E. (1973). *An Introduction to Moroccan Arabic.* The University of Michigan: Ann Arbor, MI.

Alaoui, A., Jmila, M., & Afkiniche, T. (2004/2019). *Basics in linguistics: phonology and morphology.* Rabat, INTERLANGUES: Institute of languages.

Amrous, N. (2012). On the acquisition of vowel weight in Standard Amazigh. In S. Graiouid (Ed.), *Langues et Litteratures, Amazigh Linguistics: An optimality-theoretic perspective* (Vol. 22, pp. 155-177). Rabat: Faculty of Letters and Human Sciences .

Archibald , J. (1997a). The acquisition of English stress by speakers of non-accentual languages: lexical storage versus computaion of stress. *Linguistics, 35*(1), 167-181.

Archibald, J. (1997b). The acquisition of L2 phrasal stress: A pilot study. In S. J. Hannahs, & M. Young -Scholten (Eds.), *Focus on phonological acquisition.* Amsterdam : John Benjamins.

Archibald, J. (2003). Learning to parse second language consonant clusters. *Canadian Journal of Linguistics, 48*(3/4), 149-178.

Benhallam, A. (1989). Aspects de la recherche en phonologie de l'arabe marocain. *In Langue et Socité au Maghreb: Bilan et Perspectives 13*, 13-23.

Benhallam, A. (1990a). Moroccan Arabic Syllable Structure. *Langues et littératures VIII*, 177-191.

Benhallam, A. (1990b). Native Speaker Intuitions about Moroccan Arabic Stress. In J. Pleines, *Maghreb Linguistics,* (pp. 91-109). Rabat: Editions Okad.

Benkaddour, A. (1982). *A Nonlinear Analysis of Some aspects of the Phonology and Nonconcatenative Morphology Of Arabic.* Ph.D. Dissertation. School of Oriental and African Studies, London.

Benkirane, T. (1982). *Etude phonétique et fonction de la syllabe en arabe marocain.* Thèse de 3ème cycle. Université de Provence.

Bensoukas, K., & Boudlal, A. (2012a). The prosody of Moroccan Amazigh and Moroccan Arabic: Similarities in the phonology of schwa. In T. Borowsky, S. Kawahara, T. Shinya, & M. Sugahara (Eds.), *Prosody Matters: Essays in Honor of Lisa Selkirk* (pp. 3-42). London: Equinox Publishing.

Best, C. T. (1995). A direct realist view of cross-linguistic speech perception. In W. Strange (Ed.), *Speech perception and linguistics experience: issues in cross-language research* (pp. 171-204). Baltimoe, MD: York Press.

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In M. J. Munro, & O. S. Bohn, *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 13-34). Amsterdam: John Benjamins.

Bohas, G., Hammoumi , A., & Chami , N. (1989). Accentuation et effacement dans le parler de Tanger. *Langues Orientales Anciennes: Philosophie et Linguistique 2*.

Boudlal, A. (2001). *Constraint interaction in the phonology and morphology of Casablanca Moroccan Arabic.* Doctorat d'État thesis, Mohammed V University, FLHS, Rabat.

Boudlal, A. (2006/2007). Sonority-driven schwa epenthesis in Moroccan Arabic. In K. Bensoukas, & A. Boudlal , *Languages and Linguistics* (pp. 59-81).

Boudlal, A. (2011). *Constraint Interaction in the Phonology and Morphology of Casablanca.* Doctorat d'Etat dissertation. Rabat: Faculty of Letters.

Bouziri , R., Nejmi, H., & Taki , M. (1991). L'accent de l'arabe marocain parlé à Casablanca et à Tunis: étude phonétique et phonologique. *Actes du XIIème Congrès International des Sciences Phonétiques (Aix-en-Provence)*, 134-137.

Broselow, E. (2000). Stress, epenthesis, and segment transformation in Selayarese loans. *Proceedings of the 25th annual meeting of the Berkeley linguistics society, 25*. doi:10.3765/bls.v25i1.1203

Broselow, E. (2018). Laryngeal contrasts in second language phonology. In L. Hyman, & F. Plank (Eds.), *Phonological Typology* (pp. 312-340). Berlin/Boston: Walter de Gruyter.

Broselow, E., & Xu, Z. (2004). Differential difficulty in the acquisition of second language phonology. *International Journal of English Studies 4,2 (Special Issue: Advances in Optimality Theory)*, 135-163.

Broselow, E., Chen, S.-I., & Wang , C. (1998). The emergence of the unmarked in second language phonology. *Studies in Second Language Acquisition, 20*, 261-80.

Brown, C. A. (1998). The role of the L1 grammar in the L2 acquisition of segmental structure. *Second language research*, 136-193.

Eckman, F. (2004). Optimality Theory, Markedness and Second Language syntax: the case of resumptive pronouns in relative clauses. *Studies in Phonetics, Phonology and Morphology*, 10, 89-110.

Eckman, F. R. (1977). Markedness and the Contrastive Analysis Hypothesis. *Language learning, 27*, 315-330.

El Hadri, M. (1993). *A Metrical Approach to Stress in Moroccan Arabic Verbs.* D.E.S. Thesis. Faculté des Lettres, Rabat.

Escuerdo, P., & Boersma, P. (2001). Medelling the perceptual development of phonological contrasts with Optimality Theory and the Gradual Learning Algorithm. *Proceeding of the 25th Penn Linguistics Colloquium*.

Escuerdo, P., & Boersma, P. (2004). Bridging the gap between L2 speech perception research and phonological theory. *Studies in Second Language Acquisition 26 (5)*, 551-585.

Fares, N. (1993). *Stress in Moroccan Arabic Nouns and Adjectives: A Metrical Approach.* D.E.S. thesis. Faculté des Lettres, Rabat.

Faris, M. M., Best, C. T., & Tyler, M. D. (2018). Discrimination of uncategorised non-native vowel contrasts is modulated by perceived overlap with native phonological categories. *Journal of Phonetics, 70*, 1-19.

Flege, J. E. (1991). Age of learning affects the authenticity of voice onset time (VOT) in stop consonants produced in a 2nd language. *Journal of the acoustical society of America, 89*, 395-411.

Flege, J. E. (1995). Second language speech learning: theory, findings and problems. In W. Strange (Ed.), *Speech perception and linguistics experience: issues in cross-language research* (pp. 233-277). Baltimore, MD: York Press.

Flege, J. E. (2003). Assessing constraints on second-language segmental production and perception. In A. Meyer , & N. Schiller, *Phonetics and phonology in language comprehension and production: differences and similarities* (pp. 319–345). Berlin: Mout.

Fries, C. (1945). *Teaching and Learning English as a Foreign Languge.* Ann Arbor: University of Michigan Press.

Hammond, M. (1999). *The phonology of English: A prosodic optimality-theoretic approach* . Oxford: Oxford University Press.

Hammoumi, A. (1988). *Syllabation, accentuation, éffacement et abrègement dans le parler de Fès et d'autres parlers marocains.* Thèse de doctorat. Université de la Sorbonne Nouvelle, Paris III.

Hancin-Bhatt, B. (2000). Optimality in second language phonology: Codas in Thai ESL. *Second language research, 16*(3), 201-232.

Kably, H. (2001). *Stress Assignment in Jdidi Moroccan Arabic Nouns and Adjectives: A Metrical Approach.* PhD thesis. Faculté des Lettres, Rabat.

Kager, R. (1999). *Optimality Theory.* Cambridge, England: Cambridge University Press.

Kager, R., Pater, J., & Zonneveld, W. (2004). *Constraints in phonological acquisition.* Cambridge: Cambridge University Press.

Krashen, S. D. (1982). *Principles and practices in SLA.* Oxford: Pergamon Press.

Krashen, S. D. (1985). *The input hypothesis: Issues and implications.* London: Longman Carroll.

Krashen, S. D., & Terrel, T. (1983). *The Natural Approach* . California: Alemany Press.

Lado, R. (1957). *Linguistics across cultures* . Ann Arbor: University of Michigan Press.

Major, R. C. (1987). English voiceless stop production by speakers of Brazilian Portuguese. *Journal of phonetics*, 197-202.

Major, R. C. (2001). *Foreign accent: The ontogeny and phylogeny of second language phonology.* Mahwah, NJ and London: Lawrence Erlbaum.

McCarthy , J., & Prince, A. (1995b). Prosodic Morphology. In *The Handbook of Phonological Theory, ed. John A. Goldsmith* (pp. 318-366). Cambridge, MA, and Oxford: UK Blackwell.

McCarthy , J., & Prince, A. (1995a). Faithfulness and reduplicative identity. (J. Beckman, L. W. Laura Walsh Dickey, & S. Urbanczyk, Eds.) *In University of Massachusetts Occasional Papers in Linguistics, 18*, 249-384.

McCarthy, J. (2002). *A Thematic Guide to Optimality Theory.* New York: Cambridge University Press.

McCarthy, J., & Prince, A. (1993b, January). Generalized Alignment. In Booij, G , & Van Marle, J (Eds.), *Yearbook of Morphology 1993* (pp. 79-153). Dordrecht: Kluwer.

McCarthy, J., & Prince, A. (1999). Faithfulness and identity in prosodic morphology. In R. Kager, H. V. Hulst, & W. Zonneveld (Eds.), *The Prosody-Morphology Interface* (pp. 218-309). Cambridge : Cambridge University Press.

Nejmi, H. (1993). *Contribution à une étude des processus accentuels de l'arabe marocain de Casablanca: approache phonétique et phonologique (accent de mot).* Thèse de doctorat. Paris III, Université de la Sorbonne Nouvelle.

Nejmi, H. (1995). Les variations prosodiques de l'accent de l'arabe marocain parlé à Casablanca: approche phonétique et phonologique (accent de mot). *Recherches Linguistiques. Faculté des Lettres, Ben M'Sik, Casablanca*.

Prince, A., & Smolensky, P. (2004). *Optimality Theory: Constraint Interaction in Generative Grammar.* Oxford: Blackwell.

Prince, A., & Smolensky, P. (1993). *Optimality Theory: Constraint Interaction in Generative Grammar.* Rutgers University and Univesity of Colorado at Boulder.

Prince, A., & Smolensky, P. (2004). *Optimality Theory: Constraint Interaction in Generative Grammar.* Oxford: Blackwell.

Prince, A., & Tesar, B. (2004). Learning phonotactic distributions. In R. Kager, J. Pater, & W. Zonneveld (Eds.), *Constraints in Phonological Acquisition* (pp. 245-291). Cambridge: Cambridge University Press.

Tesar, B. (1998). An iterative strategy for language learning . *Lingua*, 104, 131–145.

Tesar, B. (1999). Robust interpretive parsing in metrical stress theory. *Proceedings of the 17th West Coast Conference on Formal Linguistics*, 625–639.

Tesar, B. (2000). On the roles of optimality and strict domination in language learning . In J. Dekkers, F. Van der leeuw, & J. Van de We, *Optimality Theory: Phonology, syntax, and acquisition* (pp. 592–620). New York: Oxford University Press.

Tesar, B., & Smolensky , P. (1998). *Learnability in Optimality Theory.* Linguistic Inquiry 29: 229–268.

Tesar, B., & Smolensky, P. (1993). *The learnability of Optimality Theory: an algorithm and some basic complexity results.* Technical Report CU-CS-678-93,Computer Science Department, University of Colorado, Boulder. [ROA-2,http://ruccs.rutgers.edu/roa.html].

Tesar, B., & Smolensky, P. (1996). *Learnability in optimality theory.* (long version) [ROA-156, http://ruccs.rutgers.edu/roa.html].

Tesar, B., & Smolensky, P. (2000). *Learnability in Optimality Theory.* Cambridge, MA: MIT Press.