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An Optimality Analysis and Treatment of Phonological Disorders in the Speech of Jordanian Children: A Case Study

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Abstract

This paper presents a case study of a Jordanian child with phonological speech disorders. It seeks to investigate functional phonological disorders and their treatment among Jordanian children within an Optimality Theoretic (OT) perspective. It aims to provide treatment for children's speech errors within a constraint-based system. The analysis of the data identifies seven error patterns in the child's productions, namely: fronting, lateralization, stopping, devoicing, de-emphasization, syllable deletion and cluster reduction. Furthermore, OT is employed at the end of the study as a guideline to select the priority of treatment goals by demoting responsible markedness constraints below faithfulness constraints.

Keywords: Phonological Disorder, Jordanian Spoken Arabic, Optimality Theory (OT), Phonological Treatment

1. Introduction

A functional phonological disorder is defined as a speech impairment of no known etiology, i.e. it is not related to any organic disease. Gierut (1998) stated that children with functional phonological disorders are those who have no known cause for the noticeable impairment in their communication, and thus they are normal children with normal intelligence and skills. Moreover, Gierut (2008) insists that, with the exception of phonology, children with phonological disorders are developed normally in all other areas. Therefore, a functional disorder is not related to other organic impairments that have a known cause such as a brain injury, an intellectual disability, a cleft lip or palate, vocal abuse or misuse, or drug abuse. It is worth noting here that, among others, Gillam and Kamhi (2010), Goldstein and Horton-Ikard, (2010), and Weiss and Paul (2010) used the term Specific Language Impairment (SLI) as either an equivalent or alternative for functional phonological disorder.

In this sense, the ability to articulate sound (phonetic disorder) is different from that of using sounds (phonological disorder). In particular, children who suffer from organic problems are known as children with phonetic speech disorders. On the other hand, children who have developmental functional problems have phonological speech disorders. The difference between the two types is that phonetic disorders cannot be included in clinical phonology treatment where the latter can be phonologically treated. Accordingly, the organic problem does not affect the phonological representation of the speech; rather, it affects its target articulation. (Ball, 2016).

In recent years, there has been a dramatic shift towards a constraint-based system where the most contemporary studies of phonology have been conducted within it, namely Optimality Theory (OT). Many researchers such as McCarthy (2008), Kager (2004), and Prince and Smolensky (2004), outlined the components of OT and its mechanisms. They explained that OT has two kinds of constraints – known as the faithfulness and markedness constraints – which are always in conflict. The main components of OT grammar are the generator (GEN), the evaluator (EVAL), and the constraint set (CON). GEN is responsible for producing a set of candidates when applied to some input. All these candidates are logically possible analyses of an input. Likewise, EVAL is responsible for selecting an optimal candidate based on the constraint-ranking of a given grammar when applied to a set of output candidates. Thus, particularly in this study, EVAL is considered a child specific since it is responsible for selecting the optimal candidate according to the constraint-ranking of the child's grammar. Moreover, CON consists of two basic types of constraints mentioned earlier as markedness and faithfulness constraints.

McCarthy (2008) clarified that OT is a theory that distinguishes between markedness and faithfulness constraints only in relation to their interaction with each other. The conflict of these two constraints creates different constraint rankings, and thus different types of grammar. Therefore, as a generative model of grammar, the core aspect of OT is that Universal Grammar (UG) contains a large universal set of violable constraints that are strictly ranked within a particular language. The variations observed in languages is attributed to their difference in terms of constraint ranking. Likewise, differences in the productions of

individual children are attributed to the variations of the constraint ranking in each child's grammar.

Accordingly, the general assumption for the explanation of speech disorders is that phonological speech errors emerge when the markedness constraints outrank the faithfulness constraints in someone's grammar, and this is the opposite case of normal speaking people. Theoretically, the treatment of these speech errors requires promoting the rank of the violated faithfulness constraints at the expense of the markedness ones.

This study aims to evaluate applying OT to the assessment and treatment of phonological disorder. It also aims to provide speech-language pathologists in Jordan with beneficial information about the phonological treatment of functionally impaired Jordanian speaking children. Ultimately, this paper aims to add its findings to the existing knowledge in the field of phonological disorders in order to increase treatment efficacy. By doing so, this paper will strive to benefit children, parents, and the speech clinical system.

2. Literature Review

Recently, there has been a dramatic shift towards the constraint-based system called Optimality Theory (OT) in which most current studies in the field of phonology have been conducted. In particular, the most contemporary studies that tackle phonological speech disorders and their analysis and treatment were conducted within an OT perspective. For example, Barlow (2001), Kinney (2004), Gierut and Morrisette (2005), Dinnsen (2008a), and Shooshtaryzadeh (2014 and 2015) have distinguished works in the clinical phonology from an OT perspective.

Barlow (2001) analyzed the error patterns in a single child's productions within the framework of Optimality Theory. She provided a demonstration of the application of OT to the assessment and treatment of an English-speaking child with phonological disorders. The data was drawn from single-word responses of the Bankson-Bernthal Test of Phonology of a child aged 3 years and 9 months. The study revealed eight error patterns in the child's productions, namely: final consonant deletion, stopping, cluster reduction, gliding, prevocalic voicing, glottal replacement, unstressed syllable deletion, and vocalization. Barlow hypothesized that the main reason for these prototypical errors is the markedness constraints that outrank the faithfulness constraints in the child's grammar. She also provided a demonstration of how Optimality Theory accounts for different types of variations in the child's productions. For treating such errors, Barlow suggested focusing on the demotion of markedness constraints below faithfulness constraints. She also provided alternative treatment strategies for single consonants in relation to their OT constraints.

Moreover, Barlow (ibid.) provided a summary of the markedness and faithfulness constraints according to their occurrence cross-linguistically. She pointed out that fricatives, affricates, liquids, and consonant clusters are examples of marked properties of language according to their difficulty in production and limited usages across languages. On the contrary, vowels, glides, nasals, and stops are examples of unmarked properties of language according to their ease of articulation and frequent occurrence in all languages. In addition, Barlow pointed out

that marked sounds or sequences are lately acquired by children and cause difficulty for second-language learners.

Kinney (2004) compared analyzing phonological disorders within the derivational theory of Chomsky and Halle (1968) and within OT. He collected his data from three different case studies of three different scholars: Oller (1973), Lorentz (1976), and Edwards and Bernhardt (1973). Respectively, the first case study examined the phonological process of stopping, the second one explored the phonological process of atypical cluster reduction, and the third one investigated the phonological process of using a non-language segment. The data of the three studies was collected from English-speaking children. Kinney classified these phonological disorders into three sub-types: common, uncommon, and rare. Within the framework of OT, distinct constraint rankings were proposed for each sub-type. These rankings were also compared with normal acquisition and adult grammar. The results presented that the constraint rankings of normal child phonology, common disorders, uncommon disorders, adult grammar, and rare disorders are all different. Moreover, a continuum of markedness is presented where normal child phonology is the least marked and rare disorders are the most marked. The results also showed that in comparison to the derivational theory, OT is a better theory to analyze phonological disorders because of its typological nature.

Within the crux of OT and its clinical significance for phonological disorders, Gierut and Morrisette (2005) extended the OT model to clinical assessment and treatment through a theoretical research. The purpose of this work was to emphasize theoretically the importance of OT to keep abreast of current research in clinical phonology. The researchers concluded that there are at least three novel theoretical directions provided by OT. The first of which is the shift from mental representations and phonological rules into a constraint-based system. The second is the parallel and distributed processing of OT in integrating language with cognition. The third is the ability of OT to reflect language acquisition through a series of constraint demotion. Although this work is theoretical in nature, it highlights the role of OT in clinical assessment and treatment of phonological disorders. This is because OT is able to characterize children's sound systems in a way that is more sensitive to interactions and co-occurrences among error patterns.

Dinnsen (2008a) explored the reasons behind the resistance of some phonological errors for treatment through examining a number of published case studies within an OT perspective. More specifically, he collected his data from those studies of Gierut (1998), Gierut & Champion (1999), Elbert & McReynolds (1985), Forrest, Dinnsen and Elbert (1997), and Dinnsen, Chin and Elbert (1992). The data focused on the productions of English-speaking children who ranged in ages from three- to seven-years-old and exhibited recalcitrant or unintelligible speech error patterns. The data presented five types of children's phonological error patterns and their treatment with an optimality theoretic consideration. The five types of errors were:

Simple or tractable error patterns (e.g. labial fricatives are replaced by coronal fricatives),

Chain shift error patterns (e.g. the replacement of /s/ with [θ], but /θ/ itself is replaced with [f]),

Overgeneralization error patterns (e.g. /θ/ and /s/ which are realized as [f] and [s̪], respectively; both shift to [θ] after treatment),

Complementary error patterns (e.g. final consonant omission regardless of the consonant class), and

Implicationally-related errors (the sound is corrected in treated contexts and it persists in the untreated contexts).

Dinnsen concluded that Optimality Theory explains the variation of the different error patterns in responding to treatment. That is, in the simpler error patterns, problems can be solved by demoting that single markedness constraint which governs such kinds of errors. For the more problematic error patterns, which are governed by multiple markedness constraints, each markedness constraint must be demoted until the complete elimination of the error patterns, starting from the highest-ranked markedness constraint .

More recently, Shooshtaryzadeh (2015) investigated the basic architecture and formalities of OT on the Persian language. He took his examples of phonological disorders from Shooshtaryzadeh's (2014) work which tackled phonological development in Persian children acquiring Farsi. The researcher highlighted some of the OT advantages over rule-based generative approaches in different linguistic contexts by illustrating speech disorders, first in standard generative phonology, and then in the OT framework. By doing so, the researcher concluded that generative phonology, which focuses only on the two aspects of underlying and surface representations, has certain limitations that are not found in OT. For example, in a multilingualism context such as India, the rule-based system of generative phonology cannot illustrate the different linguistic elements which interfere with the phonological productions of a child in such a multilingual context. Conversely, the constraint-based system of OT makes it possible to indicate all of the constraints that affect a child's speech, and thus causes multiple productions in one representation at a time, even if they are from different languages used in the same society. This helps clinicians in multilingual societies obtain a comprehensive insight of the factors that affect children's phonological productions and leads them to evolve the best strategies to solve specific problems children face in complex linguistic contexts.

The assessment of the speech errors of typically developing and atypically developing phonologies in the OT approach of Shooshtaryzadeh's study also revealed that OT is able to explain phonological processes as well as the reason behind speech errors. The analyses showed that OT is able to predict the reasons behind error productions. This helps clinicians determine the child's speech problems and design more adequate treatment plans for children with functional phonological disorder. On the contrary, generative phonology cannot answer questions related to the children's phonological productions or explain the differences in typical and atypical phonological development.

In fact, functional phonological disorders in the speech of Arab children have received little attention, especially when it comes to the analysis and treatment within the OT phonological point of view. In this regard, Mitleb (1992), Abwaini (2002), and Otoom (2013) conducted

their studies on Jordanian Arabic within different phonological perspectives. Mitleb (1992), for example, examined the variability of misarticulations of two Jordanian Arabic-speaking second-graders within the framework of Generative Phonology (GP). He conducted his study following Gierut (1984, 1985) as a support to the explanatory model of generative phonology to account for misarticulations. To elicit the data, the researcher collected his speech samples using a picture-naming elicitation task as well as naming friends and family members. Moreover, he used spontaneous speech samples by asking different questions to the children. In his study, Mitleb assumed that children with specific speech impairment have an identical knowledge to that of the relevant ambient language. Moreover, he noticed violations of the markedness theory, more specifically, in relation to voicing. Mitleb attributed these violations to the markedness principles that characterize the functional speech misarticulations. Taking into account the underlying representations of the two children, it is maintained that speech misarticulations can be the result of non-ambient underlying representations and constraints posited in the child's phonemic inventory. Mitleb (1992:64) concluded that the generative approach "is a more neutral framework within which things like variations between different misarticulating children can be characterized".

Moreover, Abwaini (2002) pointed out the significance of linguistic theories in the assessment and remediation programs of speech and language disorders. Therefore, she investigated the phonological processes and the consonant substitutions of the speech of thirty functionally misarticulating Arabic-speaking Jordanian children aged from 7-12 within the nonlinear theories of linguistics. The data were elicited through a word-list test where the researcher audiotaped children's spontaneous responses and then transcribed and analyzed them using generative and autosegmental phonological approach. Abwaini found out that stopping is the most frequently used phonological process while dentalization is the least occurring one. Furthermore, the most commonly substituted segments were fricatives, and the most commonly substituted consonant is the emphatic fricative /ð/ .

Otoom (2013), on the other hand, investigated the phonological disorders exhibited in the grammar of 37 Jordanian-Arabic speaking children within the framework of OT. She analyzed variations in the speech of the children in terms of phonological disorders. The data analyses revealed that OT is a perfect model to account for phonological disorders in the speech of Jordanian children. The study also highlighted the role that OT plays in the assessment and treatment of such speech errors.

The body of work reviewed in this section suggests that this phonological topic has been given great attention in languages other than Arabic within an OT perspective. On the contrary, this topic has not received enough attention when it comes to spoken Jordanian-Arabic phonology within OT as a relatively modern theory. More specifically, none of the aforementioned works on Jordanian-Arabic is a longitudinal intervention study that analyzes and follows up the treatment of the phonological error patterns within the framework of OT - the main interest of this work. Accordingly, this study aims to link the theoretical assumptions of OT to the clinical application through a longitudinal intervention study. It is, as Edwards (1995:161) concluded, "clinical research (which) must be theory-driven, flexible and applicable to everyday practice. Modifications to nonlinear

phonological theories may result from the rigorous testing of these theories in case-by-case studies."

3. Methodology

The data of this study was gathered from a single male child who speaks Jordanian-Arabic as his mother tongue. The child was six-and-a-half years old at the time of conducting this research, and he suffers from functional (non-organic) phonological disorders. This subject was selected from the Speech and Hearing Center at Al-Ahliyya Amman University in Jordan. He had only functional phonological disorders, i.e., he is in a good health with no evidence of cognitive delay, severe teeth problems, or any abnormal oral-motor structure. He has normal physical development, a normal-functioning oral mechanism, and normal hearing. He also had normal comprehension and socially acceptable behavior. Moreover, the child passed a 25-dB pure-tone hearing screening test conducted by a speech language pathologist, using a portable audiometer.

As mentioned earlier, the child was 6 years and 6 months old, and normal child should have usually completed acquiring his/her language phonemic inventory by this age. This is based on Ingram's (1989) and Amayreh's (1998) divisions of the acquisition developmental stages in which there is an agreement that normal children complete the phonetic inventory, including difficult consonants, between the ages of four and seven.

For eliciting data, the child was enrolled in a longitudinal intervention study that aimed to suppress his phonological impairments. The child was seen for one-hour sessions, three times a week, for two months. He was given a picture-naming test which was designed by Amayreh (1994) and used by most speech pathologists in Jordan. This test assesses the 28 Arabic consonants in three word positions (28 initial, 28 medial and 23 final) by means of 58 pictures (see appendix). In addition, the researcher conducted an interview and recorded the participant's spontaneous utterances. The interview lasted for one hour and a half. The focus was on the pronunciation of individual words in isolation.

The child's utterances were audio-recorded and IPA-phonetically transcribed, then analyzed afterwards. The researcher followed up the intervention of the child's phonological disorder and applied a certain strategy in order to be able to re-rank the OT constraints according to their priorities.

4. Results and Discussions

Phonologically, experts agree that children with functional phonological disorders are a heterogeneous group with different number and type of speech errors made. This leads to the conclusion that not only do languages have different rankings of OT constraints, but so do individuals. Thus, speech errors committed by the child in this study cannot be generalized to all children who have phonological disorders as each child is expected to have his/her own error patterns.

The single child of this longitudinal intervention was 6 years and 6 months old at the time of starting this study. The child's data reflects the constraints ranking in his grammatical system. The following table illustrates the most noticeable speech errors in the child's grammar:

Table 1. Examples of the child's speech error patterns

Error Pattern	Examples
Fronting	/kur.si/ [**t**us.si] "chair", /sa.ma.ka/ [sa.ma.**t**e] "fish", /miʃ.miʃ/ [mi**s**.mi**s**] "apricot" , /ʃub.ba:k/ [**s**ub.ba:**t**] "window"
Lateralization	/qi.ṭa:r/ [qi.ṭa:**l**] "train", /qi.ra:ʔa/ [qi.**l**a:ʔa] "reading"
Stopping	/ʤa.ras/ [**d**a.las] "bell" , /fin.ʤa:n/ [**d**in.**d**a:n] "cup", /za.ra:.fa/ [**d**a.la:.feh] "giraffe", /ʤa.mal/ [**d**a.mal] "kamel", /ɣa.za:l/ [**q**asal] "deer"
Devoicing	/mo:z/ [mo:**s**] "bananas", /ɣa.za:l/ [qa.**s**al] "deer"
De-emphasization	/qi.ṭa:r/ [qi.**t**a:l] "train", /ṣu:.ra/ [**s**u:la] "picture"
Syllable Deletion	/**baṭ**.ṭi:x/ [ti:x] "watermelons", /**mif**.ta:ħ/ [ta:ħ] "key", /**fa**.ra:.ʃa/ [la:seh] "butterfly"
Cluster Reduction	/ʔa**b**.**j**aḍ/ [ʔabad] "white", /ḍi**f**.**ḍ**aʕ/ [difaʕ] "frog"

Note that there are some variations in the above production patterns. For example, the /z/ phoneme in the child's grammar has two different outputs. This singleton is produced as [s] in middle and final positions as in the above two examples /ɣa.za:l/ [qa.sa:l] and /mo:z/ [mo:s]. However, /s/ is produced as [d] in word initial position such as in the above /za.ra:.fa/ [da.la:.feh]. These two different outputs of the same input can be explained with relation to what Barlow (2001) referred to as the intraword variation (equal ranking of constraints). This occurs when there is more than one possible output of the same input in someone's grammar, and it is attributed to the equal ranking of constraints. In this case, the two markedness constraints *FRICATIVE and *VOICED-CODA are ranked equally. Other examples show more than one error pattern such as [tus.si] which is an example of both fronting and gemination of the original /kur.si/, and [du:ħ] as an example of both stopping and syllable deletion of its input /wu.ʤu:h/. Thus, in this paper, we will examine the OT's efficacy to account for all these production errors and explain them using constraints and constraints rankings.

4.1 Fronting

The process of substituting a velar or a palatal sound, like /k/ and /ʃ/ with an alveolar sound like /t/ and /s/ is known as *fronting*. As shown in the table above, fronting occurs in the child's productions, such as with /kur.si/ [tus.si] "chair" where the child used to substitute the

voiceless velar stop /k/ with the voiceless alveodental stop [t]. This production indicates the ranking of the markedness constraint *POST-ALV, which bans post-alveolar segments, over the faithfulness constraint IDENT-IO (Place) as Kager, (2004:45) indicated: "The specification for place of articulation of an input segment must be preserved in its output correspondent." Moreover, the child applied the word-middle gemination strategy in order to avoid the consonant cluster of /rs/ in /kur.si/ into [ss] in his production of [tussi]. The markedness constraint *GEM, which was proposed by Dinnsen, (2008b:160) and bans geminates, is used here to avoid geminate fricatives. This ranking is shown in Tableau (1) in which the highest ranked constraints start from the left.

Table 1. The optimal output for /kur.si/in the child's grammar

/kur.si/ "chair"	*POST-ALV	*GEM	IDENT-IO(Place)
☞ tus.si		*	*
kur.si	*!		

*POST-ALV >> *GEM>> IDENT-IO(Place)

Consequently, fronting is caused by the violation of the faithfulness constraint IDENT-IO (place) and preserves the markedness constraint *POST-ALV, which bans dorsals, at a high rank. The child was given some other words that contain the /r/ phoneme in the initial, middle and final positions. The result was that the child geminated the /r/ sound only in the case of consonant cluster in word-medial position such as with /ʔar.nab/ "rabbit" [ʔan.nab], and /mur.ʤe:.ħa/ "swing" as [mud.de:.ħa]. In other positions, the child tended to lateralize the /r/ sound such as in the above examples of /qi.ṭa:r/ [qi.ta:l] "train" and /qi.ra:ʔa/ [qi.la:ʔa] "reading".

4.2 Lateralization

The process of replacing /r/ with lateral [l] was recorded in all occurrences of the child's productions when /r/ is not part of consonant clusters. Dyson and Amayreh (2000), referred to this process using the term *lateralization*. They considered it one of the most common patterns found among Arabic-speaking children. Amayreh (2003) found that /l/ is acquired at earlier age than /r/ among children who speak Arabic language. This may be attributed to the fact that /l/ needs less effort in articulation than /r/ does. Although /l/ and /r/ are both liquids, /l/ is distinguished as a lateral phoneme in the sense that it is produced when the air is pushed to flow alongside the sides of the tongue. Accordingly, /l/ is distinguished from /r/ as being [+lateral] while /r/ is [-lateral].

As mentioned earlier, the data revealed that when /r/ is followed by another consonant in word-medial position, this /r/ is geminated such as in the production of /kur.si/ "chair" which was produced as [tus.si], and /qur.ʔa:n/ "Quran" which was produced as [quʔ.ʔan]. In all other positions and before vowels, /r/ surfaces as [l]. Accordingly, the word /ru.ʔu:s/ "heads"

surfaces as [lu.ʔu:s] where /r/ is in the initial position, the word /ba.qa.ra/ "cow" surfaces as [ba.ta.la] where /r/ is in the middle position, and the word /na:r/ "fire" surfaces as [na:l] where /r/ is in the final position. In all the previous examples, it is clear that the grammar of the child disallows the liquid /r/. This indicates that the markedness constraint *LIQUID-[r] ("No liquid [r]", Barlow 2001:245) is highly ranked in the child's grammar.

Table 2. The optimal output for /ba.qa.ra/ in the child's grammar

/ba.qa.ra/ "cow"	*LIQUID-[r]	*POST-ALV	IDENT-IO(F)	IDENT-IO(Place)
☞ ba.ta.la			*	*
ba.qa.la		*!	*	
ba.ta.ra	*!			*
ba.qa.ra	*!	*!		

*LIQUID-[r], *POST-ALV >> IDENT-IO (F), IDENT-IO (Place)

The overall ranking in Tableau (2) illustrates how the word /ba.qa.ra/ surfaces in the child's grammar. To account for the lateralization pattern, the markedness constraint *LIQUID-[r] is highly ranked among other constraints. Moreover, the Tableau shows that *POST-ALV has an equal ranking of *LIQUID-[r] since both of these constraints can cause a fatal violation for their output candidates. In this tableau, there are four possible candidates for the input /ba.qa.ra/. Accordingly, candidate (d) incurs a fatal violation of the two highly ranked markedness constraint *LIQUID-[r] and *POST-ALV since these two constraints are equally ranked in the child's grammar. Both candidates (c) and (b) incur fatal violations of *LIQUID-[r] for the former output and *POST-ALV for the latter. Thereby, the optimal candidate is (a) with the least violation of the two equally ranked faithfulness constraints IDENT-IO(F); that is, there is no featural changes (Kager, 2004: 250) and IDENT-IO(Place).

4.3 Stopping

Stopping occurs when a fricative or an affricate is substituted with a stop. In the child's stopping error pattern, the word /za.ra:.fa/ "giraffe" surfaces as [da.la:.feh] in which the stop /d/ substituted the fricative /z/. Similarly, the uvular fricative /ɣ/ in /ɣa.za:l/ "deer" surfaces as the uvular stop /q/ in [qasal]. In these two examples, stopping is the result of substituting a fricative with a stop. The main responsible constraint for this kind of speech error is the markedness constraint *FRICATIVE ("Avoid fricatives", Barlow and Gierut, 1999:1488), which outranks the faithfulness constraint IDENT-MANNER ("Preserve input manner features", ibid). This ranking is illustrated in Tableau (3), below, as follows:

Table 3. The optimal output for /za.ra:.fa/ in the child's grammar

/za.ra:.fa/ “giraffe”	*FRICATIVE	*LIQUID-[r]	IDENT-MANNER	IDENT-IO(F)
☞ da.la:.feh			*	*
da.ra:feh		!*	*	
za.la:.feh	*!			*
za.ra:.feh	*!	*!		

*FRICATIVE,*LIQUID-[r] >>IDENT-MANNER, IDENT-IO(F)

To account for the child’s stopping pattern, *FRICATIVE outranks IDENT-MANNER and IDENT-IO(F). Note that the two markedness constraints *FRICATIVE and *LIQUID-[r] are equally ranked since the child’s grammar does not allow the violation of both of them. The above Tableau shows that there are four possible candidates for the input /za.ra:.fa/ as shown on the left side of the Tableau. The more faithful candidates (c) and (d) incur fatal violations of the two markedness constraint *FRICATIVE and *LIQUID-[r]. Candidate (b) also incurs a fatal violation of the markedness constraint *LIQUID-[r] in addition to violating the faithfulness constraint IDENT-MANNER, because the output form includes a stop and a liquid /r/. Accordingly, candidate (a) incurs the least violation of the least ranked constraints and thus it is the optimal candidate.

4.4 Devoicing

It is generally known that voiced fricatives are the most difficult sounds to produce among others. In particular, voiced sibilants are commonly devoiced as a matter of simplification. Smith (1997) mentioned two reasons for devoicing: the first of which is to assimilate to an adjacent voiceless context, and the second is to reduce articulatory and aerodynamic efforts. Devoicing occurs in the child’s data when the fricative /z/ surfaces as /s/ in middle and final position such as in /mo:z/ “bananas” which was produced as [mo:s] , /ɣa:z/ “gas” as [qa:s], and /ɣa.za:l/ “deer” as [qa.sal]. Therefore, devoicing occurs in the child’s grammar to reduce articulatory efforts.

The data revealed that the child’s grammar does not exhibit the voiced sibilant /z/. In this case, I would suggest that *VOICED-SIBILANT, which bans voiced sibilants from surfaces, is a highly ranked markedness constraint in the child’s grammar. Evidence as being a markedness constraint comes from the rarity of voiced sibilants cross-linguistically and the efforts they need to produce them. One more piece of evidence comes from different studies on language acquisition which concluded that voiced sibilants are of the latest consonant to be acquired in the world’s languages (Ohala (1983), Goldman, Fristoe, and Williams (2000), Amayreh (2003)). Within this view, the markedness *VOICED-SIBILANT outranks the IDENT-IO(voice) (“Output segments preserve values of [voice] for input correspondents.”, Kager, 2004:340).

Thus, [mo:s] satisfies the markedness constraint *VOICED-SIBILANT because [s] is a voiceless obstruent in the coda position. The pattern of devoicing is illustrated in Tableau (4):

Table 4. The optimal output for /mo:z/ in the child's grammar

/mo:z / "bananas"	*VOICED-SIBILANT	IDENT-IO(voice)
☞ mo:s		*
mo:z	*!	

*VOICED-SIBILANT >> IDENT-IO(voice)

This Tableau illustrates that candidate (b) [mo:z] is prevented from surfacing in the child's grammar because it incurs a fatal violation of the highest-ranked constraint *VOICED-SIBILANT. In comparison, Candidate (a) violates IDENT-IO (voice), but satisfies higher ranked *VOICED-CODA and this makes it the optimal output.

4.5 De-emphasization

Arabic language is generally distinguished for its emphatic sounds which are produced with a secondary articulation, i.e. the root of the tongue is retracted into the pharynx (Mahadin and Bader (1996), Amayreh (2003), Dyson and Amayreh (2000)). However, there is a little difference in the number of the emphatic sounds from one dialect into another. According to Mahadin and Bader (1996), there are four emphatic consonants: /ṣ/, /ḍ/, /ṭ/, and /ð̣/ along with their non-emphatic correspondents: /s/, /d/, /t/ and /ð/ in Jordanian Arabic. The process of replacing the emphatic sound with its non-emphatic correspondent is known as *de-emphasization*. In this case, the emphatic sound loses its secondary articulation.

It was noticed that the emphatics /ṣ/, /ḍ/, /ṭ/ and /ð̣/ surfaced as /s/, /d/, /t/ and /ð/, respectively, in many productions of the child's grammar. This can be attributed to the fact that the child tends to simplify the production of the emphatics using their non-emphatic correspondents. Moreover, it can be inferred that the grammar of the child does not realize the difference between the two set of the emphatic and non-emphatic sounds and the change in meaning they can make. For example replacing /ṣ/ in /ṣa:r/ "happened" with /s/ will produce /sa:r/ "walked" which has a totally different meaning. In the same manner, change in meaning will also occur when replacing the emphatic /ṭ/ in /ṭi:n/ "mud" with its non-emphatic correspondent /t/in /ti:n/ "fig", the emphatic /ð̣/ in /ð̣all/ "stay" with its non-emphatic correspondent /ð/ in /ðall/ "humiliate", and the emphatic /ḍ/ in /ḍa:r/ "harmful" with its non-emphatic correspondent /d/ in /da:r/ "house". Tableau (5), below, reveals the optimal output for the word /qi.ṭa:r/ "train":

Table 5. *The optimal output for /qi.ṭa:r/ in the child's grammar*

/qi.ṭa:r/ "train"	*EMPHATIC	*LIQUID-[r]	IDENT-IO(F)	IDENT-IO(EMPH)

☞qi.ta:l			*	*
qi.ṭa:l	*!		*	
qi.ṭa:r	*!	*!		

*EMPHATIC, *LIQUID-[r], IDENT-IO(F) >>IDENT-IO(EMPH)

Tableau (5) reveals that the two markedness constraints *EMPHATIC (which bans the four emphatic /ṣ/, /ḍ/, /ṭ/ and /ð̣/ from surfacing in the child's grammar) and *LIQUID-[r] share the same ranking since violating any of them causes a fatal violation in the output. In this tableau, there are three possible candidates for the input /qi.ṭa:r/. The most faithful candidate (c) incurs two fatal violations of the most highly ranked markedness constraints *EMPHATIC and *LIQUID-[r]. Candidate (b) incurs a fatal violation of the markedness constraint *EMPHATIC. Candidate (a), on the other hand, incurs the least violation of the least-ranked constraints, thus it is the optimal one. The tableau also illustrates how the conflict between the markedness and faithfulness constraints causes the homonyms in the production of /qi.ṭa:r/ "train" in the optimal output is [qi.ta:l] which means "fighting".

4.6 Syllable Deletion

Syllable deletion was also found in the child's data in the productions of /baṭ.ṭi:x/ [ti:x] "watermelons", /mif.ta:ħ/ [ta:ħ] "key" /wu.ʤu:h/ [du:ħ] "faces", and /laj.mu:n/ [mu:n] "lemon". The child tends to delete the initial unstressed syllable. This result is in agreement with Demuth (2001) who explained that stressed and final syllables are those that surface in children's early productions. To account for this syllable deletion pattern the markedness constraint *INIT-UNSTRSDσ, which disallows initial unstressed syllables, outranks the faithfulness constraint FAITHSYL ("Every syllable in the input must correspond to a syllable in the output", Demuth, 2001:116). Tableau (6), below, illustrates the pattern of syllable deletion for the word /baṭ.ˊṭi:x/ "watermelons":

Table 6. The optimal output for /baṭ.ˊṭi:x/ in the child's grammar

/baṭ.ˊṭi:x/ "watermelons"	*INIT-UNSTRSDσ	*EMPHATIC	FAITHSYL	IDENT-IO(EMPH)
☞ ˊti:x			*	*
ˊṭi:x		*!	*	
baṭ.ˊṭi:x	*!	*!		

*INIT-UNSTRSDσ >> *EMPHATIC >> FAITHSYL>> IDENT-IO(EMPH)

As shown in the Tableau (6), candidate (c) incurs two fatal violations of the two high-ranked markedness constraint *INIT-UNSTRSDσ and *EMPHATIC. Candidate (b) also incurs a fatal violation because it violates the higher-ranked markedness constraint *EMPHATIC which prohibits emphatic sounds. Candidate (a) is selected as the winner or the optimal because it violates the two lower ranked FAITHSYL and IDENT-IO(EMPH). It should be noted here that syllable deletion is an optional process in the child's grammar. In other words, the data revealed that the child does not tend to drop any initial unstressed syllable from multi-syllabic words. Accordingly, it is a less serious violation of the grammar of this child to delete a syllable than to produce a fricative sound or a liquid [r]. Accordingly, the markedness constraint*INIT-UNSTRSDσ cannot be ranked above *FRICATIVE or *POST-ALV in the child's grammar.

4.7 Cluster Reduction

The pattern of reducing a consonant cluster into a single consonant is known as *cluster reduction* or *simplification*. This pattern was found in the child's grammar in the production of words such as /ʔab.jaḍ/ (*white*) which surfaced as [ʔabad] and /ḍif.ḍaʕ/ (or *frog*) which surfaced as [difaʕ]. The ranking of constraints for the pattern of cluster reduction predicts that the general markedness constraint *COMPLEX is highly ranked in the child's grammar. This ranking is shown in Tableau (7) in which the optimal output for the word /ḍif.ḍaʕ/ "frog" is illustrated:

Tableau 7. The optimal output for /ḍif.ḍaʕ/ in the child's grammar

/ḍif.ḍaʕ/ "frog"	*COMPLEX	*EMPHATIC	MAX-IO	IDENT-IO(EMPH)
☞ difaʕ			*	*
dif.daʕ	*!			*
ḍif.ḍaʕ	*!	*!		

*COMPLEX, *EMPHATIC >>MAX-IO >>IDENT-IO(EMPH)

The overall ranking of the above Tableau explains how the input /ḍif.ḍaʕ/ surfaces in the child's grammar. Candidate (b) incurs a fatal violation of high-ranked *COMPLEX because of the [fd] output sequence. Likewise, candidate (c) incurs two fatal violations of the two high-ranked *COMPLEX and *EMPHATIC. The constraint violation that candidate (a) incurs is

for the least ranked MAX-IO, a general faithfulness constraint that prevents deletion, and IDENT-IO(EMPH). Accordingly, candidate (a) incurs a less serious violation in the grammar of the child which makes it the optimal candidate.

5. Treatment

In the previous section, the child's common error patterns were analyzed within an OT perspective. It was found that OT is an adequate model to account for an individual's speech errors using constraints that are cross-linguistically available. As mentioned earlier, the child was enrolled in a longitudinal intervention study that aimed to suppress his phonological impairments. The child was seen for one-hour sessions, three times a week, for two months. At the end of this study, speech errors were reduced, and the child's grammar was closest to that of an adults. In other words, most of the faithfulness constraints in the child's grammar outranked the markedness ones which are responsible on making such speech errors.

After analyzing the above seven-speech error patterns found in the child's data, the challenging part was to re-rank the constraints that were in conflict. It was significant to promote the faithfulness constraints, as Barlow (2001) emphasized, to keep the contrasts between words in the output and thus avoid homonymy. Accordingly, the markedness constraints such as *FRICATIVE, *LIQUID-[r],*POST-ALV, *GEM and *VOICED-SIBILANT were demoted by a matter of continuous intervention sessions. This gave the chance for other faithfulness constraints such as IDENT-MANNER, IDENT-IO(Place), IDENT-IO(F), MAX-IO, and FAITHSYL to be promoted naturally without intervention.

For treatment purposes, the feasibility of the demotion of the markedness constraints was examined through correcting misarticulated sounds individually. In doing so, the researchers followed Amayreh's (2003) three-stage division of acquiring Arabic consonants. We started demoting constraints that are related to sounds acquired at early age followed by sounds that are acquired at intermediate age and ended with sounds acquired at late age. Accordingly, treatment processes started with working on the demotion of *POST-ALV constraint. In this way, the child was able to produce the velar /k/ and the palatal /ʃ/ correctly. The singleton /k/ is acquired at an early age in normal circumstances. Thus, it was a preferred starting point in this intervention study. The singleton /ʃ/, as well, is acquired normally in the second stage of child's acquisition.

The second constraint to be demoted was *LIQUID-[r] which bans the production of lateral /r/. Amayreh (2003) indicated that /r/ is a consonant that is acquired in the second stage of child's acquisition. Accordingly, the production of /r/ was corrected by the demotion of *LIQUID-[r]. As a result, the faithfulness constraint IDENT-IO(F) was naturally promoted. Likewise, the markedness *GEM was demoted in parallel since the relatively high rank of this constraint was a result of not existing /r/in the child's grammar.

Working on the demotion of the markedness constraint *FRICATIVE was the third step in the treatment processes since fricatives and affricates are the latest sounds to be acquired. Within this view, the demotion of *FRICATIVE resulted in the promotion of the faithfulness constraint IDENT-MANNER. Lastly, the markedness constraint *EMPHATIC was demoted since emphatic

sounds are the most difficult sounds for acquiring. Other errors that were related to the weak syllable deletion (*INIT-UNSTRSDσ) and consonant cluster reduction (*COMPLEX) were consequently corrected. Table (2) below illustrates the child's ranking of constraints before and after the intervention.

Table 2. The ranking of constraints before and after treatment in the child's grammar

Before Treatment	The Markedness Constraints	The Faithfulness Constraints
	*POST-ALV,*FRIC,*LIQUID-[r]>>*VOICED-SIB>>*EMPH>>*INIT-UNSTRSDσ >> IDENT-IO(Place), IDENT-MANNER, IDENT-IO(F), MAX-IO, FAITHSYL	
After Treatment	The Faithfulness Constraints	The Markedness Constraints
	IDENT-IO(Place), IDENT-MANNER, IDENT-IO(F), MAX-IO, FAITHSYL >> *POST-ALV *FRIC,*LIQUID-[r], *VOICED-SIB, *EMPH *INIT-UNSTRSDσ	

6. Conclusion

The analysis of the child's phonology helps to explain the clinical value of OT and its role in reordering the phonological constraints and thus suppressing speech errors. The study showed that this child exhibits seven phonological error patterns, namely: fronting, lateralization, stopping, devoicing, de-emphasization, syllable deletion and cluster reduction. These errors were attributed to the high-ranking of some markedness constraints in the child's grammar. More specifically, *FRICATIVE, *LIQUID-[r], and *POST-ALV are ranked relatively high in his grammar. Moreover, the variation of the same input in the output was attributed to the equal ranking of some constraints in the child's grammar.

To summarize, the data revealed that there were some singletons that were not exhibited in the child's grammar such as ʃ, ɣ, r, and z, in addition to the four emphatics /ṣ/, /ḍ/, /ṭ/ and /ð̣/. The data also revealed that some singletons have variant outputs such as /z/, /s/ and /q/ according to their position within a single word. It was also revealed that the grammar of the child demonstrated two strategies to avoid complex clusters. These are gemination (in the case of the adjacent /r/) and cluster reduction. The analysis showed the correlation between the constraints and their ranking in all the error patterns that were exhibited in the child's grammar.

Regarding the clinical application of this work, OT was used as a guideline to correct the phonological error patterns in the child's grammar and also used to decide the priorities in re-ranking the constraints. The treatment was demonstrated through demoting the highly ranked markedness constraints starting from the highest. As a result, other lower-ranked faithfulness constraints were promoted and thus speech errors were corrected.

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Appendix

Appendix 1: The child's answers on Amayreh's (1994) test

Target Sound	Word	Gloss	The child's Production
middle /t/ sound	/mif.ta:ħ/	"key"	[ta:ħ]
initial /ṭ/ sound	/ṭa:ʔi.ra/ or /ṭaj.ja:ra/	"plane"	[taj.ja:la]
middle /ṭ/ sound	/qi.ṭa:r/	"train"	[qi.ta:l]
final /ṭ/ sound	/miʃṭ/	"comb"	[mist]
middle /d/ sound	/mad.ra.sa/	"school"	[naseh]
initial /ḍ/ sound	/ḍif.ḍaʕ/	"frog"	[difaʕ]
middle /ḍ/ sound	/baj.ḍa/	"egg"	[baj.da]
final /ḍ/ sound	/ʔab.jaḍ/	"white"	[ʔabad]
initial /k/ sound	/kur.si/	"chair"	[tus.si]
middle /k/ sound	/sa.ma.ka/	"fish"	[sa.ma.teh]
final /k/ sound	/ʃub.ba:k/	"window"	[subat]
initial /q/ sound	/qur.ʔa:n/	"holy Quran"	[quʔ.ʔan]
middle /q/ sound	/ba.qa.ra/	"cow"	[ba.ta.la]
final /q/ sound	/wa.raq/	"paper"	[walʔa]
middle /ʔ/ sound	/qi.ra:ʔa/	"reading"	[qa.la.2a]
initial /m/ sound	/mawz/ or /mo:z/	"banana"	[mo:s]
initial /n/ sound	/na:r/	"fire"	[na:l]
final /n/ sound	/ta.la.fo:n/	"telephone"	[ta.fo:n]
middle /f/ sound	/sa.fi:na/	"ship"	[ta.fi.neh]
final /f/ sound	/xa.ru:f/	"sheep"	[qalu:f]
initial and final /θ/	/θa.la:θ/	"three"	[ta:teh]
initial /ð/ sound	/ða.nab/	"tail"	[ða.mab]
middle /ð/ sound	/ʤu.ðu:r/	"roots"	[ðudu:d]
initial /ḍ/ sound	/ḍahr/	"back"	[ðahel]
middle /ḍ/ sound	/naḍ.ḍa:.ra/	"eyeglasses"	[da:la]
final /ḍ/ sound	/ħa:fiḍ/	"preservative"	[ħafid]
final /s/ sound	/ʤa.ras/	"bell"	[dalas]
initial /ṣ/ sound	/ṣu:.ra/	"picture"	[su:la]
initial /z/ sound	/za.ra:.fa/	"giraffe"	[da.la.feh]
middle /z/ sound	/ɣa.za:l/	"deer"	[qasal]
final /z/ sound	/ɣa:z/	"gas"	[qas]
initial /ʃ/ sound	/ʃub.ba:k/	"window"	[sub.ba:t]
middle /ʃ/ sound	/fa.ra:.ʃa/	"butterfly"	[la:seh]
final /ʃ/ sound	/miʃ.miʃ/	"apricot"	[mis.mis]

initial /x/ sound	/xa.ru:f/	“sheep”	[qalu:f]
middle /x/ sound	/ʔax.ḍar/	“green”	[ʔaq.dal]
final /x/ sound	/baṭ.ṭi:x/	“watermelons”	[ti:x]
initial /ɣ/ sound	/ɣa.za:l/	“deer”	[qasa:l]
middle /ɣ/ sound	/maɣ.sa.la/	“sink”	[qa.sa.la]
final /ɣ/ sound	/ṣimɣ/	“glue”	[nasex]
final /ħ/ sound	/miʃ.ta:ħ/	“key”	[ta:ħ]
initial /h/ sound	/ha.dij.ja/	“gift”	[ħa.dij.jeh]
middle /h/ sound	/zu.hu:r/	“flowers”	[zu.hu:l]
final /h/ sound	/wu.ʤu:h/	“faces”	[ðu:ħ]
initial /ʤ/ sound	/ʤa.mal/	“camel”	[damal]
middle /ʤ/ sound	/fin.ʤa:n/	“cup”	[din.da:n]
final /ʤ/ sound	/da.ʤa:ʤ/	“chicken”	[ða.da:d]
initial /l/ sound	/laj.mu:n/	“lemon”	[mu:n]
initial /r/ sound	/ru.ʔu:s/	“heads”	[luʔu:s]
middle /r/ sound /	ba.qa.ra/	“cow”	[ba.ta.la]
final /r/ sound	/na:r/	“fire”	[na:l]
middle /w/ sound	/mar.wa.ħa/	“fan”	[walaħa]
middle /j/ sound	/ʔab.jaḍ/	“white”	[ʔabad]

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