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INVESTIGATION OF VOT AS AN ACOUSTIC FEATURE OF CONSONANTS IN STRESSED SYLLABLE IN ADULTS WITH DOWN SYNDROME

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Abstract

Down syndrome (DS) is the most common genetic impairment, which is caused by the copy of an additional chromosome 21. In the case of Down syndrome, physical and health disorders, intellectual disabilities, and neuron-psychological defects are undeniable. The purpose of this research is to investigate acoustically voice onset time (VOT) in stressed and unstressed positions in adults with Down syndrome. For this purpose, two minimal pairs (tɒbeʃ/tɒb-eʃ –

tɒpe∫/tɒp-e∫) are considered. In this study, 18 research participants with Down syndrome (nine boys with mean of ages 28, and nine girls with mean of ages 30), were asked to pronounce tɒbe∫/tɒb-e∫ and tɒpe∫/tɒp-e∫ and repeat them four times. The participants' productions were recorded using a Shure microphone and analyzed by PRAAT (6.0.22) software. The results revealed that VOT mean of [b, p] in stressed syllable significantly differs from that in unstressed syllable in adults with Down syndrome.

Keywords

Down Syndrome (DS), VOT (Voice Onset Time), Stressed Syllable, Unstressed Syllable, Voiced Position, Voiceless Position

1. Introduction

One kind of intellectual disability is Down syndrome (DS), which is a frequent chromosomal disorder. This occurs with an incidence of 1/700 infants. The three kinds of Down syndrome are: Trisomy 21, Translocation, and Mosaicism, of which the first one is the most common caused by the existence of an extra chromosome 21 (Roizen & Patterson, 2003). Down syndrome is the most prevalent kind of intellectual disability which emerges along with physical and neuron-psychological defects (Jahangiri & Rouhi, 2010). People with DS suffer from nerve innervation and this condition affects their muscles and speech production (Kumin, 2006). Diminishing of oral cavity as well as greater curve of palate in people with Down syndrome affect their articulation, and the enlargement of tongue in comparison to the size of oral cavity interrupts the articulation (Redman, Shapiro, & Gorlin, 1966). Between 38% and 78% people with DS have problems with identification and the treatment of hearing loss which could be sensorineural, conductive, or a mixture of them (Roizen & Patterson, 2003). Children with Down syndrome have problems with phonological awareness skills. Phonological awareness is a linguistic mental ability that enables individuals to recognize the sounds of words. Due to low skills of phoneme awareness, children with Down syndrome have some troubles in reading (Tavakol, Shafiei, & Ali Nia, 2012).

1.1 Stress in Persian

Stress is a linguistic feature which plays a prominent and distinctive role in distinguishing one syllable from other syllables in the words. It is also known as a key term in phonetic investigation of pragmatic and syntagmatic axis (Sadeghi, 2013). Word stress happens when one

syllable is pronounced stronger than the other syllables in a word. This appears in languages containing word stress such as English, Persian and Dutch (Sadeghi, 2012). Ferguson (1957) believed that a Persian word which is pronounced in isolation has one syllable of heavier stress than the others. He argued that this concept of word stress is essentially morphological. Ferguson explained that if we consider the dictionary entry form of the word, such as nouns without inflectional endings, or the infinitives, the Persian stress falls on the final syllable and if inflected form of nouns and verbs are considered, the stressed syllable might change. According to prosodic phonology, in stress system of Persian words, final stress rule could apply to all nouns, adverbs, and non-prefixed verbs as well (Kahnemuyipour, 2003). Prefixed verbs take stress on the prefix (Abolhasanizadeh, Bijankhah, & Gussenhoven, 2012). From Lehiste (1970) point of view, what should be considered regarding the question of stress are inherent features of vowels and consonants. The space surrounding vowels in both stressed and unstressed position should be the same, because the energy of syllable nucleus depends on formants' constructions, and also because the consonants around the vowels have an effect on the formants. By measuring phonological features, he defines the difference between stressed and unstressed syllables as

- Vowels in stressed syllable have higher energy.
- Vowels in stressed syllable are longer.
- Vowels are more similar to the central vowel in stressed syllable.
- Fundamental frequency is another distinguishing feature.

1.2 Voice Onset Time

Voice Onset Time (VOT) is the most reliable acoustic feature that differentiates between voiced and voiceless stops, and this stop consonant's feature shows the timing of supralaryngeal-laryngeal coordination (Abramson, 1977). VOT is a time between the release of oral construction for the production of plosives and the onset of vocal folds vibrations (Dalgic, Kandogan, & Aksoy, 2015; Lisker & Abramson, 1964). There are some factors which affect VOT; one of them is the gender of the speakers (Lisker & Abramson, 1964). The researchers who did a survey on VOT, considering the gender of the participants, were Whiteside & Irving (1998). Their results concluded that VOT of women was longer than VOT of men for voiceless stops while for voiced stops, women had shorter VOT in comparison with men (Whiteside & Irving, 1998). In other surveys, Sweeting & Baken (1982) did not find any differences between VOTs of male and female speakers. The place of articulation is another element which can have an effect on the

value of VOT. Researchers mentioned three possibilities for the effect of place of articulation on VOT.

1) When the closure goes further back, VOT becomes longer (Morris, McCrea, & Herring, 2008).

2) When we have an extended area between two articulators, VOT gets higher (Stevens, Keyser, & Kawasaki, 1986).

3) The articulators which have faster movement like tip of the tongue and lips will produce shorter VOTs (Hardcastle, 1973).

It is concluded from studies that positive and long VOTs are measured for English plosives, [p], [t] and [k] and positive but short VOTs or even the negative VOTs are for [b], [d] and [g] (Lisker & Abramson, 1964). VOT can be positive, negative or even zero; this fact depends on the characteristics of plosives. Positive VOT happens only when the vocal folds start vibrating after the release of the consonant's construction, in this case the voice has the voicing lag; on the other side, we have the negative VOT which happens when the vibration of vocal folds start before the release of consonant; and the last possibility is when the vibration of vocal folds and the release of consonants happen at the same time, in this case the VOT is said to be zero (Morris, et al., 2008; Docherty, 1992; Klatt, 1957).

2. Objectives of the Study

This study investigates the consonants acoustically in stressed/ unstressed syllables and in voiced/voiceless positions in adults with DS. For this aim, we examine two minimal pairs *tʊbeʃ (light), tʊb-eʃ (his/her swing), tʊpeʃ (nonsense word), and tʊp-eʃ (his/her top)*, in order to study the effect of stress on VOT of stops in adults with DS in Persian to find out whether the mean of this variable in stressed syllable differs from that it in unstressed syllable, and the mean VOT of [b] differs from the mean VOT of [p].

3. Significance of the Study

VOT is one of the most important acoustic features which has been studied in different languages, but there is not yet any noticeable and adequate survey about VOT in stressed position in adults with DS in Persian, and more surveys are needed. Since individuals with DS

have some difficulties in articulators, hearing, and sounds comprehensions, they have some deficits in their speech productions. As a consequence, the results of this study accommodate an appropriate database which speech therapists can use to evaluate and treat the components of speech production in young people with DS, such as phonation (producing sound), resonance, fluency, intonation, pitch variance, and voice (including aeromechanical components of respiration).

4. Methodology

In this study we analyzed the speech production of adults with DS and measured VOT in stressed and unstressed positions among 18 speakers, nine boys with mean of age 28 and nine girls with mean of age 30 years, the participants were monolingual speakers of Persian. Since most of the adults with DS refuse talking and making interactions with unknown people, we had to work with them, passing some hours talking and playing in order to make a friendly atmosphere and make them feel more comfortable to cooperate with us. At the end of each session, all participants received some gifts, chocolate, and sweet. Since some participants were illiterate, we had to use a piece of paper containing the pictures of the words and explain the meaning of the words that we wanted them to repeat in a friendly way. Then we asked them to repeat each word four times, after the researchers, through a Shure microphone. After recording all the stimuli we chose two high quality productions of each individual for further analysis. Lazard (1958) believed that in Persian, stress falls on the final syllable and clitics do not absorb the stress. Therefore, we chose minimal pairs *[tɒbeʃ] (light)/ [tɒb-eʃ] (his/her swing) – [tɒpeʃ] (nonsense word)/ [tɒp-eʃ] (his/her top)* for our study. After recording data, we analyzed them by PRAAT software (ver.6.0.22), which can analyze several sound wave and spectrographs together at the same time. Next, we made a text grid for each sound wave, and determined the boundaries between vowels and consonants, and then we used phonetic signs to label each segment (Fig. 1). Finally we measured VOT mean of consonants and analyzed them by SPSS software (ver.16).

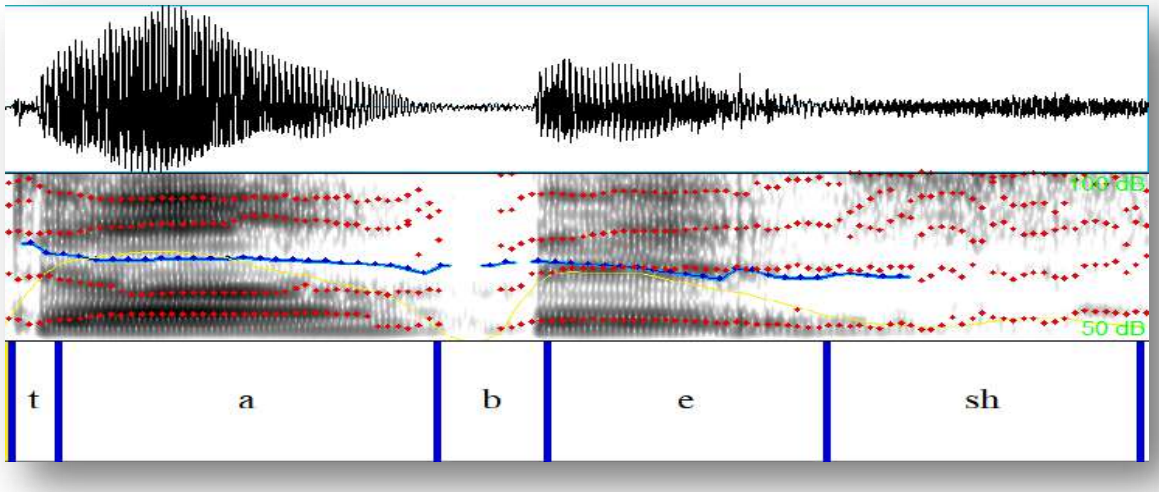

Figure 1: *Praat TextGrid for a Word [Tɒbe∫]*

5. Result and Discussion

5.1 VOT [t]

5.1.1 Stressed

The repeated measure ANOVA indicated that the effect of stress on mean VOT of [t] in adults with Down syndrome is not significantly different from that in unstressed syllable ($F[1, 11] = 0.378$; $p>0.05$).

Table 1: *Mean and Standard Deviation of VOT [t]*

Stressed/ Unstressed	***Voiced/ Voiceless***	***Mean***	***Std. Deviation***
Stressed	**Voiced**	**34.25**	**29.13**
Stressed	**Voiceless**	**44.25**	**25.54**
Unstressed	**Voiced**	**40.17**	**21.44**
Unstressed	**Voiceless**	**43.32**	**28.32**

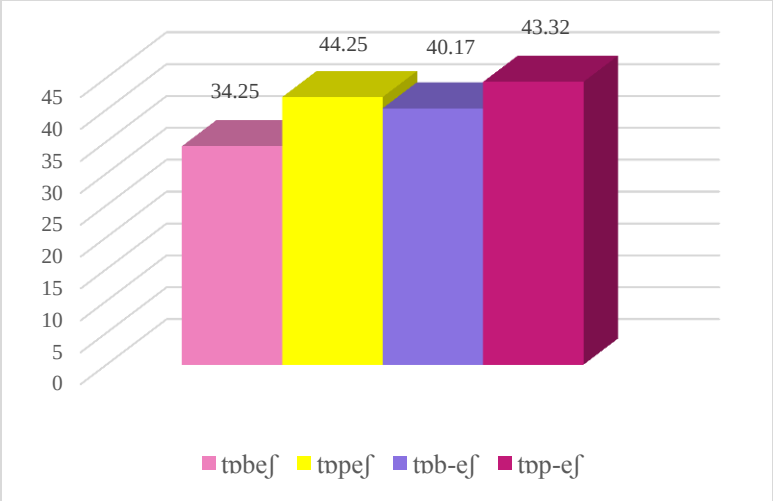

Figure 2: *VOT of [t] in Stressed and Unstressed Syllable (Self-Designed)*

5.2 VOT [b, p]

5.2.1 Stressed

The results of VOT [b, p] in stressed syllable in adults with DS are presented in (Fig. 2). Based on repeated measure procedure, mean of VOT [b, p] in adults with DS is significantly different from that in unstressed syllable ($F[1, 11] = 7.269$; $p<0.05$). The result of a post-hoc Bonferroni test clarified that mean of VOT [b, p] in stressed position in adults with DS is 22.60 (m/s) more than that in unstressed position (Fig. 3).

5.2.2 Voiced

The result of repeated measure procedure showed that mean of VOT of [b] in adults with DS does not significantly differ from VOT of [p] ($F[1, 11] =1.539$; $p>0.05$).

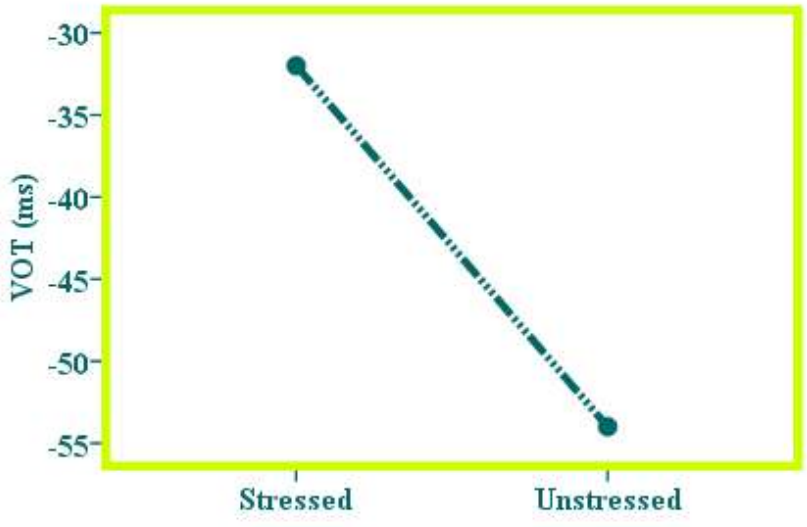

Figure 3: *The Effect of Stress on VOT [b, p]*

Table 1.2: *Mean and Standard Deviation of VOT [b, p]*

Stressed/ Unstressed	***Voiced/ Voiceless***	***Mean***	***Std. Deviation***
Stressed	**Voiced**	**-45.25**	**47.21**
Stressed	**Voiceless**	**-19.32**	**76.62**
Unstressed	**Voiced**	**-53.92**	**64.36**
Unstressed	**Voiceless**	**-55.85**	**79.79**

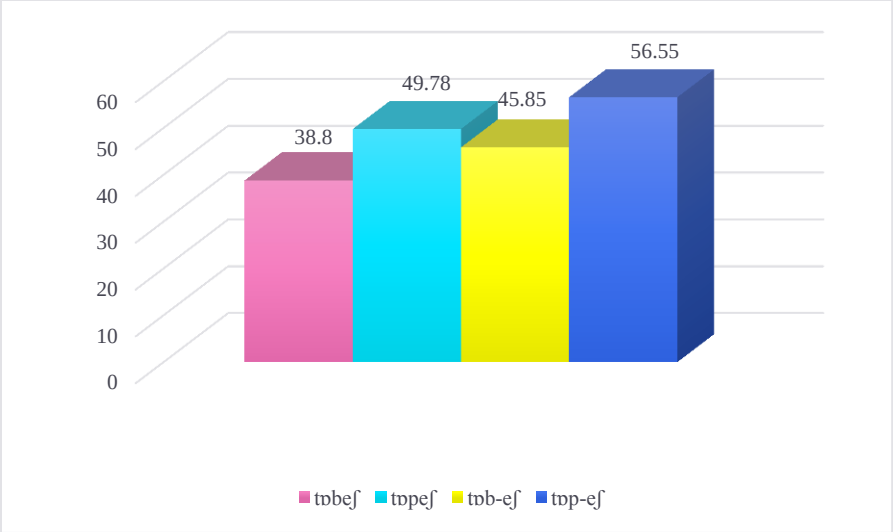

Figure 4: *VOT of [b, p] in Stressed and Unstressed Syllable (Self-Designed)*

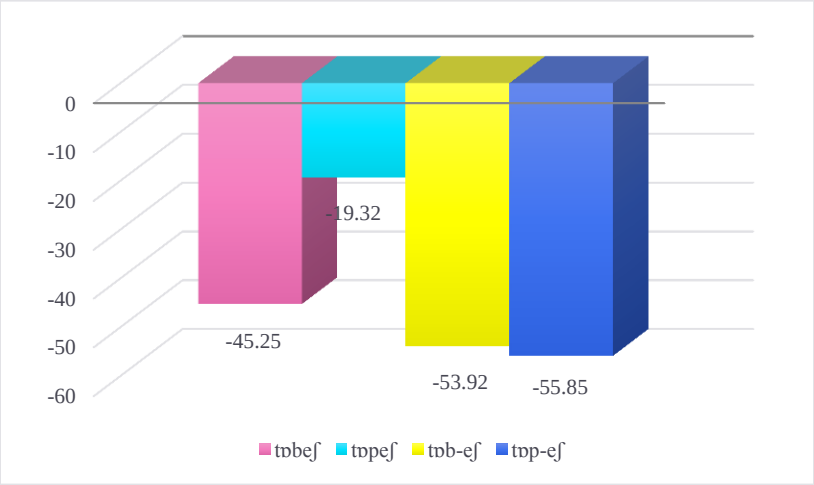

Figure 5: *VOT of [b, p] in Stressed and Unstressed Syllable (Self-Designed)*

Voice onset time (VOT) mentioned as a crucial acoustic parameter used to distinguish voiced stops from voiceless ones in diverse languages (Lane & Perkell, 2005). The purpose of this study was to investigate the difference between mean VOT of stops [t, b, p] in stressed/unstressed and in voiced/voiceless positions in adults with DS in Persian. Unfortunately, there is not any survey on VOT in individuals with DS, so we provided the results from other studies with other impairments rathe than ones with DS.

Ryalls, Gustafson, & Santini (1999) illustrated that VOT of voiceless stops in dysphagia impairments were shorter than ones in normal participants while VOT of voiced stops were longer than ones compared with normal participants. Lane & Perkell (2005) mentioned that deaf people show less tendency in order to differentiate between VOT of voiced and VOT of voiceless stops. Dalgic et al. (2015) argued that mean VOT of cochlear impairments significantly differed from that in normal ones, and the findings showed that this difference in cochlear impairments was higher than that in normal participants.

6. Conclusion

Persian is a stressed language and stress falls on the last syllable (Ferguson, 1957). Based on this study, VOT in stressed and unstressed position in people with DS's productions of [b, p], we concluded that mean of VOT [b, p], in stressed syllable was significantly different from that in unstressed syllable ($p<0.05$)– mean was 22.60 (m/s)–, whereas the result of VOT [t] in adults with DS indicated that this difference in stressed and unstressed syllable was not significant ($p>0.05$)– it was 2.50 (m/s).

Since there were only few welfare offices dedicated to adults with DS, such as Tavana, Mashiz, Pouya, all persons who worked there did not cooperate with the researchers. Another important limitation was forming a good relationship with this group of patient. Because of having difficulty in speaking and hearing, and the lack of the self-confidence and the shyness of the participants with DS, they hardly ever wanted to make interactions with the researchers especially when they were asked to speak into the microphone.

Since there was not any project worked on VOT in adults with DS in Persian, this study narrowed down its focus on the effect of stress on VOT in adults with DS in Persian, so we recommend other researchers to work on stops other than [t, b, p], minimal pairs other than ones studied in this survey, conditions other than ones investigated in this project, and participants other than ones with DS.

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